UNIVERSITÉ DU QUÉBEC À TROIS-RIVIÈRES

DOCUMENTER LES CHANGEMENTS HIVERNAUX DU TERRITOIRE PAR UNE APPROCHE COMMUNAUTAIRE À KANGIQSUALUJJUAQ, NUNAVIK

MÉMOIRE PRÉSENTÉ
COMME EXIGENCE PARTIELLE DE LA

MAÎTRISE EN SCIENCES DE L'ENVIRONNEMENT

PAR
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AVRIL 2026

UNIVERSITÉ DU QUÉBEC À TROIS-RIVIÈRES

MAÎTRISE EN SCIENCES DE L'ENVIRONNEMENT (2^E CYCLE)

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REMERCIEMENTS

La réalisation de ce mémoire n'aurait pas été possible sans le soutien et la contribution de plusieurs personnes. D'abord, j'aimerais remercier mes mentors, Esther Lévesque, Thora Herrmann et José Gérin-Lajoie, pour votre confiance et vos conseils précieux qui m'ont guidé au long de cette recherche interdisciplinaire.

Merci également à Francis Lévesque et Alexandre Roy pour leur contribution. Merci aussi aux collègues du département des sciences de l'environnement de l'Université du Québec à Trois-Rivières, du Centre d'études nordiques à l'Université Laval et de l'Université de Oulu en Finlande.

Merci à mes amis et ma famille. À mes parents qui m'ont soutenu lors de mes études et à Éric mon partenaire pour ton aide et ta relecture.

Finally, I would also like to express my appreciation to the community of Kangiqsualujjuaq for welcoming me in their community. A special thank you to Sophie Keelan for your precious help with the interviews.

RÉSUMÉ

Menée en collaboration avec la communauté de Kangiqsualujjuaq (Nunavik) dans le cadre d'un programme de suivi environnemental communautaire, ce projet vise à améliorer la sécurité des déplacements en hiver sur le territoire. Autour de cette thématique, des ateliers de cartographie cognitive et de cartographie participative ont été organisés avec des participants de la communauté (n=19) lors de deux terrains de recherche en 2023. Les ateliers ont permis de produire une carte collective des facteurs influençant les déplacements hivernaux, de documenter les observations locales des changements climatiques et de recenser les stratégies d'adaptation déjà mises en œuvre pour améliorer la sécurité sur le territoire. Les résultats montrent que les transformations de la neige et la glace constituent une source majeure de préoccupation pour les participants, en raison de leurs impacts sur les activités de subsistance. Ils révèlent également que la communauté s'adapte activement, notamment par l'amélioration des sentiers et des routes hivernales et par le renforcement du partage intergénérationnel des connaissances.

Mots-clés : déplacements hivernaux, adaptation, changements climatiques, Nunavik, Kangiqsualujjuaq, cartographie participative

TABLE DES MATIÈRES

LISTE DES TABLEAUX

LISTE DES FIGURES

CHAPITRE I.

INTRODUCTION

Au Nunavik, un territoire situé au nord du 55e parallèle au Québec, 14 communautés inuit sont localisées à proximité de la mer, le long des côtes de la baie d'Ungava et de la baie d'Hudson. Accessibles uniquement par voie maritime ou aérienne, ces villages ne sont reliés par aucune route. En hiver, lorsque la neige recouvre le sol et que les lacs et les rivières gèlent, des sentiers peuvent être empruntés en motoneige ou en chiens de traîneaux. Ces sentiers permettent d'accéder à la périphérie du village, désignée par le terme *nuna* (« notre terre ») qui englobe autant les milieux terrestres que marins (Chanteloup et al., 2019). Ce territoire revêt une importance particulière pour les Inuit, notamment pour la pratique des activités culturelles, et s'avère fondamental pour leur santé mentale, spirituelle et physique (Chanteloup et al., 2018; Lebel et al., 2022).

Les observations locales et les données scientifiques en Arctique indiquent que l'épaisseur des glaces de lacs, de rivières et de mer diminue et que la période d'eaux libres s'allonge, alors que la formation de la glace est plus tardive et la débâcle est plus hâtive (Ford et al., 2018a). Les conditions météorologiques deviennent imprévisibles, les patrons des précipitations changent et les évènements extrêmes sont plus fréquents (Gearheard et al., 2011). Ces transformations du paysage affectent profondément les communautés nordiques, notamment en ce qui concerne leurs déplacements (Ford et al., 2019; Tremblay et al., 2008). Entre 1985 et 2016, le nombre de journées propices pour aux déplacements hivernaux par voies terrestres a diminué dans les communautés nordiques (Ford et al., 2019). Cet enjeu de sécurité lié aux routes semi-permanentes a également été documenté par le savoir inuit et des observations menées au Nunavut, aux Territoires du Nord-Ouest, en Alaska et au Nunavik (Cold et al., 2020; Gearheard et al., 2011; Laidler et al., 2009; Tremblay et al., 2006)

Pour mener des projets de recherche en contextes autochtones et nordiques, plusieurs experts recommandent l'utilisation d'approches participatives (Kovach, 2021; Smith, 2012). Ces approches visent à inclure des participants à plusieurs étapes du projet, tant dans la formulation de la question de recherche que dans l'analyse. En outre, les communautés ont exprimé leur souhait de voir appliquer des processus de recherche qui respectent les savoirs inuit ou *Inuit Qaujimajatuganjit* (IQ) (Pedersen et al., 2020). Dans cette même perspective de cocréation des connaissances entre Inuit et chercheurs allochtones, le programme *Imalirijiit* (« ceux qui étudient l'eau ») favorise le dialogue entre les différents systèmes de savoirs (Gérin-Lajoie et al., 2018). Ce programme de suivi environnemental communautaire a mis en lumière l'intérêt de la communauté de Kangiqsualujjuaq pour la documentation des changements observés sur son territoire et des impacts sur les activités de subsistance. Élaborée dans le cadre du programme de recherche Imalirijiit, la présente étude cherche à répondre à la question suivante : Comment les changements environnementaux contribuent-ils à transformer l'accès au territoire et la sécurité dans les déplacements de la communauté de Kangiqsualujjuaq en hiver?

Mise en contexte

Des sentiers traversent les glaces, l'intérieur des terres et les zones côtières. Ils sont empruntés par les communautés nordiques pour rendre visite à des proches, accéder aux sites culturels et pratiquer des activités de subsistance (Aporta, 2006). L'hiver favorise particulièrement l'accès au territoire, tel que Vinnie Baron et Félix St-Aubin de Kangiqsualujjuaq le rapportent dans un ouvrage portant sur la profonde connexion entre la langue et le territoire : « Nous sommes heureux quand l'hiver est là. Parce que tout gèle et que nous pouvons aller partout où nous voulons aller. Le territoire est beaucoup plus accessible. Nous pouvons aller chasser le caribou et le lagopède. » [traduction libre] (Pratt & Heyes, 2022, p. 21)

Les déplacements sur le territoire

Modes de transports : les chiens et les motoneiges

Avant l'introduction de la motoneige, les chiens de traîneau étaient les principaux accompagnateurs des Inuit lors des déplacements et ils jouaient un rôle culturel important (Losey et al., 2018). Les chiens tiraient les équipements et transportaient des charges sur leur dos. Utilisés pour la chasse grâce à leur odorat aiguisé et leur capacité à repérer les animaux, ils pouvaient aussi aider à se repérer sur les chemins empruntés (Brinton, 2018).

Néanmoins, la population canine a grandement diminué dans les villages nordiques et, selon Lévesque (2008), les principales causes de cette diminution sont : l'introduction de la motoneige, les maladies ainsi que l'élimination des chiens errants et dangereux. Entre 1950 et 1960, les autorités gouvernementales ont mis en œuvre une régulation des chiens, passant par l'abattage massif des chiens au Nunavik et dans d'autres régions du Canada (Lévesque, 2011). Certaines organisations inuit rapportent que ces évènements ont contribué à éroder leur culture traditionnelle et engendré de nouveaux problèmes sociaux au sein des communautés (Lévesque, 2008). Cette situation est également résumée dans le livre autobiographique de l'activiste environnementale inuit Sheila Watt-Cloutier :

> De nombreuses familles ayant perdu leur attelage n'ont pas pu chasser en hiver et pendant plusieurs saisons, ce qui a entraîné une grande souffrance et une dépendance à l'égard de l'aide sociale. Si certaines familles ont pu remplacer leurs attelages par des motoneiges, beaucoup ne se sont jamais remises financièrement ni émotionnellement. [traduction libre] (Watt-Cloutier, 2016, p. 72)

C'est dans les années 1970 que la motoneige se taille une place de choix dans les déplacements des communautés nordiques (Aporta & Higgs, 2005). Malgré les désavantages de cette machine, tels que son coût élevé, son odeur, son bruit et ses bris fréquents, la motoneige reste un transport privilégié en raison de sa rapidité (Brinton, 2018).

À Kangiqsualujjuaq, l'introduction de la motoneige a entrainé une intensification des activités de chasse et pêche à proximité de la communauté, tout en réduisant les distances parcourues sur le territoire (St-Onge, 1996). Dans son mémoire de maîtrise, St-Onge (1996) avance l'hypothèse que cette transformation des pratiques de mobilité s'explique à la fois par le coût élevé de l'essence que nécessite la motoneige et par l'abondance des ressources à proximité du village.

Par ailleurs, l'utilisation de la motoneige au sud du Canada serait compromise d'ici 2050, en raison des changements climatiques (Mcboyle et al., 2007). Cette analyse repose sur l'étude du nombre de jours où une couche de neige d'au moins 15 cm serait présente, combinée à des projections basées sur un scénario climatique pessimiste, dans lequel les températures continueraient d'augmenter. En Arctique, une région qui se réchauffe à un rythme quatre fois plus important que le reste du Canada (Rantanen et al., 2022), il est pertinent d'examiner les répercussions potentielles des changements climatiques sur la pratique de cette activité.

Connaissances du territoire

La navigation sur le territoire arctique repose sur l'observation de plusieurs indicateurs environnementaux, notamment les nuages, l'état du ciel ou les mirages, qui permettent aux utilisateurs du territoire d'anticiper les conditions futures (Simonee et al., 2021; Wilson et al., 2021). Les Inuit possèdent des terminologies précises pour décrire les vents, les conditions de neige et de glace, les comportements des animaux, des marées, des courants et des astres (Aporta & Higgs, 2005). Par exemple, à Kangiqsualujjuaq, 71 termes distincts en inuktitut ont été recensés pour désigner les différentes formes de glace de mer formée en hiver et au printemps (Heyes, 2011). Ce lien entre la langue et territoire est toutefois en transformation : des différences significatives ont été observées entre les aînés et les générations plus jeunes quant à leur connaissance des termes spécifiques pour décrire l'environnement glacial et côtier (Heyes, 2002; 2007; 2011).

Les noms de lieux témoignent de la riche occupation du territoire inuit. Chez les Inuinnait (Nunavut et Territoire du Nord-Ouest), les toponymes peuvent avoir plusieurs origines. Ils peuvent faire référence à des histoires de chasse, des légendes ou à d'autres événements significatifs (Collignon, 2006). Les noms de lieux aident à se repérer géographiquement, toutefois leur fonction principale est de partager l'expérience du voyage et du territoire à d'autres interlocuteurs :

> Ils enrichissent l'expérience propre du lieu, que l'on y séjourne, qu'on le traverse ou que l'on passe à proximité. Le fait de se remémorer le nom du lieu active tout un pan de mémoire inuit, et participe à la culturalisation, l'humanisation, de l'espace parcouru. Le nom de lieu fonctionne ici comme un déclencheur : prononcé, il ouvre la porte de la mémoire. (Collignon, 2003, p. 52)

Si ces observations portent sur les Inuinnait, des travaux ont également été menés dans plusieurs régions de l'Arctique pour recueillir la toponymie inuit par cartographie participative (ex.: Müller-Wille, 1987; Collignon, 2003; Aporta, 2009; 2003). Cette approche a également joué un rôle central dans les revendications territoriales autochtones, notamment à travers le *Inuit Land Use and Occupancy Project* (Freeman, 1976). Ce vaste projet, contenant les données d'utilisation et d'occupation du territoire de plusieurs communautés dans l'Inuit Nunangat, a eu une grande portée. Il a démontré la nécessité de consigner les connaissances géographiques du territoire qui étaient jusque-là transmises oralement et a même été instrumental dans les négociations lors de la création du Nunavut (Freeman, 2011).

L'utilisation du territoire et des ressources

Au Nunavik, les villages inuit sont établis en bordure des côtes (Figure 3). Le régime foncier est encadré par la Convention de la Baie-James et du Nord québécois (CBJNQ) de 1975, l'une des premières ententes modernes de revendications territoriales au Canada. Les habitants d'Ivujivik et Puvirnituq ont initialement refusés de signer la Convention, toutefois, Ivujivik l'a rejoint en 2015. La CBJNQ divise le territoire en trois catégories de terres qui définissent les droits d'usage et de gestion des ressources (Peters, 1999). Les terres de catégorie 1, sur lesquelles sont situés les villages nordiques et leurs périphéries, sont administrées par les corporations foncières inuit. Les terres de catégorie 2 demeurent sous juridiction du gouvernement du Québec, mais les Inuit y détiennent des droits exclusifs de chasse, de pêche et de piégeage. Sur les terres de catégorie 3, enfin, ces droits sont partagés et ne sont pas réservés exclusivement aux Inuit.

