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INTRODUCTION

OHMi-Nunavik: a multi-thematic and cross-cultural research program studying the cumulative effects of climate and socio-economic changes on Inuit communities

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ABSTRACT

Adjusting to global climate and socio-environmental changes has become a major issue for many societies, especially in the Arctic. Many Inuit wish to better understand the changes taking place. In 2013, an international Observatory of Human–Environment Interactions (OHMi) was established in Nunavik to identify these changes, study their cumulative impact on the socio-ecosystem and to help develop adaptation measures to improve the well-being of Inuit communities. To this end, a team of academics and local Inuit partners joined forces to develop an integrated, interdisciplinary, collaborative research program. Using a participatory action research (PAR) approach, the OHMi Nunavik set the following research priorities: elder-youth knowledge transmission, northern agriculture, preservation of Inuit culture, language and identity, protected areas, mining employment, natural hazards and risks, and wildlife vulnerability. By strengthening the collaborations between multidisciplinary Canadian and French research teams, the OHMi Nunavik program integrates local and scientific knowledge both in planning the research and in disseminating the results.

RÉSUMÉ

L'adaptation aux changements climatiques et socio-environnementaux est devenue un enjeu majeur pour de nombreuses sociétés, notamment dans l'Arctique. De nombreux Inuit souhaitent mieux comprendre les changements qui se produisent. En 2013, un Observatoire international sur les interactions Homme-Milieu (OHMi) a été mis en place au Nunavik pour identifier ces changements, étudier leur impact cumulatif sur le socio-écosystème et pour aider à élaborer des mesures d'adaptation afin d'améliorer le bien-être des communautés inuit. À cette fin, une équipe d'universitaires et de partenaires Inuit locaux ont uni leurs forces pour développer un programme de recherche concerté, intégré et interdisciplinaire. En utilisant une approche de recherche-action participative, l'OHMi Nunavik a défini les priorités de recherche suivantes: transmission des connaissances entre les aînés et les jeunes, agriculture nordique, préservation de la culture, de la langue et de l'identité inuit, aires protégées, emplois dans les mines, risques naturels et vulnérabilité de la faune. En renforçant les collaborations entre les équipes de recherche multidisciplinaires canadiennes et françaises, le programme de l'OHMi Nunavik intègre les connaissances locales et scientifiques dans la planification de la recherche et la diffusion des résultats.

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Introduction

Adjusting to global climate and socio-environmental changes has become a major issue for Northern communities. The Arctic is one of the most rapidly changing regions on the planet, confronting Inuit communities with many challenges (Larsen and Fondahl 2015). Northern residents are witnessing accelerated

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warming in this region (Pearce et al. 2009). In addition, there is significant pressure to exploit natural resources in these regions, despite calls for sustainable development by local populations (Asselin 2011).

Arctic communities are concerned about their future and wish to better understand the social, environmental and economic changes related to ongoing industrial development and climate change (Rodon et al. 2014). These concerns include the effects of climate change, mining and non-traditional lifestyles on their health, well-being and quality of life. They also worry about the future of young people and their education, the widening generation gap, the preservation of traditional hunting, fishing and gathering techniques, as well as threats to Inuit culture and language (Laugrand and Oosten 2009).

Nunavik is an Arctic region comprising the northern third of Quebec, Canada. It has a population of approximately 12,000, mostly Inuit (Nunavimmiut), living in 14 coastal communities. In 2013, an International Observatory of Human–Environment Interactions (OHMI)[1] was established in Nunavik in collaboration with the Kativik Regional Government, the Nunavik Research Centre (Makivik Corporation), the inter-institutional Centre for Northern Studies (CEN) (based in Quebec City) and several French research institutes coordinated by the National Centre of Scientific Research (CNRS) to develop an integrated, holistic research program to assist the Nunavimmiut to address contemporary challenges and better prepare for the future.

The OHMi Nunavik is the 8th observatory founded under the network 'Laboratoire d'Excellence Dispositif de Recherche Interdisciplinaire sur les Interactions Hommes-Milieux' (LabEX DRIIHM[2]). OHMs aim at reflection, research guidance and in-depth analysis of spatio-temporal transformations within a given socio-ecosystem (Lagadeuc and Chenorkian 2009; Chenorkian 2014). Human beings are at the heart of the studied systems, the research focusing on complex interactions within the systems.

The research priority areas of the OHMi Nunavik are linked to the impact of climate and socio-environmental changes on Arctic communities: elder-youth knowledge transmission, northern agriculture (greenhouses), preservation of Inuit culture, language and identity, protected areas, mining employment, natural hazards, wildlife vulnerability, food security, landscape transformation, renewable energy, and training and capacity-building. Given the interrelationship between these topics, the OHMi Nunavik chose to study these issues as a system rather than sequentially. The research program was named TUKISIK, which means 'understanding together'[3] in Inuktitut (the Inuit language).

This paper has three aims: (i) to introduce the OHMi Nunavik Special Issue, (ii) to present the originality of the OHMi Nunavik methodological approach, which involved multidisciplinary experimental science, citizen science, traditional knowledge, and collaborative research, and (iii) to provide a brief overview of six ongoing projects, the interrelationships between these projects, and how each could contribute to the well-being of Nunavik communities. The themes of the six projects are: (1) the relationship of dogs to Inuit health and well-being; (2) strategies to ensure food security; (3) reducing fossil fuel dependence with renewable energy and energy efficiency; (4) risk assessment of landslides in a national park; (5) Inuit modes of relating to the land; and (6) monitoring water quality of a local river. Finally, the short-term benefits so far generated by the OHMi research projects are discussed.