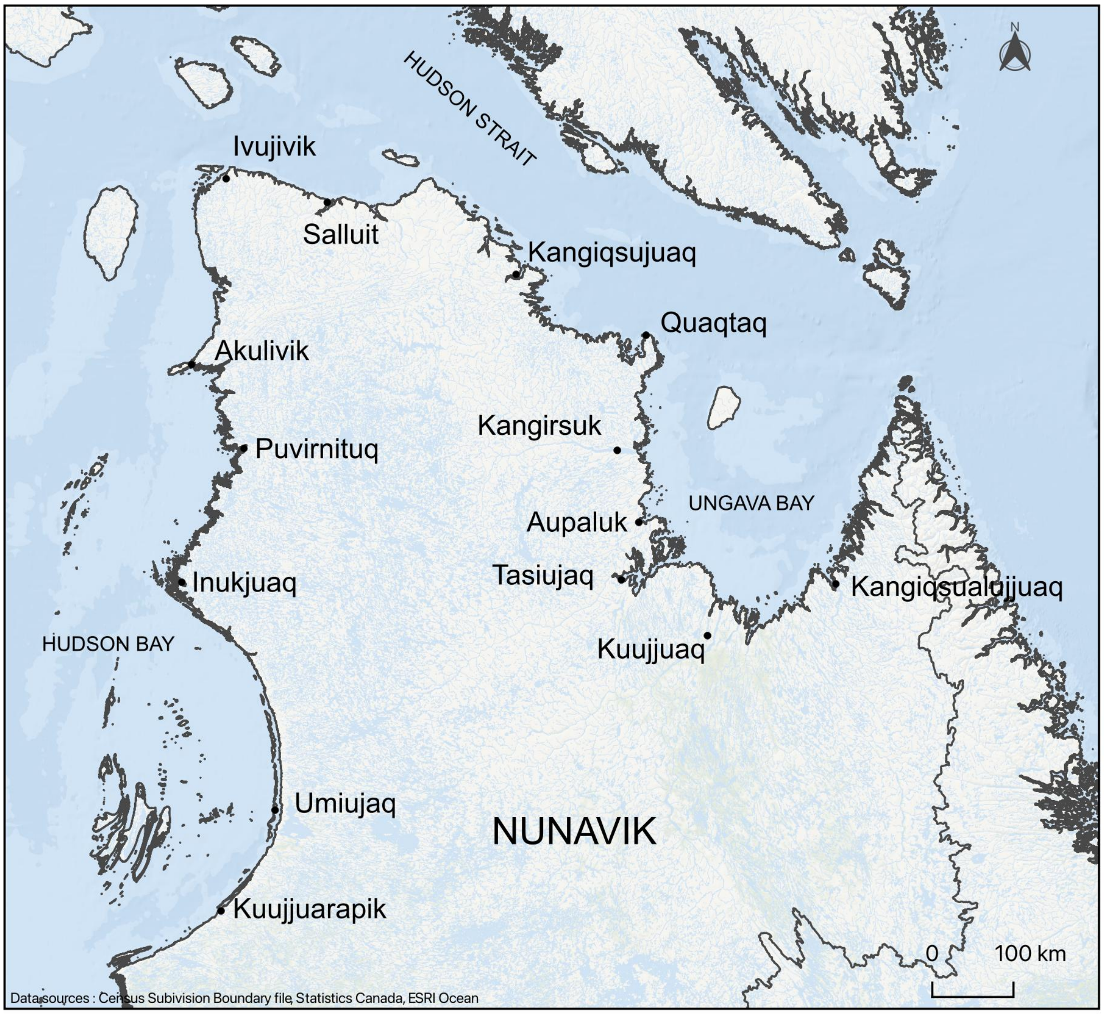

Figure 1. Les villages du Nunavik

Le village de Kangiqsualujjuaq, la communauté la plus à l'est du Nunavik, est situé le long de la baie d'Ungava, à l'embouchure de la rivière George. Avant la sédentarisation dans les communautés, l'occupation du territoire suivait un rythme saisonnier, dicté par les activités de chasse, trappe, pêche et cueillette. Les Inuit qui fréquentaient la rivière George quittaient le poste de traite à l'automne afin de rejoindre leurs camps pour l'hiver (Heyes et al., 2003 dans Administration régionale Kativik, 2005). Durant cette saison, des activités telles que la chasse au caribou, la pêche à l'omble chevalier et le piégeage étaient pratiquées. Au printemps, les familles retournaient dans des camps situés sur les deux rivières principales : George et Kuururjuaq (Koroc). En été, l'omble chevalier était aussi pêché, tandis que le saumon servait exclusivement de nourriture pour les chiens. En juin, les œufs d'eiders et de goélands étaient récoltés, puis la chasse aux phoques s'étendait du début de l'été à la fin du mois d'août. Finalement, le cycle annuel se terminait à la fin de l'été, un moment où les hommes revenaient près de l'emplacement actuel du village afin de décharger le bateau de la Compagnie de la Baie d'Hudson (Heyes et al., 2003 dans Administration régionale Kativik, 2005).

Aujourd'hui, la plupart des Nunavimmiut (habitants du Nunavik) se rendent occasionnellement ou régulièrement sur le territoire, tandis que 13 % ne sortent jamais de la communauté (Furgal et al., 2022). Les déplacements consistent majoritairement à effectuer de courts séjours d'une journée (42 %). Toutefois, les résidents de la baie d'Ungava ont davantage tendance à fréquenter le territoire pour une durée de plusieurs jours, comparativement aux autres régions du Nunavik (baie d'Hudson et le détroit d'Hudson) (Furgal et al., 2022).

L'accès au territoire est essentiel pour la récolte de ressources alimentaires traditionnelles et diverses organisations contribuent à faciliter cette relation. Le Programme d'aide aux Inuit pour les activités de chasse, de pêche et de piégeage, coordonné par le gouvernement régional Kativik, vise à promouvoir les activités traditionnelles (ARK, 2018). Par exemple, le congélateur communautaire est géré par ce programme. C'est un espace de partage qui permet de stocker la nourriture traditionnelle à la disposition des membres de la communauté.

Des programmes de réduction du coût de la vie viennent également en aide aux chasseurs en subventionnant les frais d'essence, les véhicules ou les équipements de chasse (ex. motoneiges, moteurs, véhicules tout-terrain, remorques, *qajaq, qamutik*, tarières à glace). Enfin, *Anguvigaq* est l'organisation principale qui protège les droits de chasse et de pêche pour l'ensemble des Inuit au Nunavik. Composée d'un représentant dans chacune des communautés, *Anguvigaq* gère les aspects liés à la faune et définit des directives pour la recherche, la conservation et la récolte de nourriture.

Concepts et définitions

Savoirs inuit

Conceptualisés à l'origine par les Inuit du Nunavut afin de guider les politiques gouvernementales et les services publics du territoire, les systèmes de connaissances inuit sont nommés *Inuit Qaujimajatuqangit* (IQ) (Karetak et al., 2017; Lévesque, 2014). Ce concept, plus récemment mobilisé au Nunavik, désigne l'ensemble des valeurs, des normes, des pratiques et des manières d'appréhender le monde qui caractérisent la vie et la culture des Inuit (Wenzel, 2004). L'IQ a été introduit pour élargir d'autres notions relatives aux savoirs autochtones, notamment celle des savoirs écologiques traditionnels (SET), définis comme ceci :

> [...] un ensemble de structures et de ressources composées de relations sociales et d'institutions (capital social) fondé sur des croyances philosophiques et des enseignements culturels (capital culturel), transmis par les pratiques et les protocoles (méthodes) de la tradition orale qui ont été appliqués à des régions écoculturelles données et développées depuis un grand nombre d'années (Lertzman 2006, p. 45).

L'emploi du terme « traditionnel » pourrait à tort suggérer que les savoirs ont un caractère statique, mais, en réalité, autant les SET que IQ sont dynamiques, adaptatifs et vivants (Lertzman, 2010).

Le développement d'approches collaboratives, telle que le *Two-Eyed seeing* (Reid et al., 2021), visant à mobiliser conjointement les perspectives autochtones et les connaissances scientifiques occidentales au sein d'un même projet, peut mener à l'enrichissement du contexte des résultats, au complément des données manquantes et à l'émergence de nouvelles questions de recherche. La valeur des savoirs autochtones a d'ailleurs été reconnue dans plusieurs publications, particulièrement en gestion de la faune en Arctique. Par exemple, les observations de chasseurs inuit ont permis de détecter le choléra aviaire chez des oiseaux, alors que la maladie n'aurait pas été discernée par une équipe composée exclusivement de biologistes (Henri et al., 2018).

La combinaison des savoirs doit reposer sur des principes de respects et de réciprocité, garantissant une participation pleine des peuples autochtones à chaque étape du processus (Castleden et al., 2012). Les principes d'IQ doivent être incorporés à toutes les étapes possibles d'un projet et non seulement lors de la collecte de données (Pedersen et al., 2020), contribuant à une décolonisation de la recherche en contexte autochtone et inuit. À cet égard, Ikaarvik, un regroupement de jeunes chercheurs inuit du Nunavut, propose des recommandations destinées à orienter les futures recherches menées dans leur communauté. Définissant un nouveau concept appelé ScIQ, qui combine à la fois savoir inuit et science, ce collectif vise à favoriser l'engagement des communautés au sein des projets de recherche (Pedersen et al. 2020).

Vulnérabilité

Initialement développé pour l'étude des catastrophes et des risques naturels durant les années 1970, le concept de vulnérabilité a par la suite été appliqué aux études portant sur les changements climatiques (Ford & Smit, 2004). La vulnérabilité y est définie comme la susceptibilité d'un groupe ou d'une personne à subir des dommages en réponse à un stimulus (IPCC, 2014). Cette approche vise à identifier qui est vulnérable, à quel stress, de quelle manière et quelles sont les capacités des personnes concernées à s'adapter aux risques.

La vulnérabilité est fonction de l'exposition, de la sensibilité, tandis que la capacité d'adaptation détermine l'aptitude à répondre à ces impacts (IPCC, 2014). Le schéma conceptuel de la vulnérabilité (Figure 2) intègre également une dimension temporelle, permettant d'envisager les expositions, sensibilités et capacités d'adaptation futures (Smit & Wandel 2006). L'exposition réfère à la nature du risque climatique et la sensibilité nous renseigne sur le degré auquel une personne ou un groupe est affecté. Cette dernière est notamment influencée par les conditions de vie, les rôles de genre, ainsi que les caractéristiques du ménage ou de la communauté (Bunce et al., 2016) : un ménage à faible revenu sera ainsi davantage sensible aux aléas climatiques. La capacité d'adaptation d'un système correspond à la faculté de s'adapter aux conséquences des variations climatiques et d'accroître la résilience des individus touchés par des catastrophes (IPCC, 2014).

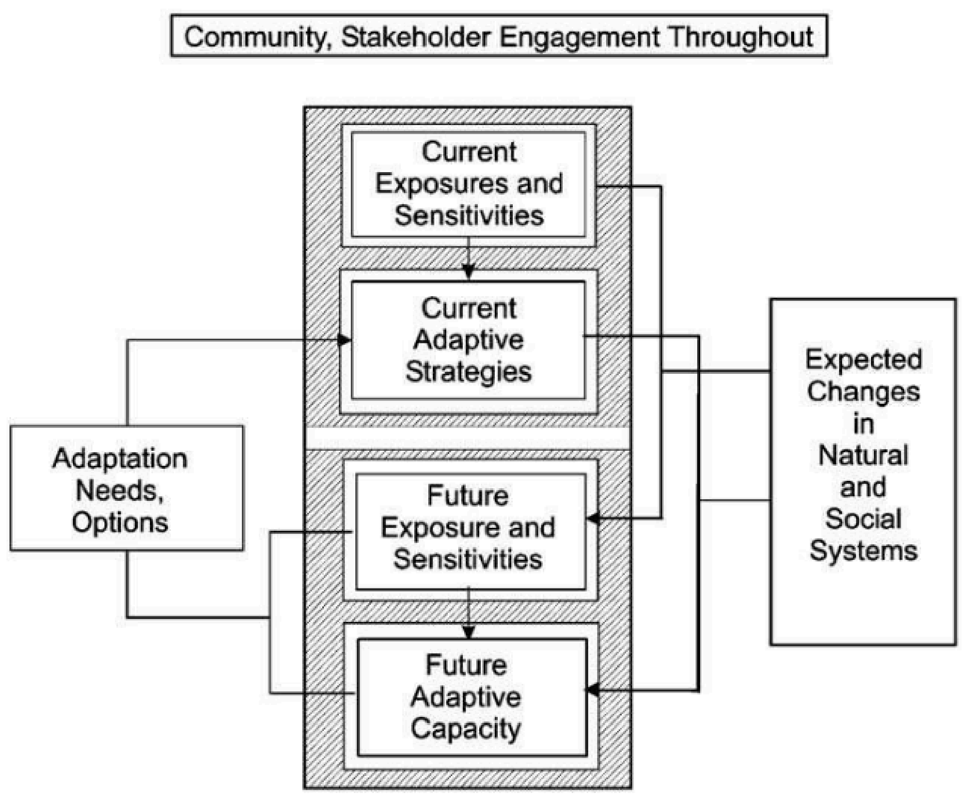

Figure 2. L'approche de la vulnérabilité schématisée par Smit & Wandel (2006)

Sensibilité et exposition

Les approches de vulnérabilité appliquées en Arctique ont mis en évidence plusieurs formes d'exposition aux changements environnementaux lors de pratiques d'activités de subsistance (Bunce et al., 2016; Ford et al., 2008, 2013; Ford & Pearce, 2010; Laidler et al., 2009; Pearce et al., 2010; Prno et al., 2011). Ce corpus souligne notamment le rôle crucial de la glace de mer pour les chasseurs inuit, ainsi que les répercussions possibles des variations d'épaisseur, d'étendue et de la durée d'englacement (Aporta, 2011; Laidler et al., 2009, 2010). D'autres études discutent également des changements hydrologiques en eau douce et de leurs effets sur l'accès au territoire et la pratique de la chasse (Cold et al., 2020; Ziegler et al., 2024). La variabilité croissante des conditions météorologiques, ainsi que l'augmentation de la fréquence et de l'intensité des événements extrêmes, font par ailleurs l'objet d'une attention soutenue. Les changements dans les régimes des vents, en intensité ou en direction, compromettent notamment la capacité des communautés à s'appuyer sur des indicateurs environnementaux fiables pour pratiquer leurs activités traditionnelles (Fox et al., 2020; Gearheard et al., 2010).

D'autres études mobilisant le concept de vulnérabilité ont souligné les effets des changements climatiques sur la santé humaine, notamment sur le bien-être, la santé mentale, et la sécurité alimentaire. Une diminution de la disponibilité et de l'accessibilité aux espèces animales peut augmenter la dépendance aux aliments du magasin, limiter l'apport de *country food* (« nourriture du territoire ») riche en nutriments et ainsi accroître l'insécurité alimentaire (Statham et al., 2015). Par ailleurs, il a été démontré que la perte de paysages et la perturbation du mode de vie peuvent créer de l'anxiété et de la dépression chez les Inuit (Cunsolo Willox et al., 2015).

Capacité d'adaptation

La capacité d'adaptation constitue un autre concept central des études de vulnérabilité. Wenzel (2009) rappelle à cet égard que les Inuit se sont adaptés à de multiples transformations : « En ce qui concerne le changement climatique et les changements écologiques qui l'accompagnent et qui pourraient affecter la subsistance des Inuit, il convient de rappeler que les Inuit disposent d'une base expérientielle qui s'étend sur un millénaire d'adaptation. » [traduction libre] (p.97)

Pearce et al., (2015) identifient trois formes principales d'adaptations dans leur cas d'étude sur la chasse de subsistance, soit la flexibilité, l'évitement des dangers et la préparation en cas d'urgence. Ces stratégies s'appuient sur les savoirs écologiques traditionnels. La flexibilité consiste d'abord à ajuster le calendrier saisonnier de chasse, utiliser d'autres routes de déplacements ou modifier l'espèce chassée (Berkes & Jolly, 2002). Ensuite, l'évitement des dangers renvoie à l'observation accrue des conditions et à la maîtrise des techniques de navigation. Enfin, la préparation désigne la capacité à adopter des mesures préventives accrues pour assurer sa survie sur le territoire (Pearce et al., 2015).

Quatre barrières fondamentales qui empêchent des déplacements sécuritaires sur le territoire sont identifiées par Davis et al. (2022) : les coûts élevés de la vie en Arctique, la perte des savoirs traditionnels, l'héritage et les politiques coloniales ainsi qu'une temporalité imposée contrainte par le travail, notamment. Dans ce même ordre d'idées, les coûts associés à la récolte de nourriture du territoire constituent le principal obstacle à une consommation accrue de ces ressources par les Nunavimmiut (Furgal, Lemire, et al., 2022). Une autre étude arrive aux mêmes conclusions : 44 % des répondants issus des communautés de Quaqtaq, Inukjuak et Kangiqsualujjuaq, identifient les contraintes financières comme le facteur limitant le plus important à la récolte de nourriture traditionnelle (Natcher et al., 2016).

Les approches de vulnérabilité ont néanmoins fait l'objet de critiques importantes. D'une part, qualifier une population de "vulnérable" peut comporter une connotation négative et favoriser des interventions externes pour remédier aux enjeux, ce qui limiterait l'autonomie de cette population (Haalboom & Natcher, 2012). D'autre part, cette approche ne discute pas nécessairement des liens entre le colonialisme et de la dégradation de l'environnement (Cameron, 2012). Effectivement, en négligeant de mentionner comment l'extraction des ressources du territoire contribue à cette vulnérabilité, comme l'industrie minière ou le transport maritime, ces études ne prennent pas en compte toutes les dimensions sociales, économiques et politiques pourtant déterminantes (Cameron, 2012). Ford et al. (2018b) répondent à ces critiques et argumentent plutôt que ce type d'approche reste encore pertinente parce qu'elles permettent de mieux comprendre les interactions dynamiques et complexes entre les humains et leur environnement. Dans ce mémoire, une approche de vulnérabilité est privilégiée. Une attention particulière sera portée sur les stratégies d'adaptations répertoriées afin de respecter l'agentivité de la communauté face aux enjeux des changements climatiques.

Approche communautaire

Dans le contexte des systèmes socioécologiques en Arctique, l'échelle communautaire est reconnue depuis longtemps comme un cadre d'étude pertinent (Smit & Wandel, 2006). La recherche ancrée au sein d'une communauté met en valeur la collaboration et vise à répondre aux enjeux et aux priorités des membres de cette communauté. Se distançant des traditions de recherche passées qui se produisaient *sur* les Autochtones, il s'agit maintenant de conduire la recherche *avec* et *pour* les communautés autochtones (Koster et al., 2012). Par ailleurs, ces approches nécessitent d'investir davantage de temps, comme en prenant le thé avec les gens lors des visites dans les communautés, car l'établissement de relations solides requiert une grande confiance et un respect mutuel (Castleden et al., 2012).

Comme mentionné plus tôt, ce projet de maîtrise s'est inscrit dans le programme de suivi environnemental communautaire *Imalirijiit*. Ce programme a débuté en réponse à une étude de faisabilité minière sur le bassin versant de la rivière George en 2016 (Gérin-Lajoie et al., 2018). La communauté de Kangiqsualujjuaq, située à l'embouchure de cette rivière, se souciait des conséquences de la mise en chantier d'une mine de terres rares sur la qualité de l'eau et la pratique des activités traditionnelles. En réponse à ces interrogations, le suivi communautaire établi a pour but de récolter des données environnementales indépendantes de l'industrie minière grâce à la collaboration entre des institutions de recherche régionales, provinciales et internationales. *Imalirijiit* inclut aussi la formation de jeunes à l'aide de camps scientifiques déployés sur le territoire, visant à assurer le transfert des connaissances et à développer localement des outils de gestion environnementale (Gérin-Lajoie et al., 2018).

Depuis le début du programme, une variété de thématiques ont été abordées (Figure 3) et plusieurs articles en sciences naturelles ont été publiés par des chercheurs collaborant au projet (ex.: Bayle et al., 2022; Bockhoff et al., 2025; Marginson et al., 2023, 2024; Sicaud et al., 2024). Alors que les recherches en sciences naturelles se concentrent davantage sur les réponses climatiques de la cryosphère et de la biosphère, les recherches en sciences sociales sont plutôt axées sur les enjeux culturels, économiques ou politiques des changements environnementaux (Chanteloup et al., 2018). Il apparaît donc essentiel d'intégrer les sciences sociales à ce suivi à long terme, et c'est dans cette optique que la présente recherche a été élaborée.

Figure 3. Axes de recherche de Imalirijiit

Projet de recherche : objectifs et méthodologie

Le but de ce mémoire est d'évaluer comment les changements environnementaux affectent la communauté de Kangiqsualujjuaq en lien avec l'accès au territoire et aux ressources en hiver. La question émerge d'un besoin de la communauté et qui a été impliqué dans la conception du projet. Aux fins de cette recherche, l'hiver est défini de début décembre à fin avril, période correspondant aux activités de chasse et de pêche hivernale de la communauté. Plus précisément, les objectifs sont de :

1) Caractériser le contexte et les éléments propices aux déplacements sur le territoire;
2) Documenter les observations des changements climatiques en hiver;
3) Illustrer les adaptations existantes pour améliorer l'accès et la sécurité sur le territoire.

Deux méthodes participatives ont été mobilisées pour répondre à ces objectifs. Pour répondre partiellement aux trois objectifs, le *Fuzzy cognitive mapping* (FCM), a été utilisé. Il s'agit d'une méthode semi-quantitative utile en contexte participatif et de prise de décisions, permettant d'analyser les priorités de divers groupes (Sarmiento et al., 2024). Elle consiste d'abord à identifier des facteurs autour d'un sujet central, puis à les relier entre eux. Dans un second temps, des pondérations quantitatives (entre -1 et 1) peuvent être assignées aux relations entre les facteurs, faisant ressortir les éléments prioritaires (Özesmi & Özesmi, 2004). La méthode est reconnue pour faciliter la représentation de plusieurs types de savoirs, comme les connaissances locales, non académiques ou autochtones (Badry et al., 2023).

Pour atteindre les objectifs deux et trois, la cartographie participative a également été utilisée. Cette méthode consiste à créer des cartes avec et pour des populations locales (Corbet, 2009). La cartographie participative autochtone représente des connaissances géographiques vastes, traditionnellement transmises oralement, et peut servir d'outil de réappropriation et de revendication (Glon, 2012). Dans cette étude, les cartes sont employées comme support pour nourrir les discussions. Les considérer comme un outil d’entrevue est une approche fréquemment mise en œuvre dans la recherche en contexte culturel inuit (Depaiva, 2018).

Cette recherche a été approuvée par le comité d'éthique de la recherche de l'Université du Québec à Trois-Rivières (UQTR). Pour assurer une participation libre et éclairée, un formulaire de consentement a été remis et expliqué aux participants avant les entretiens. Dans ce formulaire, ils ont pu consentir à l'enregistrement audio ou vidéo des entretiens ou à l’anonymat. Ces mesures ont été mises en place afin de respecter les principes éthiques et la confidentialité des données

CHAPITRE II.

"WE LOSE THE SNOW IN ONE DAY NOW": CHANGING WINTER HARVESTING CONDITIONS IN KANGIQSUALUJJUAQ, NUNAVIK

Manuscrit en préparation pour une publication en anglais.
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Abstract

A collaboration between researchers and the local community of Kangiqsualujjuaq in Nunavik through a community-based monitoring program has revealed that winter travel remains a major concern for this Inuit community. To address this issue, we identified and evaluated the key factors of winter travel on the land for the community, and examined how they are changing within a changing socio-ecological system. To this end, fuzzy cognitive mapping and participatory mapping workshops were held with participants (n=19) during two fieldwork sessions in 2023. This resulted in a collective mental map of winter travel and its related drivers. Furthermore, observations on climate change and adaptation measures to improve travel safety were also analyzed. Results show that participants were highly concerned about changes in snow and ice and their impact on land-based activities. Moreover, adaptation measures are already in place to mitigate the effects on livelihood, such as improving trail conditions for safety and sharing knowledge about winter conditions.

Résumé

Une collaboration entre des chercheurs et la communauté de Kangiqsualujjuaq au Nunavik, prenant la forme d'un suivi environnemental communautaire, a révélé que les déplacements hivernaux constituent toujours une préoccupation majeure pour cette communauté inuit. Pour répondre à cette préoccupation locale, les facteurs clés influençant les déplacements hivernaux de la communauté sur le territoire, ainsi que leur évolution au sein d'un système socioécologique en transformation, ont été étudiés à l'aide d'ateliers de cartographie cognitive floue et de la cartographie participative. Au total, dix-neuf participants (n = 19) ont pris part à ces travaux lors de deux terrains de recherche menés en 2023. Il en a résulté une carte cognitive collective des facteurs importants utilisés lors des déplacements en hiver, des observations sur le changement climatique et des mesures d'adaptation visant à améliorer les déplacements sur le territoire. Les résultats montrent que les participants sont préoccupés par les changements liés à la neige et à la glace. En outre, des mesures d'adaptation sont déjà mises en place pour atténuer les effets de ces changements, comme l'amélioration de la qualité des sentiers et le partage des connaissances du territoire.

Introduction

For Inuit of Nunavik, in the Canadian Arctic, participating in land- and sea-based subsistence activities is an integral part of culture, well-being, the economy and food security (Furgal et al., 2022), thus requiring reliable access to land. As water bodies are frozen and snow covers the land in winter, access to hunting and fishing grounds is at its peak. In the Arctic, trails are essential for visiting other communities, accessing important cultural places, and harvesting food (Aporta, 2009). However, as temperatures now rise four times the global average in this region (Rantanen et al., 2022), rapid environmental changes are creating challenges for transportation, especially in winter when traveling by snowmobiles, dog teams or all-terrain vehicles. In fact, the number of "good travel days" in winter, corresponding to acceptable thresholds for temperature, wind, and visibility criteria, has decreased in the Arctic, and this trend is expected to continue in the future (Ford et al., 2019, 2023). Arctic communities are especially vulnerable to decreases in extent and thickness of sea ice, crucial for travel and hunting (Laidler, 2007). Across Inuit Nunangat (the Inuit homeland in Canada), shifts in snow cover, thawing of permafrost, and changes in weather and wind patterns are occurring (Fox et al., 2020). Furthermore, ecosystems in subarctic regions are vulnerable to transformations that could induce cascading effects, including vegetation shifts that affect snowpack dynamics or accelerate permafrost degradation (Saulnier-Talbot et al., 2024).

Studies related to environmental change and Inuit have used different approaches, such as highlighting local narratives and experiences on climate change through interviews (Berkes & Jolly, 2002; Ford et al., 2012), promoting a food security framework (Guyot et al., 2006; Natcher et al., 2016), using a mental health approach (Cunsolo & Ellis, 2018; Cunsolo Willox et al., 2015; Lebel et al., 2022) or proposing a vulnerability approach (Pearce et al., 2010; Statham et al., 2015). In vulnerability studies, exposure, sensitivity and adaptative capacities are crucial concepts (Ford & Smit, 2004). Exposure and sensitivity indicate how communities or individuals are affected by climatic stimuli, while adaptive capacities help mitigate these impacts. Flexibility represents one example of adaptive capacity. It can be manifested by adjusting the timing and location of hunting activities or focusing on a different species (Berkes & Jolly, 2002; Pearce et al., 2015). Many vulnerability studies also recommend using a participatory approach, which can foster genuine collaboration and engagement to benefit local communities (Chanteloup et al., 2019; Dufour-Beauséjour & Plante Lévesque, 2020). This partnership can enhance the research project while also strengthening local management capacity (Gérin-Lajoie et al., 2018).

Although there is a substantial body of literature in vulnerability studies within a context of rapid environmental change for Inuit, many of these studies focus on regions above the tree line and/or in Nunavut. In areas near the tree line, previous participatory research has identified several changes in snow and ice conditions (Cuerrier et al., 2015; Rapinski et al., 2018; Ready & Collings, 2021). Despite the implementation of a community-based ice monitoring programs in a few communities across Nunavik in 2006 (Tremblay et al., 2006, 2008), recent efforts suggests that winter travel safety remains a primary concern among Nunavummiut (Makivvik, 2024).

Documenting land use patterns and current challenges can help identify potential adaptation pathways. In response to key concerns described above, the objectives of this paper are: 1) to present the current state of knowledge on trail use and hunting practices within a subarctic community in Nunavik; and 2) to give a voice to community members as they share observations about the changing environment, their effects on winter travel and safety, and the strategies Inuit choose to adapt to these changes.