Ecosystem approach

Location

The research is based in Nunavik, an Arctic region located in the northern third of Quebec, Canada, north of the 55th parallel. The population of 12,000 is mainly Inuit, living in 14 coastal communities along the eastern Hudson Bay, the Hudson Strait, and Ungava Bay. Figure 1 shows the location of these communities as well as the national parks in the region. OHMi Nunavik currently has projects in four northern villages and two national parks.

OHMi research priorities

The research priorities of OHMi Nunavik were initially identified in 2013 during a one-week field trip of two academics in Kangiqsujuaq and Kuujjuaq, two of the 14 Nunavik communities. Then, the topics were carefully selected by all the academics and Nunavimmiut participants at a 3-day participatory workshop in Québec City and a first call for projects was launched in 2014. The annual calls for projects are widely disseminated in France and Canada. Several French/Canadian/Inuit interdisciplinary teams have responded, resulting in the funding of 16 annual projects since 2014. The projects are grouped into six main interdisciplinary programs (Figure 1): ECOHEALTH, IMALIRIJIIT,[4] NIQILIRINIQ,[5] NUNA,[6] SEQINEQ,[7] VERSANTS. The themes of these research areas are respectively *Dogs-Human Health, Water quality, Food security, Relationship to the land, Energy*, and *Landslide*

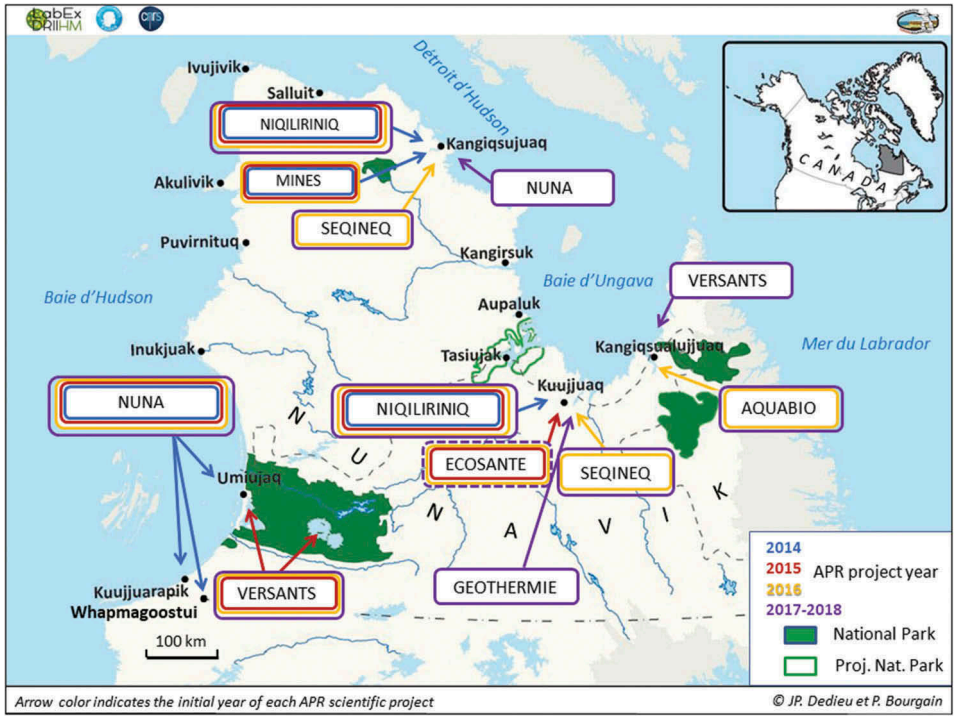

Figure 1. Location of OHMI research activities in Nunavik (Québec, Canada).

risks. All these programs are closely interrelated. The OHMi board has made the choice to support a small number of projects (five to seven each year) and strengthen the existing research teams rather than attracting new teams to the program as it takes time to build a trust relationship with the communities. Each year at the annual TUKISIK seminar, participants attempt to strengthen the ties between project teams by exchanging on various issues such as research ethics, communication with communities, outreach, and data management.

OHMi interdisciplinary research teams

The OHMi Nunavik team is multidisciplinary. For example, the community-based water quality survey (Gérin-Lajoie et al. 2018) brings together ecologists, chemists, geographers, and remote sensing specialists. The academics also work in collaboration with an Environment Canada Laboratory, which conducts field sampling and analysis of water samples, as well as with the Nunavik Research Centre, which analyzes contaminants in fish specimens. Veterinarians, epidemiologists and anthropologists are involved in the ECOHEALTH program. Researchers in the different projects also cross-collaborate: for example, the engineers in SEQINEQ (energy) are looking at how to heat greenhouses more efficiently in collaboration with the nutritionists and geographers in NIQILIRINIQ (food security). These teams also work closely together to gain a better understanding of the particularities of greenhouses in a Northern context, in terms of both physical and social aspects (Lamalice et al. 2018).

Developing collaboration between OHMi researchers has been important for several reasons. One is that researchers want to avoid being intrusive: different groups of scientists may feel like an 'invasion' to small communities (200–2000 inhabitants). Another is to avoid repetitive interviews and visits, which can lead to research fatigue and saturation. A third is to reduce research costs by sharing documents, data and travel logistics. Lastly, the aim is to create synergies in the way results are conveyed to local Inuit partners. For example, the NIQILIRINIQ (food security), SEQINEQ (energy) and ECOHEALTH projects deal with the same communities and closely interact with each other. The ECOHEALTH program served as a source of inspiration to NIQILIRINIQ regarding the 'Ecohealth' approach, which is based on systemic, holistic, cross-disciplinary, participatory research oriented toward local and sustainable solutions with gender and social equality (Charron 2012). The SEQINEQ team designed its project collaboratively with NIQILIRINIQ. They shared data and the same Inuit research assistant and intend to develop a web portal to disseminate their results together. SEQINEQ is looking at how to heat greenhouses, thus NIQILIRINIQ serves as a laboratory for that project (Lamalice et al. 2018). These collaborations

are leading to an interdisciplinary synergy that can respond more effectively to the diverse needs of stakeholders, especially with regard to implementing new strategies for food and energy security in Nunavik. Interactions such as these will increase over time as researchers come to know each other and identify their needs for specific expertise. The five communities directly involved in OHMi Nunavik also support this aim of collaborative research.

Participatory action research and community-based environmental monitoring

For the most part, the TUKISIK programs use the methodologies of participatory action research (PAR) and community-based environmental monitoring (CbEM). These approaches have been used for many years in the Canadian Arctic by CEN[8] and ArcticNet[9] researchers (Allard and Lemay 2012). The PAR approach is based on the idea that research should be done 'with' and 'for' rather than 'on' people. It employs a wide range of tools to support evidence-based thinking and processes that link traditional/local knowledge with expert/scientific understanding to create new social knowledge. The PAR approach promotes action learning, meaningful collective work, and community decision-making, empowering participants to define their priorities and to take action (Chevalier and Buckels 2009;[10] Blangy et al. 2010; Blangy 2017). The CbEM approach is a useful way to build bridges between Indigenous and scientific knowledge, to create trust between communities and scientific institutes, to engage community members in the scientific process, and to generate community-oriented data that can be used to make conservation management decisions (Lefler 2010). In this way, the joint use of PAR and CbEM can lead to community empowerment, especially in terms of the involvement of young people. Nevertheless, there are also challenges associated with PAR and CbEM, such as non-systematic data collection, loss of interest by volunteers, and how data ownership is defined.

In the remote Indigenous communities in Northern Canada, there is growing interest in PAR and CbEM programs. This can be tied to an increase in the following: recognition of the value of Indigenous knowledge, use of participatory methods for community-based research (Berkes and Armitage 2010), community concern regarding the local impacts of environmental change related to anthropogenic activities, interest in building local capacity to monitor changes, and community control over resource management decisions (Gordon et al. 2008; Gearheard et al. 2010). This approach is responsible for the success of the community-based environmental water-quality monitoring program (Gérin-Lajoie et al. 2018).

The challenge of community-based monitoring is that it takes months or even years to establish contact with a community, gain its trust, and develop a real partnership. In the initial outreach it is essential to consult representatives from municipal councils, landholding committees, culture committees and youth committees to begin building these relationships. For example, the NUNA (relationship to the land) participation-based program has been particularly well-received as it aims to promote the inhabitants' own perceptions and has focused attention on Tursujuq National Park (Chanteloup et al. 2018). However, participation and responsibility sharing between researchers and inhabitants has not always been symmetrical. The research strategy was primarily framed by the researchers, although it was discussed with the various research stakeholders. Researchers also encountered translation problems and cultural misunderstandings. For example, words such as 'landscape' and 'national park' lack equivalents in Indigenous languages.

Research questions and benefits by theme

Ecohealth: the relationship of dogs to Inuit health and well-being

This project explores the crucial status of dogs within Inuit culture and how they help to improve the well-being of Arctic communities. Prior to the settlement of the Inuit in the 1950s, dogs formed a vital part of the community, essential for survival in harsh living conditions (Lévesque 2015). Today, interactions with dogs are changing, and they may even represent a threat to human health (Messier et al. 2012; Jenkins et al. 2013; Aenishaenslin et al. 2014; Goyette et al. 2014; Schurer et al. 2015). The objective of this project is to understand the impact of dogs on the health and well-being of Kuujjuaq residents (Figure 2) and to mitigate the risks of Inuit–dog–environment interactions to optimize wellness.

Long an integral part of the Inuit's physical, social and cultural environment, dogs today may also pose a health threat to Nunavik residents due to attacks, bites, and the risk of rabies and other diseases, sometimes resulting in death (Herbert 2007; Jenkins et al. 2013; Aenishaenslin et al. 2014). Dogs in the North are not always tied up and breed freely, leading to a recurring overpopulation that exacerbates these threats. The prevention of issues resulting from human–dog interactions in Nunavik first requires

Figure 2. Poster presenting the most significant results of the survey of Kuujjuaq residents (Inuit and Western) according to a participatory process.

acknowledging Inuit perspectives and the positive impacts of dogs on well-being.

This study is part of a broader initiative carried out by the Université de Montréal (vetnunavik.ca) to set up different animal health services in response to the veterinary public health issues in Nunavik. The problem is complex, with numerous interrelated issues. Stakeholders include public health officials, as well as municipal and regional governments, with individuals playing an important role in a context where two cultures coexist: Inuit and Western. Certain solutions implemented by some are perceived as problematic by others. The trauma following the dog culls by authorities in the 1950s and 60s is still very present in Inuit communities (Lévesque 2015).

To mitigate risks from dogs while maintaining their positive impacts, an 'Ecohealth' approach was chosen. This is based on systemic, holistic, cross-disciplinary, participatory research, oriented toward local and sustainable solutions with gender and social equality (Charron 2012). In addition, a 'two-eyed seeing' framework was adopted, that is, the principle that the contributions of both Indigenous and Western epistemology and knowledge are equally required in order to understand and solve issues (Martin 2012).