Methods

Study context

This study was conducted in the northern village of Kangiqsualujjuaq ("very large bay" in Inuktitut) in Ungava Bay, Nunavik. Located north of the 55th parallel in Quebec, Canada, Nunavik is home to a mainly Inuit population living in 14 coastal communities that are not connected by roads. Kangiqsualujjuaq is the easternmost village and is distinct for its proximity to the tree line and several large bodies of freshwater, including the George and Kuururjuaq Rivers (Figure 4). For instance, the George River watershed encompasses an area of more than 42,000 km^2 (Sicaud et al., 2024). With an annual mean temperature of -3,5 °C between 2008 and 2022 (Sarrazin & Allard, 2024), Kangiqsualujjuaq is situated in a discontinuous permafrost region (L'Hérault & Allard, 2018).

The Hudson's Bay Company established a trading post in the 19th century, marking the first permanent settlement near the village. Kangiqsualujjuaq was formally established as a permanent village in 1980 (Makivvik, 2021) and has a population of 956 as of the 2021 census (Statistics Canada, 2021). Today, wage labor and subsistence activities are integral components of the economy. Similar to other northern communities, wage labor is often undertaken to facilitate other family member's harvesting activities (Natcher et al., 2016). Hunting, fishing, and gathering provide a livelihood for many residents, who possess an extensive sharing network of traditional foods (Lamalice et al., 2020). Country food from the land, is varied and includes fish (*e.g.* arctic char), seafood (*e.g.* mussels), land animals (*e.g.* caribou), sea mammals (*e.g.* seals) and berries (*e.g.* blueberries). Traditional foods remain important for Inuit because they hold cultural significance, provide nutritional benefits, and are often preferred over store-bought food (Lamalice et al., 2020).

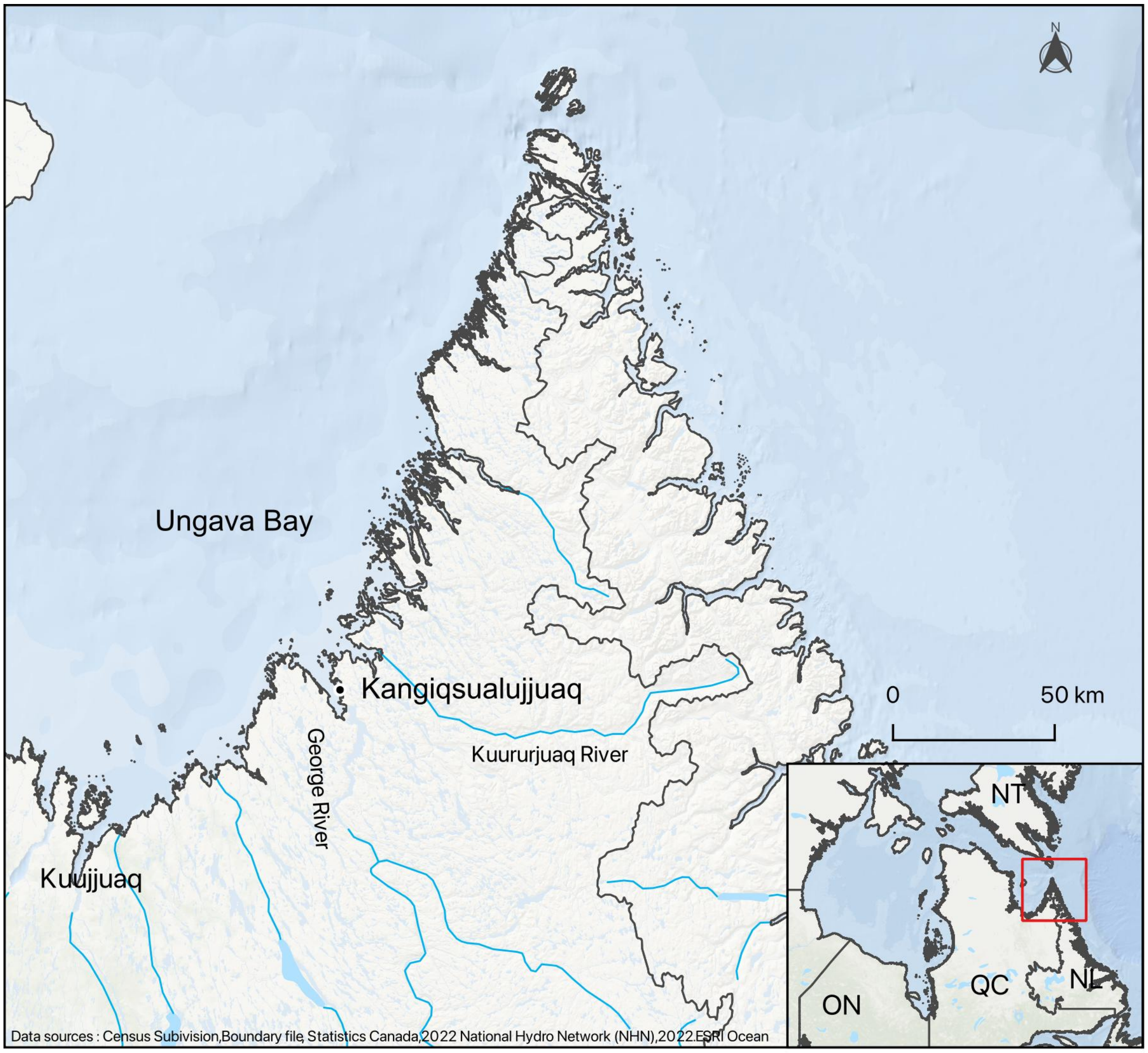

Figure 4. Location of Kangiqsualujjuaq community in Quebec, Canada

Community-based approach

Since 2016, Kangiqsualujjuamiut ("people of Kangiqsualujjuaq") and university researchers have collaborated in a community-based environmental monitoring project called *Imalirijiit* ("those who study water"). *Imalirijiit* was first established to monitor water quality in the George River watershed, where a rare-earth mining development was planned upstream (Gérin-Lajoie et al., 2018). The program also organizes land-based camps that combine science training for youth and the sharing of traditional Inuit knowledge from Elders and hunters on the land. This research project was developed as part of *Imalirijiit* program in response to a direct request from the community.

The strong relationships established with the community prior to this research facilitated the organization of multiple meetings with the village council. Meetings took place at both the design stage (February 2023) and after data collection (March 2025). They created opportunities for dialogue and allowing the research outputs to be in alignment with the community's needs. Throughout the process, the recommendations from Pedersen et al. (2020) for good practices when conducting research with Inuit communities were followed. Among these recommendations is the importance of identifying existing interviews and mapping initiatives to avoid duplication of effort and reduce research fatigue within communities. In keeping with this approach, we gathered past maps produced on the territory, building on existing knowledge.

Data collection

To document local observations, two complementary methods were used: fuzzy cognitive mapping (FCM) and participatory mapping (PM). Exchanges were conducted in English and in Inuktitut with the help of an interpreter, a knowledgeable and respected community member. Data collection sessions lasted between 1.5 and 3 hours per method. Community members were invited on recommendation of the interpreter and on the criterion that they travel on the land at least once each winter. A total of 19 community members participated in the study, either individually or in groups (Table 1). The majority of participants were males (84%), with an age range of 25 to 77 years (average of 54 years).

Table 1. Number of participants in the workshops

Gender	Fuzzy cognitive mapping	Participatory mapping	Participated in both	Total
Male	12	8	4	16
Female	2	2	1	3

Fuzzy cognitive mapping (FCM)

FCM offers insight into how different stakeholders make sense of an issue and its contributing factors (Andersson & Silver, 2019). FCMs are a visual representation of a central topic, with factors (variables) and their causal relationships (connections between factors). Weights can also be assigned to relationships to indicate their relative importance (*e.g.*: on a scale of 1 to 5). We used FCM in our work to facilitate discussions regarding factors impacting winter travel conditions. We followed the best practices of FCM with stakeholders in an ecological context by Özesmi & Özesmi (2004). Two FCM workshops were conducted using this method, with a total of 14 participants in February 2023 (Figure 5). A facilitator guided the exercise, while a reporter took notes.

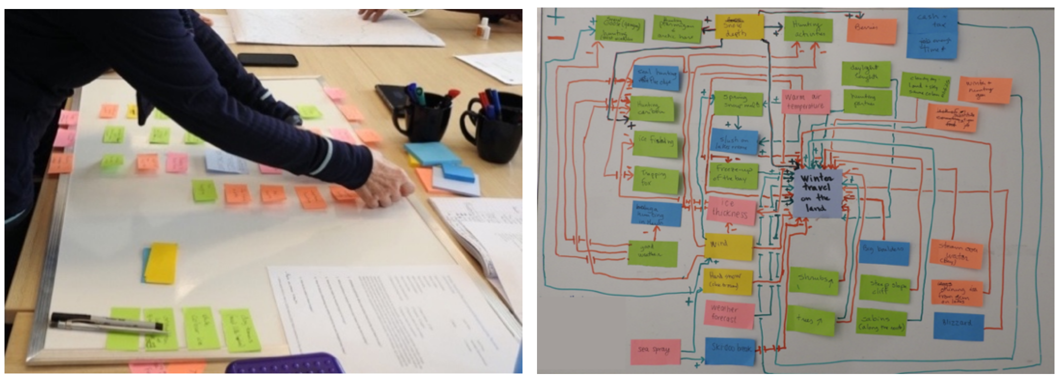

Figure 5. Fuzzy cognitive mapping in practice (left) and resulting map (right).

Generally, groups formed should be relatively homogenous to ensure that participants share similar understandings of an issue (Andersson & Silver, 2019). We planned to conduct separate FCM workshops for different age groups: one for Elders and one for adult hunters. However, with our discussions with community representatives, they have rather advocated creating intergenerational groups to promote knowledge sharing. Furthermore, the relationships between the factors were not scaled because there were too many to consider. A participative approach necessitates flexibility (Chanteloup et al., 2019), which proved essential for building trust and enhancing validity and richness of data.

Participatory mapping

Participatory mapping (PM) is mainly a collaborative process (Palsky, 2013) that "attempts to make visible the association between land and local communities by using the commonly understood and recognized language of cartography" (Corbet, 2009, p.6). It can help identify areas people perceive as important in a specific landscape (Dawson et al., 2020). PM workshops were carried out in Kangiqsualujjuaq in December 2023 with 10 participants, either in pairs or individually.

In these sessions, maps were primarily used as a visual aid to support the discussions. The interview guide was divided into three thematic sections: 1) Mapping areas for winter activities; 2) Safety concerns; 3) Implications of changes and adaptive measures. Participants were provided with existing trail maps (*see* Tremblay et al. (2006)) displaying documented winter trails and landscape features, onto which they annotated their contemporary snowmobile routes. These maps then served during follow-up and in-depth interviews, where participants compared past and current trail networks. Participants also provided detailed information regarding the harvesting location, species, and any changes they have observed regarding the landscape, such as snow and ice conditions. To preserve data confidentiality, the spatial data derived from the maps are not presented in this article. The maps were returned to the community, and this paper focuses on the qualitative data gathered through the mapping process.

Data analysis

Fuzzy cognitive maps (FCM) were merged and digitalized using yEd software (yWorks, 2025). The in-degree (sum of incoming arrows) and out-degree (sum of outgoing arrows) were calculated for each factor, helping to understand their roles in the system (Andersson & Silver, 2019). Then, centrality was calculated, which corresponds to the sum of in and out-degree. Centrality can indicate the factor's influence on the "winter travel" system. To simplify the map, factors were grouped into themes based on a categorization framework by Johnson et al. (2022): environmental, sociocultural, socioeconomic factors and key drivers. Key drivers are elements that have a major impact on the system.

During participatory mapping sessions, the 10 participants collectively mapped more than 6000 km of trails, with the longest itinerary totaling 195 km. They also identified harvesting sites for 15 different species including Arctic char, caribou, lake trout, brook trout, ptarmigan, seal, fox, polar bear, wolf, otter, snow geese, Canada geese, beluga, mussels, and seaweed.

The verbatim transcripts of all audio recordings along with notes from FCM and PM interviews, were prepared in English. Thematic analysis of transcripts (Gaudet & Robert, 2018) was conducted using NVivo 14. The transcripts were analyzed using inductive coding, with two primary themes emerging: changes (*e.g.* snow, water and ice, weather, vegetation) and adaptations. Indigenous knowledge was also coded, however the results are not presented in this article, because other work covered this subject extensively in Kangiqsualujjuaq (see Heyes, 2011). Initial results of FCM were presented in the community for validation in December 2023 with 4 participants of the original groups. The results presented in this article were also validated at a *Parnasimautik* assembly in March 2025. This yearly event aims to discuss different priorities in the communities and involves the whole village (Makivik Corporation, 2015).

Results

Inuit have developed a rich and complex knowledge of the land through activities such as hunting, fishing, and gathering. Recent environmental changes are already altering these activities, which depend on specific conditions such as sufficient snow or ice cover. Our results underline some of the required conditions for winter travel and harvesting, as well as how they are changing near the tree line in Nunavik.

Map of knowledge: Fuzzy cognitive mapping

Community members identified 61 factors relevant to winter land travel and mapped 79 relationships among these factors (Figure 6). Factors with the highest centrality (addition of in-degree and out-degree) are “ice thickness”, “slush on lakes”, “seal hunting”, “spring snowmelt”, “wind” and “travel speed.” They represent topics of importance to both groups, and during the validation process, these factors were spontaneously mentioned by participants.

In the second step of data analysis, factors were grouped into main themes to facilitate comprehension. The majority of the factors (59%) referred to the physical elements of an ecosystem (ice, snow, weather, vegetation, water, moon and sun cycles, and landscape obstacles) and were grouped as Environmental factors. Sociocultural factors correspond to activities and cultural practices (23%). Finally, Socioeconomic factors, which refer to income, education, and employment, represent 18% of all factors.

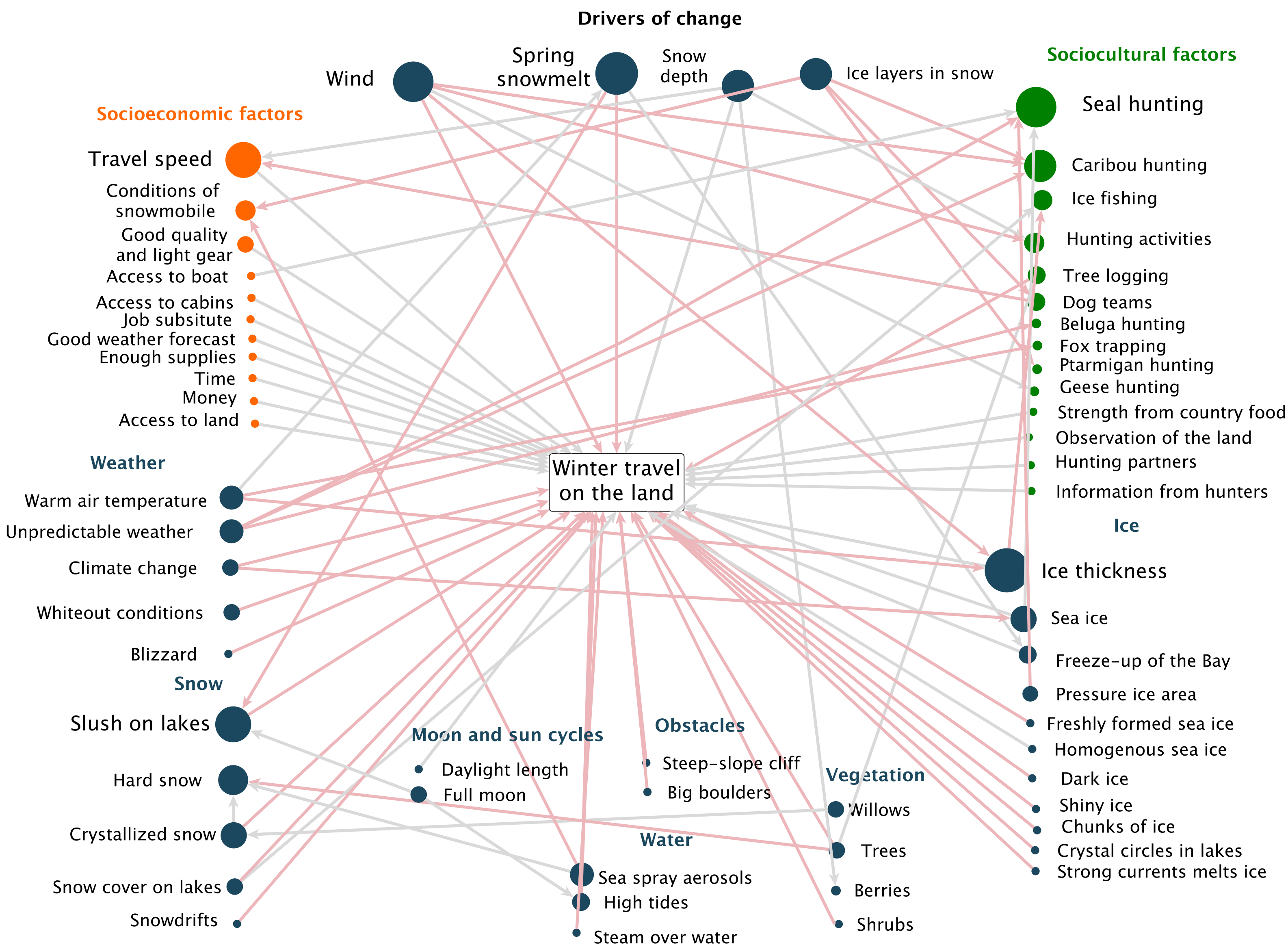

Figure 6. Relations among factors (61) grouped into three categories (environmental (n=36, marine blue), socioeconomic (n=11, orange) and sociocultural (n=14, green)) influencing winter traveling on the land in a context of environmental change. This data was obtained from two fuzzy cognitive mapping workshops with Inuit land-users in 2023 in Kangiqsualujjuaq (Nunavik, Québec). Drivers of change are factors that have the most outward connections. Lines represent the type of relationship between two elements: grey (positive) and red (negative). Size of circles represents relative centrality of each parameter.

Drivers of change are factors with a high outdegree, meaning they exert a dominant influence in the system. The four drivers of change (spring snowmelt, wind, snow depth, and ice layers in snow) are all environmental factors. In one focus groups, a participant recalled a past hunting experience, addressing almost all the drivers of change (snow depth, wind, and spring snowmelt) and their impact on travel on the land:

> We went hunting. There was a lot of snow, good ice, and suddenly it got windy. The water got warmer. It was the fastest melting. In just two days, it melted. We couldn’t go back using the same trail. We had to make a detour and use another trail where there was more snow.

Although at the start of the hunting trip, optimal conditions were met (safe to travel on ice on lakes, rivers, and sea, and enough snow on the land), a sudden change in weather altered trail conditions. Then, relying on knowledge of the land, this hunter and his group were able to select an alternative itinerary. This example shows how environmental changes are directly impacting travel and decision-making, and how they constrain travelers to adapt.

Another type of factor that can be highlighted easily with FCM is receiving factors. In contrast to drivers of change, they correspond to factors with the strongest indegree, meaning they are sensitive to external pressures and change. In our results, several sociocultural factors (seal hunting, caribou hunting, ice fishing) emerged as receiving factors, as their practice depends on specific conditions. For instance, participants noted that access to quality equipment and stable employment (socioeconomic factors) facilitates both hunting and travel on the land. At the same time, they are also viewed as non-negotiable, regardless of employment status, because it provides food for family members:

> Even if they [hunters] have a job, if they start to run out of food, country food, they just have to go. Nothing stops them. Even if they have a permanent job. If you run out of food for your family and your household, then you have no choice but to go.

Observed changes in winter travel conditions

Analysis of the interview data identified six themes of change: snow, water and ice, weather, vegetation. Participants also described the impacts associated with these changes. The main observations are presented below (Table 2).

Table 2. Observations and impacts of changes in winter travel conditions as reported by Inuit land-users (n= 19) in Kangiqsualujjuaq in 2023

Observations	Impacts
Snow	
Shorter winter	Multiple (eg. harvesting season, well-being)
Reduced snowfall	Multiple (eg. less berries, access)
Softer snow	Difficult igloo building
	Improved skiing conditions
Less snowdrifts	Hard to navigate
	Smoother travel
Water and ice	
Shorter ice season	Increased search and rescue
Less ice thickness	
Warmer seawater	Northward expansion of aquatic species
Weather	
Unpredictable weather	Multiple (more complex decision-making)
More wind	
Vegetation	
More willows	Softer snow texture

Snow

Local observations indicate a shorter duration of snow cover. The first snowfall is approximately 3 months later compared to 40 years ago. Indeed, according to participants, snow typically appeared from the end of September to the beginning of October in the 1980s. During our interviews in December 2023, there was still insufficient snow for traveling. Participants also noted a decrease in snowfall, which can, in turn, diminish berry productivity in the summer. According to a respected Elder in the community, a lot of snow in winter is a sign that there will be many berries in summer.

In addition, the timing of spring snowmelt is changing. Snowpack can melt rapidly, as one hunter shared: “In the end of April, we can sometimes lose the snow in one day now. We never used to see that. It used to be a nice long May [of travel on the land].”

Moreover, snow texture changes were observed, particularly an increase in crystallized snow. Crystallized snow can create a softer and less dense snowpack. As a result, this represents a significant challenge to the construction of igloos:

> About 15 years ago [circa 2007], the snow suddenly changed. It used to be all hard, all solid. In one winter, it was all crystals. (…) After that, the snow was always soft. We were not able to make snow blocks for igloo or tent blocks.

Changes in snow texture also affect skiing conditions, an activity practiced by one of the participants: “My friend told me that [in] 2000, it was the first time he noticed snow was more powdery. (…) Now, it's like heaven, skiing on powder snow.”

Participants further identified changes in snowdrifts patterns: “Nowadays, we see less snowdrifts, those very long ones. They used to be very hard to ride on. Maybe this year there will be some.” Although fewer snowdrifts provide a smoother and flatter surface for travel, it also diminishes a traditional wayfinding method. Formed by wind-blown snow accumulating on the ground, snowdrifts have been used for orientation purposes (Aporta, 2006), as indicated by an Elder in the interviews : “Long time ago, Inuit had observations for the land with *Qimutjuk* (“Snowdrifts”), they would know which direction to go. Orientation, like an *inukshuk*. Those are the good guidelines for the older times."

Water and ice

Ice conditions have also undergone significant changes, according to observations by Inuit hunters. Participants were highly concerned with the shortened ice season, in both marine and freshwater environments. The freeze-up now occurs later in the year (January/February), causing Kangiqsualujjuaq's residents to lose up to 2 or 3 months of usable ice. As temperatures rise across arctic regions, the ice starts to form later, and the season ends earlier:

> It's different now. A long time ago, it used to freeze-up real fast, but now global warming is affecting the freeze up, by slowing it down. Right now, maybe in January or February, sea ice is going to freeze.

Ice thickness is also decreasing, especially in freshwater environments. As one participant recalled : "in those times, the lake ice was a lot thicker than now." Less time with ice limits access to places for hunting, such as the land across the George River located in front of the village. To safely cross this river, two weeks of -25°C temperature are necessary for the ice to freeze (Municipal official, personal communication, 2023). This river crossing is frequently used by those engaged in goose hunting in the spring.

Several ice-related impacts on land safety were identified during the interviews, including increased search and rescue operations: "There were more rescues activated [this spring (2023)] than in previous years. We get more calls in the spring when the ice and snow is melting faster." However, a shorter ice season was also viewed positively by some participants, as it provides earlier access to boating. Finally, participants were concerned that rising seawater temperatures may impact marine animals, potentially leading to an expansion of their habitat northward.

Weather

Participants described the weather as more variable than in the past: “When I was a kid, winter was nice and steady, now it has a lot of wind. The weather is more unpredictable.” Traditional weather-forecasting and orientation techniques, such as looking at snowdrifts, clouds, and wind patterns, are becoming less reliable.

One notable change in weather conditions is the occurrence of rain on already accumulated snow in winter, as reported by this hunter: “We can’t predict the weather anymore. Last year we had rain in December.” Several interviewees noted that winter rain can form an ice layer on top of snow, with significant impacts on both humans and animals. For instance, ice layers can damage dog’s paws when traveling by dog sleds. It can also alter access to food for animals, such as caribou: “If it rains in winter, the rain will freeze, and the caribou will not be able to find their food, lichen.”

Vegetation

One participant associated the changing snow texture with the expansion of shrubs in the North: “Since there are a lot of willows now, the snow is mostly soft. It used to be harder but (…), it’s like *pukak* (“crystallized snow”) everywhere.” Erect shrubs can trap snow and prevent wind from compacting it. As a result, hard snow does not form as easily and could create challenging travel conditions.

In winter, participants generally did not perceive shrub expansion as a negative impact travel, as sufficient snow accumulation on top of vegetation limits this issue. In summer, however, the opposite is true, as shrubs and trees can create obstacles on the land:

> Long time ago, it was easier to travel, because there was less shrubs and trees. (…) It’s difficult to travel now because there’s global warming and that causes to the trees to grow.

Adaptation strategies

In a rapidly changing environment, adaptive strategies are crucial to reduce vulnerability. Interviews in Kangiqsualujjuaq reveal that adaptation is an ongoing process, and responses to altering conditions are already happening. These reported adaptations can be grouped into two main themes: adjustments in transport safety and information-sharing methods. The identified strategies occur at different spatial scales, ranging from individual decisions, such as using different equipment, to community-level efforts to integrate technologies and transfer knowledge (Table 3).

Table 3. Adaptation measures to cope with changes in winter travel conditions as reported in 2023 by Inuit participants in Kangiqsualujjuaq, Nunavik.

Scale	Safety and Transport	Sharing Information
Individual	Change in transportation mode	Devices (incl. cellphone, GPS)
Community	Sharing resources and equipment	Communication tools for warning
Community/Regional	Trail visibility	Data availability
Individual/ Community/Regional	Traditional and alternative trails	Intergenerational knowledge transfer

Safety and Transport

Despite the traditional use of dog sleds or snowmobiles during winter, alternative methods of transportation reveal the evolution of mobility in Kangiqsualujjuaq. In 2022, it was the first time that an interviewed hunter used his boat for goose hunting during the spring, as the ice had already broken up. Other than a longer boat season, some residents are exceptionally transported by air for hunting activities: “In the spring, when we want to go fishing, we’re using helicopters and airplanes these days, because the route to fishing spot is already melted and it’s not accessible.” Elders who are no longer able to travel on land can also sometimes fly to go fishing, as some initiatives of regional government can provide that service. Whilst alternative transportation may offer a solution to some immediate safety concerns, it could create a more significant challenge, in terms of high cost.

Besides paying more for land access, sharing resources and equipment among community members was identified as a potential strategy for enhancing safety on the land: “If the hunters are short on gas, (…) there is some available [on the land]. (…) We’re sharing. If they can afford it, they will return what they were using. It’s part of our way of life.” Gasoline is stored in easily accessible locations for hunters, providing a reliable source of fuel.

As part of the participatory mapping process, winter roads in use circa 2006 were provided as a reference to assess whether these trails had been altered or remained usable. The majority of mapped trails closely aligned with those recorded in earlier mapping efforts, suggesting continuity in trail use over time. A participant explains that the use of a conventional trail is still an important safety strategy, as it allows a rapid rescue for emergency teams:

> We still use them [main trails], because if somebody gets stranded on the land, (…) we’re pretty sure that they could be here. Their location were pronounced for place names [located on the trail] and they [rescue team] go directly.

Combining traditional trails with Inuktitut place names (toponyms) can help locating individuals stranded on the land. Yet during critical seasonal transitions, particularly the shift from winter to spring, knowledge of alternative routes becomes essential: “If there's water flowing, and you have to cross the river, there's an alternate route. (…) I'm not going to rely on this traditional route, but when it's fall, it's more accessible than [during] the spring meltdown.” Participants also reported traveling more in land at the start of the snow season, and more on sea ice at the end of the season.