One aspect of the study was a survey conducted with 67 Kuujjuaq dog owners. Of these, 35 (52%) were Inuit: a participation that was higher than expected. This survey comprehensively documented dog demographics, housing, feeding and health (Aenishaenslin and Ravel 2016). It also provided insight on contacts between dogs and wildlife. With regard to human–dog interactions, Inuit more often than non-Inuit respondents strongly agreed that dogs are important. Inuit also more often reported that they, or a member of their family, had been bitten or scratched by a dog in Nunavik. In case of a dog bite, 70% of respondents would go to the hospital, 21% would kill the dog, and Inuit would less often than non-Inuit consider the risk of rabies. Finally, more Inuit strongly agreed that there were too many dogs in Kuujjuaq, highlighting the dog overpopulation issue.

To report back on the most significant survey results to the residents of Kuujjuaq, three focus groups were held to discuss the content and format in which they should be disseminated. This process led to the production of three posters that were displayed throughout the village and a radio broadcast (also available on Facebook) on the day the annual Ivakkak dogsled race ended in Kuujjuaq in April 2016 (Figure 2). In addition, results from the surveys were combined with direct observations and participative observations to draw a graph illustrating the complexity of the problem (Figure 3). This breaks down the diverse topics raised by Nunavik residents about dog health and well-being, and about human health and well-being as related to dogs, showing the links between those topics. This identification of the issues at stake relating to Inuit–dog–environment interactions is the starting point for a joint prioritization of the issues and a selection of optimal mitigating measures in the context of Nunavik. This will be carried out with participatory multicriteria analysis (Aenishaenslin et al. 2013; Marsh et al. 2013).

NIQILIRINIQ: strategies to ensure food security and sovereignty

The researchers involved in NIQILIRINIQ (also named Food System or Greenhouse) study how the recent establishment of horticultural production in greenhouses in the Arctic could contribute to improving

Figure 3. Issues related to dog health (upper half) and human health (lower half) in Nunavik and links between them as documented through direct observation, participatory observation, and a dog-owner survey.

the quality of life, health and well-being of Nunavik residents. Before colonialism and settlement, the Inuit were self-sufficient in terms of food provision. Today, 80% of the Inuit diet is composed of store-bought food and 62% of Inuit households face food insecurity (Huet et al. 2012). In less than a century, this has resulted in drastic changes that negatively impacted the health of Northern residents. The OHMi Nunavik team is working on developing alternative food security strategies in collaboration with Northern communities. The first objective is to document the advantages and challenges of the different food systems in Nunavik: the current store-based food supply system, the 'country-food' system,[11] and the more recent local food production system. The second objective is to contribute to the development of alternative food procurement strategies in Kuujjuaq and Kangiqsujuaq by supporting and accompanying the implementation of gardening projects to improve the supply and availability of fresh local food.

In Nunavik, rapid changes in the Arctic environment coupled with lifestyle disruptions due to settler colonialism (e.g., forced sedentarization, evangelization, and integration into the market economy) have greatly affected the ability of residents to meet their dietary needs in a way that responds to cultural sensitivity as well as to a holistic conception of health (Counil et al. 2009, 2010). The increase in consumption of store-bought food along with a decline in physical activity have led to the rise of chronic diseases such as obesity and Type 2 diabetes (Damman et al. 2008; Château-Degat et al. 2011). Fresh products such as fruit and vegetables are eaten in low quantities, due to the high cost of shipping and storage, which makes them very expensive, and the long delivery time, which tends to damage them, making their consumption less attractive (Avard 2015).

This research project began in 2015, taking over from an investigation that started in 2009 on Northern agriculture in Kuujjuaq (Avard 2015;

Lamalice et al. 2016), where two community greenhouses are in operation. The success of Kuujjuaq's greenhouses was of interest to other Nunavik villages facing food insecurity. The current project was co-constructed with local residents around three main themes: (1) Ethnobotany: Which plants are residents particularly interested in and could they be cultivated in a greenhouse? (2) Nutrition and health: What are the nutritional contributions of a community greenhouse in the Arctic? What are the benefits for health and well-being? (3) Technical aspects: What productivity can be expected from a greenhouse? How can gardening techniques be learned and the knowledge shared? How should the greenhouse be designed? What kind of energy system should it use?

Given these multifaceted challenges, a multidisciplinary perspective combining local stakeholders, geographers, ethnobotanists, nutritionists, and energy engineers seemed indispensable. Two field trips were organized to launch this action research project in Kuujjuaq and Kangiqsujuaq. The first phase identified the benefits of a greenhouse project from the viewpoint of the gardeners in Kuujjuaq, and the aspirations of the residents of Kangiqsujuaq, who are planning to develop their own gardening activities. Data was collected using participatory workshops and supplemented by semi-structured interviews as well as questionnaires. Nine gardeners from Kuujjuaq's greenhouses volunteered to gather data during the 2016 season.

Benefits of a northern greenhouse project

The main benefit cited by Kuujjuaq gardeners in terms of their participation in the community greenhouse is the general well-being it brings, followed by pride in producing their own food and nutritional benefit of this food. These benefits have an important environmental dimension, with some gardeners explaining that it is a 'more ecological' way to produce and consume food in the North, as shipping food by airplane is highly polluting. Participation in the community greenhouse project represents a learning opportunity for gardeners, as well as for young people.

Comparing the actual benefits perceived by gardeners after the establishment of a greenhouse (as in Kuujjuaq) with the initial motivations of a community before a greenhouse is developed (as in Kangiqsujuaq) gave rise to interesting observations. In Kuujjuaq, the main benefit was related to general well-being, whereas in Kangiqsujuaq the production of good quality food was the most-cited benefit, followed by the cost, as fresh food is currently expensive.