Improving visibility on the trails is another method to improve safety. To address this issue, members of the community have started placing 6-foot trees or light reflectors every winter. However, it was noted by one participant that some individuals may rely too much on reflectors, as it can encourage individuals to ride at unsafe speeds: “The reflectors are the main points because some Inuit don't have good observation. They're just zooming on the trail. (…) And they're only looking for colored reflectors.”

Sharing Information

Most participants used devices while travelling on land. These devices, such as GPS (Global Positioning System) or cellphones, can assist the users in many ways. GPS devices are valued by hunters for orientation, especially when weather conditions would otherwise limit visibility. They can also help with registering trails or hunting grounds, which was done by most participants. One hunter stated that: “Nowadays, I would not travel without my device”, yet another cautioned against becoming overly dependent on this technology. Indeed, two respondents lost their trail data when changing their cellphone. Other possible challenges with a device include having to charge the mobile phone during travel or carrying multiple GPS batteries because they are more susceptible to freezing in winter conditions.

However, with these devices, travel safety can be enhanced by exchanging information among hunters or the whole community: “When we say the ice condition in the spring is not safe, we have a public announcement that [says] it's no longer accessible.” These public announcements are usually broadcasted on community radio or on social media platforms (*e.g.:* Facebook). They act as early warning systems, informing the public about potential dangers.

Effective communication of trail conditions relies on access to reliable, up-to-date information and this need that was raised across several interviews: “I think they should have some website for the youth to get information about snow conditions and ice formation. I think it should be public.” Indeed, a measure to improve travel safety would be to provide an easily accessible platform, with simple information on traveling conditions. In the previous quote, the interviewee also expresses his desire for youth to have more opportunities. For example, transfer of knowledge regarding how to survive on the land, could potentially be integrated into the school curriculum: “It should be taught in school: weather conditions. What to expect if there is going to be a storm, or how it’s going to look the morning before.” Younger, less experienced individuals learn by observing and accompanying hunters. Through this process, they can learn about navigation, animals, landscape, potential hazards, or in this case, trail networks: “Growing up, with my father's knowledge (...). He was teaching me: we can go on this route, but here's an alternate route. It's longer, but it's more safe (…).”

Discussion

This study presents an overview of Kangiqsualujjuamiut’s observations on climate change in winter and how these observations impact access to the land. Our results are consistent with a significant body of research that has documented climate change impacts on subsistence harvesting and travel across the Arctic (Berkes & Jolly, 2002; Charlie et al., 2022; Cold et al., 2020; Ford et al., 2008; Pearce et al., 2015; Rapinski et al., 2018; Tremblay et al., 2006).

Community observations

Perceptions of the risks associated with hunting and fishing are built by individuals’ relationships with the land. Inuit have gathered complex knowledge by practicing these activities, and all interviewees were active on the land during winter. Compared to 40 years ago, participants report a delay of up to 3 months for snowmobiling, mainly due to insufficient snow cover and later freeze-up. A shorter winter has also been noted in studies across Nunavik, Nunavut, and Alaska (Cuerrier et al., 2015; Herman-Mercer et al., 2019; Statham et al., 2015). Other changes in the winter landscape identified by the participants include altered snow texture, changes in snowdrifts, and unpredictable weather.

Focusing on winter in this study could have limited observations of other processes impacting travel and harvesting, such as erosion, shallow waterways (*e.g*. Ziegler et al., 2024) and permafrost thaw (*e.g.* Gibson et al., 2021). This is particularly relevant, given that some rivers and lakes near the community are reported to have dried up due of a lack of rainfall (Dubos et al., 2023). We recommend that future studies incorporate Inuit knowledge of hydrological dynamics to track changes.

Travel barriers

Access to the land for the community is not only restricted by environmental conditions. Socioeconomic factors also emerged as significant barriers in our results: access to good quality and lightweight gear, good snowmobile conditions, and money. This aligns with broader findings in the literature: financial constraints have been identified as the main barrier to wildlife harvesting in Kangiqsualujjuaq (Natcher et al., 2016), while equipment and fuel costs can limit both the distance traveled and the frequency of trips (Brinkman et al., 2014). Besides, household income and gender were both drivers in how hunters select the safety of a hunting patch (Hillemann et al., 2023). For instance, individuals with more financial resources may be able to harvest less common but highly important cultural species, such as caribou (Hillemann et al., 2023). The cash economy presents a dual dynamic: while it provides funds to purchase necessary equipment, it also competes for time available to practice land-based activities. Nevertheless, many participants reported that when weather conditions are optimal for hunting during the work week, finding a temporary job substitute was simple ("job substitute" factor in Figure 7). This flexibility reflects what is observed across Arctic communities, where some employers recognize the importance of hunting and accommodate more adaptable work schedule (Bunce et al., 2016).

Community adaptations

Kangiqsualujjuamiut have developed several adaptation strategies. Participants reported changes in transportation modes, including switching from a snowmobile to a boat or even to airplanes and helicopters in the spring. Other publications note the adoption of larger boats (Green et al., 2021) or the use of all-terrain vehicles (ATV) when snow cover decreases (Cold et al., 2020). In addition, we hypothesized that a considerable number of trails would be altered or abandoned by land-users. This was not supported by our findings, as all trails remained in active use, as summarized by one participant: “We still use the same old trails. Now with our modern skidoos, we can go everywhere and to more places. I don't think there's a trail that we don't use anymore because of global warming.” Nevertheless, many also reported that alternative trails are needed when ice conditions are unsafe, a process referred to as “trail switching” (Ford et al., 2019). Traveling farther inland when the ice is unsafe is a form of trail switching. Another strategy that aims to improve trail visibility and wayfinding is to install artificial trail markers, such as reflectors, along designated grooming trails. To our knowledge, the use of artificial reflectors had been only once documented before in Nunatsiavut (Riedlsperger, 2014).

Other themes of discussion included ways to improve current travel conditions. A significant number of participants called for a designated platform to access data concerning snow and ice conditions. Available data is not always representative of local needs across the Arctic (Simonee et al., 2021), and Inuit land-users note gaps between available forecasting products and their needs. They are asking for more real-time, accessible, and relevant information (Simonee et al., 2021). Different projects have focused on improving forecast for local communities. For example, in Nunavik high-resolution images were developed to predict sea ice processes (Dufour-Beauséjour et al., 2020; Gauthier et al., 2010) while time-lapse cameras have monitored avalanches (Veilleux et al., 2021). Additionally, SIKU, a mobile app, can help register trails, snow, ice, and Inuit knowledge on a cellphone, which can be then used to improve forecasts and travel safety (Krupnik et al., 2010). Participants expressed a strong interest in the app, and we recommend conducting focus groups in Kangiqsualujjuaq to engage individuals in using SIKU or another platform for improving available data and mobility.

Variables for decision-making

Environmental factors impacting winter travel on the land were dominant in this study, encompassing 11 ice-related variables, 8 snow-related variables, and 5 weather-related bariables. These align with many weather, water, ice, and climate (WWIC) indicators used to assess Inuit travel safety and support adaptation across Inuit Nunangat (Bishop et al., 2025). The identification of factors representative of the experience of Kangiqsualujjuamiut contributes to broader Inuit adaptation research, as Bishop et al. (2025) found a lack of studies on WWIC located in Nunavik, with only 9 out of 123 variables focusing on the region.

In our results, environmental, sociocultural, and socioeconomic factors are interconnected, as reflected in the 79 relationships captured in Figure 7. Fox et al. (2020) argue that human-relevant environmental variables (HREVs), which integrate both social and environmental factors, better reflect Inuit decision-making processes. For example, *wind chill*, which combines *temperature* and *wind,* is a commonly used HREV for evaluating weather conditions. Relationships created from cognitive maps could be used to assess other human-relevant variables (HREV) and to communicate important information to the public. For instance, *wind, ice thickness*, *ice fishing*, and *air temperature* were important variables for the participants, which could be used to develop an *Ice Fishing Risk Index*. To improve communication and data availability, more effort is needed on relevant factors to assess changes and inform the public about potential hazards and conditions.

Methods contributions

To the best of our knowledge, this is the first study on land-based travel using Fuzzy cognitive maps (FCM) and qualitative data from participatory mapping in Inuit Nunangat. Focused on identifying relationships among factors and the main issue, FCM proved to be a valuable tool for braiding local, western, and traditional knowledge. Even when a factor is difficult to quantify, FCM provides a framework to consider it into the analysis. The representation also presents a more holistic view of the environment, one closer to Nunavimmiut's worldview (Chanteloup et al., 2018). Participants demonstrated a high level of engagement throughout the process, with individuals providing suggestions to the animator on how sticky notes should be positioned. Andersson & Silver (2019) reported that FCM can help build a partnership between participants and researchers. Indeed, based on both our experience and the findings of Tratt et al. (2020), this experience appears to be validating for the participants. FCM may also facilitate reaching a consensus, as the group can contribute to suggestions or provide validation in real time. Furthermore, as stated in the methodology section, the community proposed merging different age groups, which is not typically advised in this method, as it necessitates maintaining relatively homogeneous groups for effective comparison (Andersson & Silver 2019). However, a key benefit of heterogenous groups was the facilitation of knowledge transfer, as Elders and younger hunters shared their expertise of the land.

During the participatory mapping workshops, participants often emphasized that their trails were stored only in their memories. This aligns with previous research describing Inuit geographical knowledge as extensive and transmitted through oral history (Aporta, 2006). Using existing mapping products helped facilitate dialogue, and the project enabled us to provide updated GIS maps to the community. However, these maps will not be made publicly available, in accordance with the community needs. The publication of land-use information can expose communities to several risks, including unwanted development and challenges to land rights negotiations (Glon, 2012). This example further emphasizes the importance of community collaboration and validation at every stage of participatory research.

Conclusion

This study documented changes in winter landscapes in Kangiqsualujjuaq through a community-based approach, highlighting both the locally perceived impacts and the strategies Kangiqsualujjuamiut have developed to cope with them. The main contribution of this work lies in documenting winter landscape transformations, facilitating intergenerational knowledge sharing, and identifying avenues for future research that will support community resilience.

Acknowledgments

Sophie Keelan for her essential contribution as an interpreter and all participants from Kangiqsualujjuaq: Elijah Kelly Annanack, Jack Annanack, Jamie Annanack, Nedlidd Annanack, Sarah-Pacha Annanack, Tuumasi Annanack, Jaiku Arnatuk, Kenny Arnatuk, Tommy Assevak, Leevan Etok, Lucassie A. Etok, Henry Ittulak, Susie Morgan, David Snowball, Felix St-Aubin, Claude St-Aubin, Sammy Unatweenuk, Tommy Unatweenuk. We thank Polar Knowledge Canada, Northern Scientific Training Program (NSTP) and ArcticNet for funding this project.

CHAPITRE III.

CONCLUSION

Le projet de maîtrise visait à documenter les conséquences des changements climatiques hivernaux sur la communauté de Kangiqsualujjuaq, dans la région du Nunavik, en se concentrant sur les déplacements sur le territoire. Pour ce faire, le premier objectif était de caractériser les éléments qui permettent un déplacement. Le second objectif avait pour but de documenter des observations des changements climatiques à l'aide du savoir inuit et local et finalement, le dernier objectif était d'illustrer les adaptations possibles ou mises en place dans la communauté. Pour répondre à ces préoccupations, deux méthodes ont été utilisées, soit le *Fuzzy cognitive mapping* (FCM) et la cartographie participative. Le FCM a permis de faire ressortir des éléments importants pour la communauté, alors que la cartographie participative a servi de support pour approfondir des discussions sur le territoire.

L'introduction du mémoire présentait les principaux concepts utilisés pour formuler la question de recherche. Le savoir inuit est à la fois riche et complexe et découle d'observations du territoire à travers la pratique d'activités, telles que la chasse et la pêche. Le cadre de la vulnérabilité a permis d'aborder la question de l'adaptation aux changements climatiques, en considérant les aléas climatiques et leur interrelation avec les activités humaines. Les approches de recherche communautaires ont été essentielles pour faciliter le recrutement des participants, établir une relation de confiance et faire évoluer les questions de recherche au fil du projet. Plusieurs retours avec la communauté ont eu lieu, suivant un souci d'impliquer la communauté à toutes les étapes de la réalisation de la recherche et ces retours ont eu un grand impact sur la forme finale du projet. Notamment, à l'évènement *Parnasimautik* en mars 2025, où une présentation orale a eu lieu devant la communauté et dans laquelle des cartes produites dans le cadre de ce projet ont été montrées. Ces cartes contenaient des informations sur l'utilisation du territoire, telles que des itinéraires de chasse, des lieux de collecte de nourriture et des connaissances écologiques locales. Cette rencontre a permis de constater la nature sensible du contenu représenté. En contexte autochtone, la confidentialité revêt une importance particulière, car ces données sont liées à l'identité et l'autodétermination des communautés. Pour ces raisons, ces cartes ont été partagées à la communauté, mais elles ne sont pas présentées dans ce mémoire et demeureront confidentielles.

L'article principal comprenait la méthodologie de recherche, les résultats et la discussion. Les annexes disponibles à la fin du document fourniront les questions d'entrevues et un retour des résultats à la communauté sous forme de livret. Du point de vue méthodologique, il s'agit du premier projet né d'un partenariat avec des Inuit et des chercheurs et qui, à notre connaissance, combine à la fois le FCM et la cartographie participative. La méthode apporte un cadre dont la grande flexibilité est favorable pour représenter diverses formes de savoirs. Elle a été particulièrement utile pour d'abord établir un portrait général des conditions de déplacements et dans un deuxième temps pour détailler des éléments ressortis comme plus importants lors d'entrevues individuelles. La représentation graphique permet également d'illustrer des concepts qui peuvent être difficiles à quantifier. En effet, des concepts généraux comme le bien-être ou le respect peuvent être intégrés dans un FCM, tel que MacMillan et al. (2024) le soulignent dans leur étude portant sur les habitats des orignaux, fondée sur les savoirs des Cris de la Baie-James. Les approches participatives utilisées ont pu représenter pour les participants un espace de reconnaissance de leur expérience et de leur point de vue. Ils ont également favorisé des moments de transfert des connaissances entre les générations, grâce à la création de groupes de partages de divers âges et milieux. Ils constituent eux-mêmes un résultat en soi, dépassant les objectifs initiaux de la recherche

Les résultats montrent d'abord l'interconnexion des écosystèmes humains et environnementaux. Ils laissent entrevoir que l'hiver, tel que connu par les utilisateurs du territoire, est en pleine transformation. Les participants de cette étude rapportent des changements notables à la neige, à la glace, aux vents, à la météo, à la température de l'air, à la glace de lac et de mer. Certains endroits, particulièrement dans l'estuaire de la rivière George, ne gèlent plus de la même manière qu'auparavant, limitant l'accès à certaines parties du territoire. Cette étude a également révélé des mesures d'adaptation adoptées ou que souhaite adopter la communauté à divers niveaux, de l'individu au niveau régional, témoignant d'une capacité d'adaptation active de la communauté de Kangiqsualujjuaq face aux changements climatiques. Plusieurs participants ont exprimé leur besoin de plateformes fiables pour accéder à des données pertinentes concernant les conditions du territoire. Enfin, les résultats démontrent la complexité des décisions liées à la mobilité. L'utilisation de routes traditionnelles reste privilégiée pour assurer la sécurité, mais les participants soulignent la nécessité de connaître des itinéraires alternatifs, particulièrement au printemps, lorsque les conditions deviennent critiques. Une vigilance accrue lors des périodes de transition, au printemps ou à l'automne, est nécessaire pour des déplacements sécuritaires.

Au niveau pratique ou professionnel, cette recherche pourra notamment être utilisée par des acteurs des milieux institutionnels au Nunavik afin d'établir des stratégies d'adaptation localisées. À cet égard, la première stratégie d'adaptation aux changements climatiques au Nunavik, récemment élaborée, possède plusieurs mesures qui ont pour but d'améliorer la sécurité dans les déplacements, comme favoriser davantage la transmission des savoirs au sein du cursus scolaire (Makivvik, 2024).

Futures recherches

Les participants ont mentionné, à plusieurs reprises, leurs préoccupations à l'égard des jeunes du village. Pour de futures recherches, il serait pertinent d'intégrer le point de vue de jeunes adolescents et de jeunes adultes (moins de 25 ans) pour obtenir un portrait plus représentatif de la communauté et un échantillon plus diversifié. Par ailleurs, plusieurs personnes reconnues comme détentrices de savoir liés au territoire n'étaient pas disponibles lors des terrains de recherche, ce qui constitue également une limite à considérer. La visite en début décembre 2023 a été plus difficile en matière de recrutement, car plusieurs membres étaient sollicités pour participer à des rencontres à l'extérieur du village. Dans les communautés nordiques, il est courant que les membres soient impliqués dans plusieurs organisations, assumant à la fois des fonctions politiques et administratives en raison de leur petite taille. Dans le futur, réaliser des terrains de recherche plutôt en novembre ou février dans la communauté serait plus favorable afin de ne pas surcharger les personnes déjà impliquées.

Comme le soulignent Gearheard et al. (2006), accompagner des membres de la communauté sur le territoire et sur la glace permet de saisir des nuances que les entrevues individuelles en espace clos ne peuvent apporter. L'intégration d'une démarche d'observation participante serait une méthode complémentaire intéressante qui permettrait de valider les changements environnementaux rapportés et d'accroître la confiance dans les résultats. Des observations menées sur plusieurs hivers, voire sur une année complète pour prendre en compte la variabilité interannuelle ou saisonnière, pourraient également être explorées. Ce projet a d'ailleurs démontré que la densification des arbustes représente un obstacle sur les chemins empruntés en été, alors qu'en hiver, leur présence a très peu d'effet sur la capacité à se déplacer. Ainsi, un même changement environnemental peut engendrer des vulnérabilités distinctes selon les saisons. Une approche intégrant la saisonnalité contribuerait à approfondir les connaissances des impacts des changements climatiques sur la mobilité et la sécurité des communautés nordiques.

RÉFÉRENCES BIBLIOGRAPHIQUES

Andersson, N., & Silver, H. (2019). Fuzzy cognitive mapping : An old tool with new uses in nursing research. *Journal of Advanced Nursing*, *75*(12), 3823-3830. https://doi.org/10.1111/jan.14192

Aporta, C. (2003). New Ways of Mapping : Using GPS Mapping Software to Plot Place Names and Trails in Igloolik (Nunavut). *ARCTIC*, *56*(4), 321-327. https://doi.org/10.14430/arctic629

Aporta, C. (2006). Routes, trails and tracks : Trail breaking among the Inuit of Igloolik. *Études/Inuit/Studies*, *28*(2), 9-38. https://doi.org/10.7202/013194ar

Aporta, C. (2009). The Trail as Home : Inuit and Their Pan-Arctic Network of Routes. *Human Ecology*, *37*(2), 131-146. https://doi.org/10.1007/s10745-009-9213-x

Aporta, C. (2011). Shifting perspectives on shifting ice : Documenting and representing Inuit use of the sea ice: Shifting perspectives on shifting ice. *The Canadian Geographer / Le Géographe Canadien*, *55*(1), 6-19. https://doi.org/10.1111/j.1541-0064.2010.00340.x

Aporta, C., & Higgs, E. (2005). Satellite Culture : Global Positioning Systems, Inuit Wayfinding, and the Need for a New Account of Technology. *Current Anthropology*, *46*(5).

ARK. (2005). *Projet de parc de la Kuururjuaq (Monts-Torngat-et-Rivière-Koroc). État des connaissances.* Administration régionale Kativik, Service des ressources renouvelables, de l'environnement et de l'aménagement du territoire, Section des parcs, Kuujjuaq, Québec.

ARK. (2018). *Rapport annuel du Programme d'aide aux Inuits pour leurs activités de chasse, de pêche et de piégeage*. Administration régionale Kativik.

Badry, N. A., MacMillan, G. A., Stern, E. R., Landry-Cuerrier, M., Hickey, G. M., & Humphries, M. M. (2023). Boundary Spanning Methodological Approaches for Collaborative Moose Governance in Eeyou Istchee. *Environmental Management*. https://doi.org/10.1007/s00267-023-01918-6

Bayle, A., Roy, A., Dedieu, J.-P., Boudreau, S., Choler, P., & Lévesque, E. (2022). Two distinct waves of greening in northeastern Canada : Summer warming does not tell the whole story. *Environmental Research Letters*, *17*(6), 064051. https://doi.org/10.1088/1748-9326/ac74d6

Berkes, F., & Jolly, D. (2002). Adapting to Climate Change : Social-Ecological Resilience in a Canadian Western Arctic Community. *Conservation Ecology*, *5*(2), art18. https://doi.org/10.5751/ES-00342-050218

Bishop, B., Paquette, E., Carter, N., Ljubicic, G., Oliver, E. C. J., & Aporta, C. (2025). Inuit uses of weather, water, ice, and climate indicators to assess travel safety in Arctic Canada, Alaska, and Greenland : A scoping review. *FACETS*, *10*, 1-25. https://doi.org/10.1139/facets-2024-0107

Bockhoff, M., Marginson, H., Ittulak, H., Roy, A., & Amyot, M. (2025). Influence of vegetative cover on snowpack mercury speciation and stocks in the greening Canadian subarctic region. *Environmental Research*, *264*, 120333. https://doi.org/10.1016/j.envres.2024.120333

Brinton, M. (2018). *Risk and Uncertainty Regarding Inuit Transportation in the Face of Climate Change* [Master of Arts in Anthropology]. Boise State University.

Bunce, A., Ford, J., Harper, S., Edge, V., & IHACC Research Team. (2016). Vulnerability and adaptive capacity of Inuit women to climate change : A case study from Iqaluit, Nunavut. *Natural Hazards*. https://doi.org/10.1007/s11069-016-2398-6

Cameron, E. S. (2012). Securing Indigenous politics : A critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. *Global Environmental Change*, *22*(1), 103-114. https://doi.org/10.1016/j.gloenvcha.2011.11.004

Castleden, H., Morgan, V. S., & Lamb, C. (2012). "I spent the first year drinking tea" : Exploring Canadian university researchers' perspectives on community-based participatory research involving Indigenous peoples: Researchers' perspectives on CBPR. *The Canadian Geographer / Le Géographe Canadien*, *56*(2), 160-179. https://doi.org/10.1111/j.1541-0064.2012.00432.x

Chanteloup, L., Joliet, F., & Herrmann, T. M. (2018). The environment of the Nunavimmiut as seen through their own eyes. *Écoscience*, *25*(4), 359-379. https://doi.org/10.1080/11956860.2018.1517631

Chanteloup, L., Joliet, F., & Herrmann, T. M. (2019). Learning and insights from a participatory photography project with Cree and Inuit about the land (Nunavik, Canada). *Polar Geography*, *42*(2), 125-143. https://doi.org/10.1080/1088937X.2019.1578291

Charlie, A., Proverbs, T. A., Hodgson, E. E., & Hovel, R. A. (2022). Shifting Seasons and Threats to Harvest, Culture, and Self-Identity : A Personal Narrative on the Consequences of Changing Climate. *GeoHealth*, *6*(12). https://doi.org/10.1029/2022GH000617

Cold, H. S., Brinkman, T. J., Brown, C. L., Hollingsworth, T. N., Brown, D. R. N., & Heeringa, K. M. (2020). Assessing vulnerability of subsistence travel to effects of environmental change in Interior Alaska. *Ecology and Society*, *25*(1), art20. https://doi.org/10.5751/ES-11426-250120

Collignon, B. (2003). Les toponymes inuit, mémoire du territoire : Étude de l'Histoire des Inuinnait. *Anthropologie et Sociétés*, *26*(2-3), 45-69. https://doi.org/10.7202/007048ar

Collignon, B. (2006). Recueillir les toponymes inuit. Pour quoi faire? *Études/Inuit/Studies*, *28*(2), 89-106. https://doi.org/10.7202/013198ar

Corbet, J. (2009). *Good practices in participatory mapping*. International Fund for Agricultural Development (IFAD).

Cuerrier, A., Brunet, N. D., Gérin-Lajoie, J., Downing, A., & Lévesque, E. (2015). The Study of Inuit Knowledge of Climate Change in Nunavik, Quebec : A Mixed Methods Approach. *Human Ecology*, *43*(3), 379-394. https://doi.org/10.1007/s10745-015-9750-4

Cunsolo, A., & Ellis, N. R. (2018). Ecological grief as a mental health response to climate change-related loss. *Nature Climate Change*, *8*(4), 275-281. https://doi.org/10.1038/s41558-018-0092-2

Cunsolo Willox, A., Stephenson, E., Allen, J., Bourque, F., Drossos, A., Elgarøy, S., Kral, M. J., Mauro, I., Moses, J., Pearce, T., MacDonald, J. P., & Wexler, L. (2015). Examining relationships between climate change and mental health in the Circumpolar North. *Regional Environmental Change*, *15*(1), 169-182. https://doi.org/10.1007/s10113-014-0630-z

Davis, K., Ford, J. D., Quinn, C. H., Mosurska, A., Flynn, M., IHACC Research Team, & Harper, S. L. (2022). Shifting Safeties and Mobilities on the Land in Arctic North America : A Systematic Approach to Identifying the Root Causes of Disaster. *Sustainability*, *14*(12), 7061. https://doi.org/10.3390/su14127061

Dawson, J., Carter, N. A., Van Luijk, N., Weber, M., & Cook, A. (2020). Arctic corridors and northern voices project : Methods for community-based participatory mapping for low impact shipping corridors in Arctic Canada. *MethodsX*, *7*, 101064. https://doi.org/10.1016/j.mex.2020.101064

Depaiva, A. (2018). *Understanding the Role and Value of Participatory Mapping in an Inuit Knowledge Research Context* [Master of Arts, Carleton University]. https://doi.org/10.22215/etd/2018-12620

Dubos, V., May, P., Gillis, C.-A., St-Hilaire, A., & Bergeron, N. (2023). Nunavik anadromous Arctic char life histories, behaviour, and habitat use informed by both Inuit knowledge and western science : A year in Ungava Bay. *Arctic Science*, as-2022-0019. https://doi.org/10.1139/as-2022-0019

Dufour-Beauséjour, S., & Plante Lévesque, V. (2020). Our practice of outreach during the Ice Monitoring project in Nunavik : An early-career researcher perspective. *FACETS*, *5*(1), 123-137. https://doi.org/10.1139/facets-2019-0021

Dufour-Beauséjour, S., Wendleder, A., Gauthier, Y., Bernier, M., Poulin, J., Gilbert, V., Tuniq, J., Rouleau, A., & Roth, A. (2020). Combining TerraSAR-X and time-lapse photography for seasonal sea ice monitoring : The case of Deception Bay, Nunavik. *The Cryosphere*, *14*(5), 1595-1609. https://doi.org/10.5194/tc-14-1595-2020

Ford, J. D., Bolton, K. C., Shirley, J., Pearce, T., Tremblay, M., & Westlake, M. (2012). Research on the Human Dimensions of Climate Change in Nunavut, Nunavik, and Nunatsiavut : A Literature Review and Gap Analysis. *ARCTIC*, *65*(3), 289-304. https://doi.org/10.14430/arctic4217

Ford, J. D., Clark, D. G., Copland, L., Pearce, T., IHACC Research Team, Ford, J. D., Harper, S., Ford, L. B., Carcamo, C., Garcia, P., Lwasa, S., Namanya, D., New, M., Zavaleta-Cortijo, C., & Harper, S. L. (2023). Projected decrease in trail access in the Arctic. *Communications Earth & Environment*, *4*(1), 23. https://doi.org/10.1038/s43247-023-00685-w

Ford, J. D., Clark, D., Pearce, T., Berrang-Ford, L., Copland, L., Dawson, J., New, M., & Harper, S. L. (2019). Changing access to ice, land and water in Arctic communities. *Nature Climate Change*, *9*(4), 335-339. https://doi.org/10.1038/s41558-019-0435-7

Ford, J. D., Couture, N., Bell, T., & Clark, D. G. (2018). Climate change and Canada's north coast : Research trends, progress, and future directions. *Environmental Reviews*, *26*(1), 82-92. https://doi.org/10.1139/er-2017-0027

Ford, J. D., McDowell, G., Shirley, J., Pitre, M., Siewierski, R., Gough, W., Duerden, F., Pearce, T., Adams, P., & Statham, S. (2013). The Dynamic Multiscale Nature of Climate Change Vulnerability : An Inuit Harvesting Example. *Annals of the Association of American Geographers*, *103*(5), 1193-1211. https://doi.org/10.1080/00045608.2013.776880

Ford, J. D., & Pearce, T. (2010). What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic : A systematic literature review. *Environmental Research Letters*, *5*(1), 014008. https://doi.org/10.1088/1748-9326/5/1/014008

Ford, J. D., Pearce, T., McDowell, G., Berrang-Ford, L., Sayles, J. S., & Belfer, E. (2018). Vulnerability and its discontents : The past, present, and future of climate change vulnerability research. *Climatic Change*, *151*(2), 189-203. https://doi.org/10.1007/s10584-018-2304-1

Ford, J. D., & Smit, B. (2004). A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated with Climate Change. *ARCTIC*, *57*(4), 389-400. https://doi.org/10.14430/arctic516

Ford, J. D., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusarjuat, H., & Qrunnut, K. (2008). Climate change in the Arctic : Current and future vulnerability in two Inuit communities in Canada. *The Geographical Journal*, *174*(1), 45-62. https://doi.org/10.1111/j.1475-4959.2007.00249.x

Fox, S., Qillaq, E., Angutikjuak, I., Tigullaraq, D. J., Kautuk, R., Huntington, H., Liston, G. E., & Elder, K. (2020). Connecting understandings of weather and climate : Steps towards co-production of knowledge and collaborative environmental management in Inuit Nunangat. *Arctic Science*, *6*(3), 267-278. https://doi.org/10.1139/as-2019-0010

Freeman, M. M. R. (Éd.). (1976). *Land use and occupancy*. Minister of Supply and Services Canada.