The choice of crops

The two greenhouses in Kuujjuaq are divided into 4 m^2 garden beds which are allotted to gardeners through an annual draw. Leafy green vegetables and radishes represent the main crops as they grow quickly and are therefore the first ready for harvest. Lettuce and arugula also allow several harvests in one season, which is an advantage in the short Arctic summer. In Kangiqsujuaq, where a greenhouse/gardening project is being launched, community members expressed the types of plants they wanted to grow during a workshop in 2016. Interestingly, the first plants considered were local/traditional plants: blueberries (kigutanginnaqutik), cloudberries (arpiqutik) and black crowberries (paurngaqutik). The preferred vegetables were tomatoes, potatoes, carrots and lettuce. These responses indicate the importance people in Kangiqsujuaq give to local plants, which are a key part of the traditional diet as well an integral part of Inuit culture and spirituality. Moreover, recent changes in local climatic conditions are affecting the availability and productivity of wild berries, which further explains the desire to grow these local plants.

The preliminary results show that developing local food production corresponds not only to a need expressed by residents, but has the potential to overcome certain difficulties associated with the transport, freshness, affordability and availability of food, as well as to enhance well-being, health and youth education. The development of community greenhouse projects cannot replace the cultural and spiritual experience of going on the land to gather berries or plants. Nevertheless, the benefits reported by greenhouse gardeners, who most cited well-being as a positive effect, are encouraging. In addition to the social aspects of gardening, the nutritional contributions of the garden plants were also evaluated in term of micronutrients (minerals and vitamins). Further, environmental issues linked to greenhouse gardening were studied, as fertilization of the local soil used in the garden beds, greenhouse energy optimization to increase the length of the growing season, and mitigation of carbon dioxide emissions. Those questions and their results are discussed in Lamalice et al. (2018). Although community greenhouses and gardening projects cannot solve the multiple issues linked to food insecurity in the region, they can be considered as one element of a community-based strategy to increase food independence in the North.

SEQINEQ: reducing fossil fuel dependence with renewable energy and energy efficiency

Nunavik's electricity production is currently based on diesel-powered generators (Hydro-Québec 2013a, 2013b). Heating and domestic hot water are mainly fueled by oil. In 2009, each household in the region consumed an average of 3200 liters of heating oil, for an annual total of 28 million liters (Cherniak et al. 2015). This dependence on fossil fuels causes a number of problems, ranging from the emission of greenhouse gases and pollutants to increased vulnerability to price changes and supply problems. Furthermore, due to population growth and industrial development, Nunavik's energy consumption is projected to increase by 23% every ten years (Hydro-Québec 2013b). To meet this rising demand for energy while reducing dependence on petroleum products, several solutions have been considered (e.g., hybrid wind/diesel systems, micro-hydropower plant) but have not yet been implemented for technical and/or economic reasons (Cherniak et al. 2015). The SEQINEQ project is investigating a strategy known as 'negaWatt' well-known to French energy engineers aiming at first implementing energy reduction actions, then energy efficiency measures, before finally implementing renewable energy solutions (Négawatt 2015).

Energy reduction is best explained by the motto 'The best way to save energy is to avoid consuming it!' This type of measure is only possible if there is a genuine desire for energy reduction in a local community. It can be promoted through awareness-raising actions that accept and encourage the participation of all stakeholders. In Nunavik these types of actions have been carried out by the Kativik Municipal Housing Bureau, which is in charge of 2700 dwellings and has integrated energy issues in its 'Nanuk' workshops targeting primary school children (Pivallianiq 2017).

Energy efficiency involves minimizing the energy consumption of a given service. In Nunavik, the main sources of energy consumption are lighting, electronics and household appliances (electricity); and heating and domestic hot water (fuel). Given the region's cold weather, heating undoubtedly makes up the largest proportion of energy consumption. To reduce it, the energy efficiency of buildings must be improved, for example by improving the quality of insulation and ventilation systems. Programs are in progress to investigate the best way to do this. Of these, a new housing prototype was built in Quaqtaq in 2015 as part of the 'Living in Northern Quebec' research project (established in 2015 to address the Northern Indigenous habitat in all its complexity). Architects and engineers came up with a design based on the principles of the 'passive house', obtaining high efficiency through position relative to the sun, better insulation, triple-pane windows, and a tightly sealed thermal envelope (Arsenault 2016).

Regarding renewable energy solutions, the SEQINEQ team first focused on the suitability of photovoltaic technologies. These systems, which are reliable and easy to maintain, have been used for 7 years in a pilot project in Iqaluit (Nunavut) and have shown higher performance levels than initially expected (Cherniak et al. 2015). The team is currently working on a similar economic study of a solar thermal technology that converts photons to heat with higher efficiency than photovoltaic solutions (60–70% electricity conversion with photons compared to 10–15% with photovoltaics).

Case study: Kuujjuaq cooperative greenhouse

A case study was developed in collaboration with the NIQILIRINIQ (Greenhouse) team to investigate technical solutions for energy-efficient greenhouses (Lamalice et al. 2018). To launch this, interviews were conducted with local stakeholders involved in the community greenhouse projects in Kuujjuaq and Kangiqsujuaq in the summer of 2016. These discussions highlighted many technical challenges in terms of water, soil and energy supply. In parallel, the Kuujjuaq greenhouse was equipped with probes to record temperature and relative humidity and pyranometers to measure solar radiation inside and outside the greenhouse. Three main findings resulted from data analysis (Lamalice et al. 2018):

(1) There is a large contrast between day and night temperatures (Figure 4): during the growing season, this difference is an average 25 °C, which is damaging to plant growth.
(2) Solar energy technology has high potential in Kuujjuaq: from July 2016 to June 2017, recorded solar radiation was 1156 kWh/m^2 (in the same period it was 1235 kWh/m^2 in Toulouse in the south of France).
(3) The temperature within the horizontal axis of the greenhouse is homogeneous; the vertical gradient is low except when the ventilation is turned on.

These results suggest implementing a thermal storage system in the greenhouse. The objective would be to avoid the loss of excess heat to the atmosphere by storing it during the day so it can be used during the night (Figure 5). As there is a large amount of available solar energy, the storage system could be coupled with a thermal solar system to increase the growing period which is 3.5 months currently.

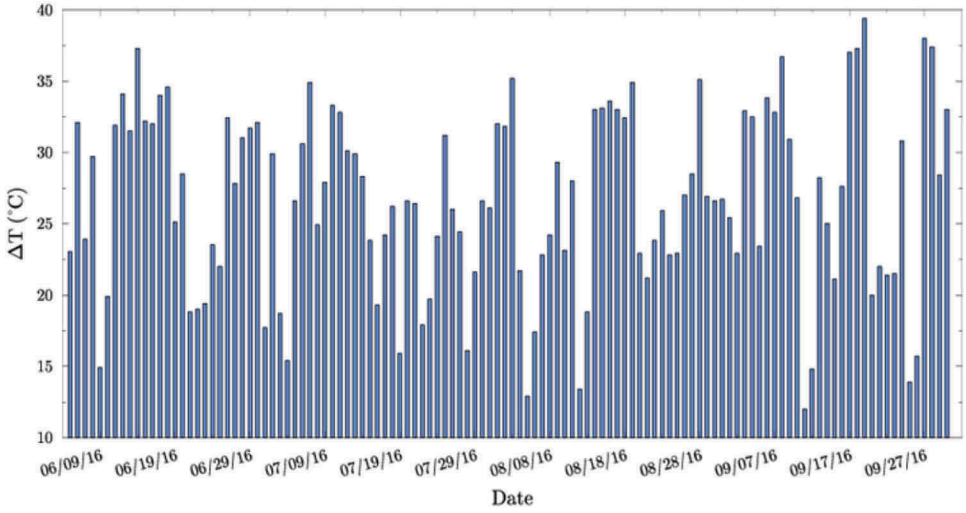

Figure 4. Temperature difference between day and night in the Kuujjuaq greenhouse.

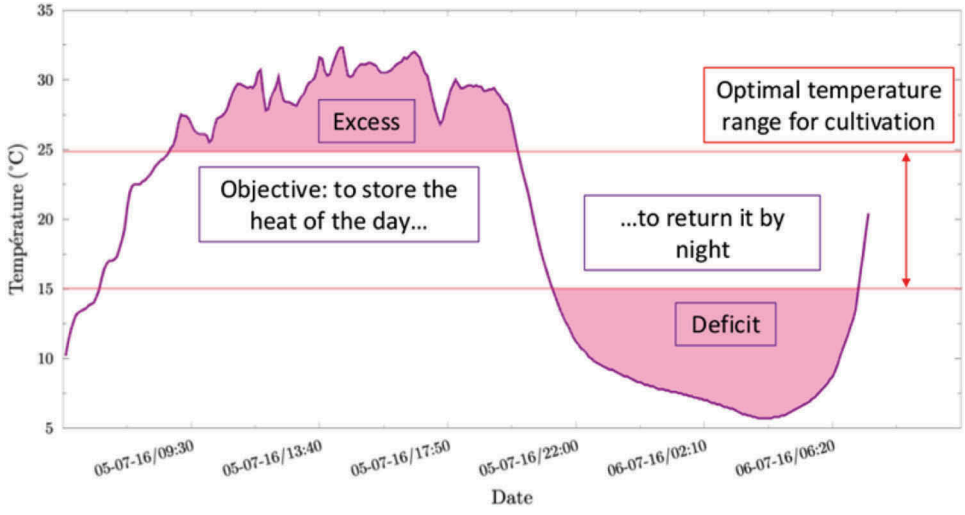

Figure 5. Representation of the thermal storage function in the greenhouse.

Versants: *risk assessment of landslides in a national park*

This study focuses on the threat posed by mass earth movement events in the area of Clearwater Lake (Wiyâshâkimî in the Cree language) located about 115 km east of Hudson Bay (56°20′N; 76°17′W) in Tursujuq National Park (Figure 1). Clearwater Lake includes two neighboring craters with distinctive inner rings of islands. One of the largest islands with the most prominent hills is Lepage Island (Figure 6(a)). Those hills, which formed around 6000 yr BP (following deglaciation), are exposed to harsh climatic conditions. Despite the fact that elevation ranges between only 50 and 160 m, the cumulative effects of periglacial processes and gravity significantly affect the recurrent geodynamics on these slopes (Bégin and Filion 1985; Marion et al. 1995). As Tursujuk National Park includes multifunctional spaces where both environmental protection and use by local cultures need to be taken into account, the park authorities wanted to know if there are risks of gravity-related earth movements for park visitors. The objectives of this study were thus to identify the range of slope processes that are currently active (including rockslides, screes and debris flows), estimate their degree of activity, and document the risk for park visitors. Aerial and satellite images were analyzed to determine the most dynamic sectors. During the summers of 2015 and 2016, landforms created by different gravity processes were identified, measured and analyzed using geomorphological approaches, both on the ground and from a helicopter.

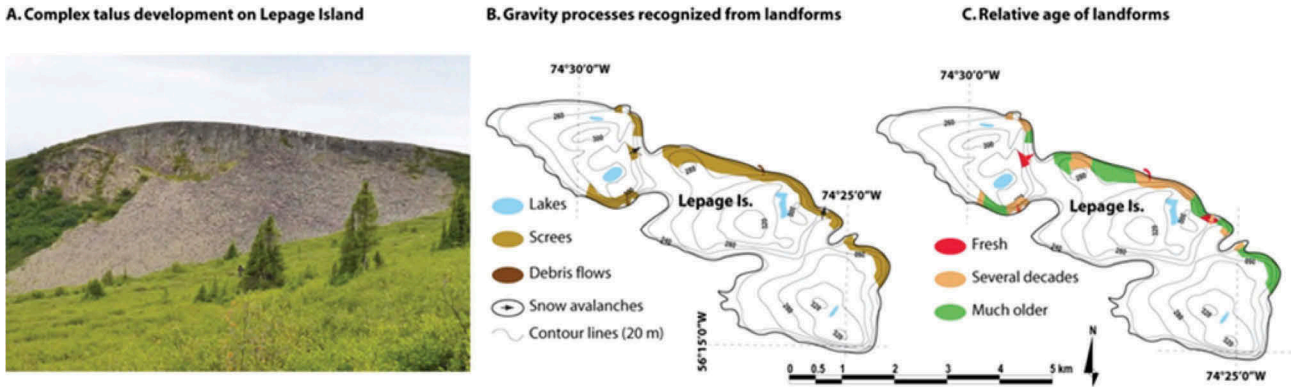

Figure 6. Slopes on Lepage Island, inner ring of Clearwater Lake (A), preliminary results on gravity processes recognition (B) and their relative age or degree of activity (C).

The northern face of Lepage Island shows a wide range of gravity processes (Figure 6(b)), with both recent/active and inherited landforms (Figure 6(c)). This indicates that slope geodynamics may have been active during the entire post-deglaciation period (i.e., the last 6000 years). Active slope processes primarily include screes and debris flows, which are prominently visible. Snow avalanches have less evident outlines as they create few landforms in the area, but some have been locally observed.

Slope morphometry was characterized in detail along three distinct slopes of scree talus using field-based methods, including geomorphological, granulometric and plant distribution surveys. The details of this slope morphometry study are presented in Decaulne et al. (2018). Results showed that the accumulation of talus exhibits a complex signature of several slope processes. Some of these processes are still active, leaving fresh deposits, attesting that risk is present. More accurate dating helped to reconstruct the post-deglaciation chronology of gravity processes (Bhiry et al. 2017). The findings were presented to local relevant authorities in short reports highlighting the precise locations of potentially dangerous processes.

NUNA: Inuit modes of relating to the land

NUNA explores concepts of contemporary native territoriality in comparison with the Western idea of wilderness, especially as related to the representation of the Far North (Joliet 2015). Living between western and traditional local ways of life, the Nunavummiut have regularly expressed their attachment to traditions and the land (Collignon 2006; Aporta 2011). Continuing the research carried out by Joliet (2015) on the Inuit's relationship to the land,[12] the team focused on the contemporary territoriality of Inuit and Cree, within the context of the creation and opening of the Tursujuq National Park (Figure 1).

The research aimed at understanding and characterizing the way Nunavimmiut and Cree relate to places around and within the perimeter of the Tursujuq National Park. It is carried out in partnership with the park authorities and in close collaboration with the communities of Umiujaq, Kuujjuarapik and Whapmagoostui (Figure 1). Research on the social acceptability of the national park has been designed and conducted using a participatory approach, integrating local communities throughout the whole research process and enabling participants to become research actors (Joliet and Blouin-Gourbilière 2012; Joliet 2015). An analysis of photographs and videos produced by community members allowed the research team to characterize various modes of landscape sensitivity and identify four main elements of contemporary Inuit territoriality (Joliet and Chanteloup 2016):

(1) In Indigenous cultures, nature is 'socialized'. It does not correspond to the Western conception of wild, unspoiled nature for an individual to contemplate or surpass. Many of the photographs showed scenes of daily life in which Indigenous people bond with the environment, whereas villages were never photographed.
(2) The photographs revealed a marked taste for monumental landscapes (e.g., waterfalls), a mirror of the permanence of Indigenous presence on the land. Some photographs showed ephemeral phenomena (e.g., sunsets, rainbows, cloudbanks, snow or ice), expressing the adaptability of the Inuit people to changing environmental conditions.
(3) Nature is seen as a healing place to face hard times. The strength of a mountain or the stillness of a lake bring peace and strength. This function of the land is as important as its provisioning function (through hunting, fishing and gathering).

(4) The changing world (climate change, globalization) is perceived as a contemporary challenge that Indigenous people have to face.

Chanteloup et al. (2018) report the views, feelings and day-to-day experience of the Nunavik (Quebec, Canada) environment by the Inuit people from different generations, looking at the multiple dimensions of their surroundings. It focuses on understanding and characterizing contemporary Inuit relationships with the environment, the meaning and the values given to the latter, and how they are evolving. Through Inuit photographs and short films, interviews, and group discussions, they provide an understanding of Inuit-environment interlinkages and bring to life the multiple ties of the Nunavimmiut with the environment.

IMALIRIJIIT: water quality of a local river

IMALIRIJIIT, meaning 'those who study water' in Inuktitut, is a community-based water quality survey which is described in detail in Gérin-Lajoie et al. (2018). This project involved science land camps, capacity-building workshops, and scientific data collection with the participation of youth, elders, local experts, and researchers. It was co-initiated by the Inuit community of Kangiqsualujjuaq and university researchers. This community is located at the mouth of the George River (58.69° N, 65.94° W) in Nunavik (Figure 1). Community members indicated they wanted their own independent long-term survey of water quality of the river in order to generate baseline data. They also showed interest in a youth-training component for local capacity-building. The community was eager to participate in this monitoring project due to their concerns about a rare-earth mining project that might soon begin operating in the upper watershed of the George River. The river is crucial for Inuit traditional fishing, hunting and gathering activities. The primary objectives of the study were to:

(5) Include and train Indigenous youth in environment-, food- and energy-based science activities in an outdoor, hands-on, non-academic framework where they can explore issues relevant to their lived experience.
(6) Establish a community-based environmental water-quality monitoring program and build capacity through long-term partnerships with local organizations, universities and government agencies.
(7) Develop an interactive multimedia map of the George River watershed. The map is based on interviews focusing on land use and Inuit knowledge, observations during the land camps and data collection.

The first Science Land Camp took place in July 2016, aiming to monitor water quality in the George River. Work at one sampling station included site characterization, in-situ measurements, and collection of water samples for further analysis in a laboratory. Macroinvertebrates were sampled at an additional station in a tributary brook; subsampling and identification were done at the camp. Remote sensing images were used to complement in-situ measurements to estimate three water-quality parameters: turbidity (suspended sediments), chlorophyll and temperature. Coupled with a topographic geodatabase and a runoff station (Quebec Gov.), the ongoing work aims to provide temporal mapping of water quality at the scale of the entire river basin (15 m resolution).

The first objective of the project was achieved by organizing three Science Land Camps (2016, 2017 and 2018). The students rapidly learned how to conduct the experiments, were generally engaged, and remembered the protocols. Interviews and discussions with elders and guides took place several times to encourage intergenerational knowledge transfer and to take into account Inuit knowledge and observations of hydrological changes related to the George River, thus linking scientific and Inuit knowledge. Events and awards such as 'Scientist of the day' were used as tools to boost youth motivation. Camping on the land, doing hands-on activities that mix science with other activities, and sharing between generations and cultures all contributed to a different perception of science for the local participants and a better link between community and researchers.

The second objective was achieved with the establishment of a water-quality monitoring program. Qualitative observations compiled by the students showed clear, transparent water at all stations, which is consistent with the data collected in 2016 highlighting the very high water quality of the site. Dissolved concentrations of 35 metals at all sampling stations were below Canadian regulatory guidelines (CCME, 1999). From visual observations, it was determined that the riverbed is composed of sediments ranging in size from sand to large boulders; aquatic vegetation is very rare and sparse. Consistent with water analyses, the dominant macroinvertebrates identified (*Ephemeroptera, Plecoptera* and *Trichoptera*) are good indicators of a pristine environment.

Even if participating in scientific experiments with committed local adults and elders had an important

positive impact on the young, as reported by Gérin-Lajoie et al. (2018), it is now clear that youth training is not sufficient, efforts will also need to be put into training adults. This would contribute to create much-needed jobs such as field research assistants in northern communities and create local interest for involvement in science projects.

Summary

The OHMi Nunavik is a recently established collaborative research network involving local Inuit community members, community organizations and researchers. The ecosystem research approach has the potential to generate many benefits for the communities, contributing to more than just the stated objectives. For example, although the goal of the NIQILIRINIQ (greenhouses) project was a concrete improvement in food security and independence, leading to improved nutrition, the preliminary results show that the establishment of local food production not only corresponds to a need expressed by Northern residents for fresh food, but has the potential to enhance well-being, health and youth education. Collaboration between thematic teams gives rise to an interdisciplinary synergy that allows researchers to better respond to the diverse preoccupations of the stakeholders. The NIQILIRINIQ and SEQINEQ teams are working together to gain a better understanding of the particularities of greenhouses in a Northern context and have designed a case study of technical solutions to make greenhouses more energy efficient. Another key result from the participatory action research (PAR) approach comes from a survey undertaken by the ECOHEALTH team with Kuujjuaq dog's owners. Diverse topics were raised by Nunavik residents about dog health and well-being, and about human health and well-being as they relate to dogs. This analysis is the starting point for a joint prioritization of the issues and the selection of optimal mitigating measures. One of these is raising the awareness of children about how to behave in the presence of dogs. The VERSANTS team noted recent earth movements on hillsides in the Tursujuq National Park that may represent hazards. This information was passed to park authorities and users to warn them about visiting hazardous zones. The team is continuing to study slopes in other regions regularly frequented by tourists and residents of Nunavik. The NUNA team successfully explored ways the Inuit and Cree relate to the land. Photographs and videos produced by local volunteers are displayed at the Visitor Information/Interpretation Center of the Tursujuk National Park in Umiujaq. The IMALIRIJIIT project helped to establish a community-driven long-term water-quality monitoring program. Both local and regional organizations invested significant effort, material and human resources that were essential to the success of the science camps.

In conclusion, collaborating with the communities at all steps of the research process helps to increase engagement in the search for solutions to local problems. The co-construction of research questions could be replicated in other communities in order to build durable partnerships and benefits for Nunavik. The ecosystemic approach OHMi's multidisciplinary team aims to promote empowerment within local communities in the face of the major changes taking place in the Arctic.

Notes

1. http://ohmi-nunavik.in2p3.fr/.
2. http://www.driihm.fr/#les-observatoires-hommes-milieux.
3. TUKISIK is the diminutive of Tukisigasuaqatigit.
4. Meaning 'Those who study water'.
5. Meaning 'Taking care of food'.
6. Meaning 'Land'.
7. Meaning 'Sun/energy'.
8. CEN: http://www.cen.ulaval.ca.
9. ArcticNet: http://www.arcticnet.ulaval.ca.
10. www.sas2.net.
11. Food hunted and gathered from the land.
12. Supported by the French Polar Institute (IPEV).

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