Freeman, M. M. R. (2011). Looking back-and looking ahead-35 years after the Inuit land use and occupancy project : Looking back-and looking ahead. *The Canadian Geographer / Le Géographe Canadien*, *55*(1), 20-31. https://doi.org/10.1111/j.1541-0064.2010.00341.x

Furgal, C., Lemire, M., Lévesque, B., Martin, R., & Boyd, A. (2022). *Hunting, fishing, gathering ammunition use and public health messaging* [QANUILIRPITAA? 2017, Nunavik Inuit Health Survey]. Nunavik Regional Board of Health and Social Services (NRBHSS) & Institut national de santé publique du Québec (INSPQ).

Furgal, C., Pirkle, C., Lemire, M., Lucas, M., & Martin, R. (2022). Food Security. Dans *Nunavik Inuit Health Survey 2017 Qanuilirpitaa ? How are we now?* (Quebec: Nunavik Regional Board of Health and Social Services (NRBHSS) & Institut national de santé publique du Québec (INSPQ)).

Gaudet, S., & Robert, D. (2018). *L'aventure de la recherche qualitative : Du questionnement à la rédaction scientifique*. Les Presses de l'Université d'Ottawa.

Gauthier, Y., Tremblay, M., Bernier, M., & Furgal, C. (2010). Adaptation of a radar-based river ice mapping technology to the Nunavik context. *Canadian Journal of Remote Sensing*, *36*(sup1), S168-S185. https://doi.org/10.5589/m10-018

Gearheard, S., Aporta, C., Aipellee, G., & O'Keefe, K. (2011). The Igliniit project : Inuit hunters document life on the trail to map and monitor arctic change: The Igliniit project. *The Canadian Geographer / Le Géographe Canadien*, *55*(1), 42-55. https://doi.org/10.1111/j.1541-0064.2010.00344.x

Gearheard, S., Matumeak, W., Angutikjuaq, I., Maslanik, J., Huntington, H. P., Leavitt, J., Kagak, D. M., Tigullaraq, G., & Barry, R. G. (2006). "It's Not that Simple" : A Collaborative Comparison of Sea Ice Environments, Their Uses, Observed Changes, and Adaptations in Barrow, Alaska, USA, and Clyde River, Nunavut, Canada. *AMBIO: A Journal of the Human Environment*, *35*(4), 203-211. https://doi.org/10.1579/0044-7447(2006)35%255B203:INTSAC%255D2.0.CO;2

Gearheard, S., Pocernich, M., Stewart, R., Sanguya, J., & Huntington, H. P. (2010). Linking Inuit knowledge and meteorological station observations to understand changing wind patterns at Clyde River, Nunavut. *Climatic Change*, *100*(2), 267-294. https://doi.org/10.1007/s10584-009-9587-1

Gérin-Lajoie, J., Herrmann, T. M., MacMillan, G. A., Hébert-Houle, É., Monfette, M., Rowell, J. A., Anaviapik Soucie, T., Snowball, H., Townley, E., Lévesque, E., Amyot, M., Franssen, J., & Dedieu, J.-P. (2018). IMALIRIJIIT : A community-based environmental monitoring program in the George River watershed, Nunavik, Canada. *Écoscience*, *25*(4), 381-399. https://doi.org/10.1080/11956860.2018.1498226

Gibson, C. M., Brinkman, T., Cold, H., Brown, D., & Turetsky, M. (2021). Identifying increasing risks of hazards for northern land-users caused by permafrost thaw : Integrating scientific and community-based research approaches. *Environmental Research Letters*, *16*(6), 064047. https://doi.org/10.1088/1748-9326/abfc79

Glon, É. (2012). Cartographie participative autochtone et réappropriation culturelle et territoriale : L'exemple des Lil'wat en Colombie-Britannique (Canada). *Espace populations sociétés*, (2012/1), 29-42. https://doi.org/10.4000/eps.4827

Guyot, M., Dickson, C., Paci, C., Furgal, C., & Chan, H. M. (2006). Local observations of climate change and impacts on traditional food security in two northern Aboriginal communities. *International Journal of Circumpolar Health*, *65*(5), 403-415. https://doi.org/10.3402/ijch.v65i5.18135

Haalboom, B., & Natcher, D. C. (2012). The Power and Peril of "Vulnerability" : Approaching Community Labels with Caution in Climate Change Research. *ARCTIC*, *65*(3), 319-327. https://doi.org/10.14430/arctic4219

Henri, D. A., Jean-Gagnon, F., & Gilchrist, H. G. (2018). Using Inuit traditional ecological knowledge for detecting and monitoring avian cholera among Common Eiders in the eastern Canadian Arctic. *Ecology and Society*, *23*(1), art22. https://doi.org/10.5751/ES-09289-230122

Herman-Mercer, N. M., Laituri, M., Massey, M., Matkin, E., Toohey, R., Elder, K., Schuster, P. F., & Mutter, E. (2019). Vulnerability of Subsistence Systems Due to Social and Environmental Change : A Case Study in the Yukon-Kuskokwim Delta, Alaska. *ARCTIC*, *72*(3), 258-272. https://doi.org/10.14430/arctic68867

Heyes, S. (2002). *Inuit and Scientific Ways of Knowing and Seeing the Arctic Landscape* [Master of Landscape Architecture]. Adelaide University.

Heyes, S. (2007). *Inuit Knowledge and Perceptions of the Land-Water Interface* [PhD, Department of Geography]. McGill University.

Heyes, S. A. (2011). Cracks in the knowledge : Sea ice terms in Kangiqsualujjuaq, Nunavik: Cracks in the knowledge. *The Canadian Geographer / Le Géographe Canadien*, *55*(1), 69-90. https://doi.org/10.1111/j.1541-0064.2010.00346.x

Hillemann, F., Beheim, B. A., & Ready, E. (2023). Socio-economic predictors of Inuit hunting choices and their implications for climate change adaptation. *Phil. Trans. R. Soc.*, *378*(20220395). https://doi.org/10.1098/rstb.2022.0395

IPCC. (2014). *Climate change 2014 : Impacts, adaptation, and vulnerability Working Group II contribution to the fifth assessment report of the Intergovernmental panel on climate change*. Cambridge University press.

Johnson, D. N., Van Riper, C. J., Stewart, W. P., Metzger, M. J., Oteros-Rozas, E., & Ruiz-Mallén, I. (2022). Elucidating social-ecological perceptions of a protected area system in Interior Alaska : A fuzzy cognitive mapping approach. *Ecology and Society*, *27*(3), art34. https://doi.org/10.5751/ES-13424-270334

Karetak, J., Tester, F. J., & Tagalik, S. (2017). *Inuit qaujimajatuqangit : What Inuit have always known to be true*. Fernwood Publishing. WorldCat.

Koster, R., Baccar, K., & Lemelin, R. H. (2012). Moving from research ON, to research WITH and FOR Indigenous communities : A critical reflection on community-based participatory research. *Canadian Geographies / Géographies Canadiennes*, *56*(2), 195-210. https://doi.org/10.1111/j.1541-0064.2012.00428.x

Kovach, M. (2021). *Indigenous methodologies : Characteristics, conversations, and contexts* (Second edition, 1 online resource (xii, 313 pages) : illustrations). University of Toronto Press. WorldCat.

Krupnik, I., Aporta, C., Gearheard, S., Laidler, G. J., & Kielsen Holm, L. (2010). *SIKU : Knowing Our Ice : Documenting Inuit sea ice knowledge and use* (Springer).

Laidler, G. J. (2007). *Ice, Through Inuit Eyes : Characterizing the importance of sea ice processes, use, and change around three Nunavut communities* [PhD thesis]. University of Toronto.

Laidler, G. J., Elee, P., Ikummaq, T., Joamie, E., & Aporta, C. (2010). Mapping Inuit Sea Ice Knowledge, Use, and Change in Nunavut, Canada (Cape Dorset, Igloolik, Pangnirtung). Dans *SIKU: Knowing Our Ice* (p. 45-80). Springer.

Laidler, G. J., Ford, J. D., Gough, W. A., Ikummaq, T., Gagnon, A. S., Kowal, S., Qrunnut, K., & Irngaut, C. (2009). Travelling and hunting in a changing Arctic : Assessing Inuit vulnerability to sea ice change in Igloolik, Nunavut. *Climatic Change*, *94*(3-4), 363-397. https://doi.org/10.1007/s10584-008-9512-z

Lamalice, A., Herrmann, T. M., Rioux, S., Granger, A., Blangy, S., Macé, M., & Coxam, V. (2020). Imagined foodways : Social and spatial representations of an Inuit food system in transition. *Polar Geography*, *43*(4), 333-350. https://doi.org/10.1080/1088937X.2020.1798541

Lebel, L., Paquin, V., Kenny, T.-A., Fletcher, C., Nadeau, L., Chachamovich, E., & Lemire, M. (2022). Climate change and Indigenous mental health in the Circumpolar North : A systematic review to inform clinical practice. *Transcultural Psychiatry*, *59*(3), 312-336. https://doi.org/10.1177/13634615211066698

Lertzman, D. (2006). Rapprocher le savoir écologique traditionnel et la science occidentale dans la gestion durable des forêts : Le cas de la Commission scientifique Clayoquot. *Recherches amérindiennes au Québec*, *36*(2-3), 43. https://doi.org/10.7202/1081855ar

Lertzman, D. (2010). Best of two worlds : Traditional ecological knowledge and Western science in ecosystem-based management. *BC Journal of Ecosystems and Management*, *10*(3), 25.

Lévesque, F. (2008). *Les Inuit, leurs chiens et l'administration nordique, de 1950 à 2007* [Thèse de doctorat]. Université Laval.

Lévesque, F. (2011). Le contrôle des chiens dans trois communautés du Nunavik au milieu du 20e siècle. *Études/Inuit/Studies*, *34*(2), 149-166. https://doi.org/10.7202/1004074ar

Lévesque, F. (2014). Revisiting Inuit Qaujimajatuqangit : Inuit knowledge, culture, language, and values in Nunavut institutions since 1999. *Inuit Studies*, (38). https://doi.org/10.7202/1028856ar

L'Hérault, E., & Allard, M. (2018). *Production de la 2ième approximation de la carte de pergélisol du Québec en fonction des paramètres géomorphologiques, écologiques, et des processus physiques liés au climat.* (p. 61) [Rapport final Réalisé pour le compte du Ministère des Forêts, de la Faune et des Parcs, Gouvernement du Québec.]. Centre d'études nordiques, Université Laval.

Losey, R. J., Wishart, R. P., & Loovers, J. P. L. (2018). *Dogs in the North : Stories of Cooperation and Co-Domestication* (R. J. Losey, R. P. Wishart, & J. P. L. Loovers, Éds.; 1re éd.). Routledge. https://doi.org/10.4324/9781315437736

MacMillan, G., Badry, N., Sarmiento, I., Grant, E., Hickey, G., & Humphries, M. (2024). Cree knowledge, fuzzy cognitive maps, and the social-ecology of moose habitat quality under an adapted forestry regime. *Ecology and Society*, *29*(4), art34. https://doi.org/10.5751/ES-15508-290434

Makivvik. (2015). *Parnasimautik*. Parnasimautik. https://parnasimautik.com/

Makivvik. (2021). *Kangiqsualujjuaq*. Kangiqsualujjuaq. https://www.makivik.org/kangiqsualujjuaq/

Makivvik. (2024). *Nunavik Climate Change Adaptation Strategy*. Department of Environment, Wildlife and Research (DEWR), Makivvik.

Marginson, H., MacMillan, G. A., Grant, E., Gérin-Lajoie, J., & Amyot, M. (2023). Rare earth element bioaccumulation and cerium anomalies in biota from the Eastern Canadian subarctic (Nunavik). *Science of The Total Environment*, *879*, 163024. https://doi.org/10.1016/j.scitotenv.2023.163024

Marginson, H., MacMillan, G. A., Wauthy, M., Sicaud, E., Gérin-Lajoie, J., Dedieu, J.-P., & Amyot, M. (2024). Drivers of rare earth elements (REEs) and radionuclides in changing subarctic (Nunavik, Canada) surface waters near a mining project. *Journal of Hazardous Materials*, *471*, 134418. https://doi.org/10.1016/j.jhazmat.2024.134418

Mcboyle, G., Scott, D., & Jones, B. (2007). Climate change and the future of snowmobiling in non-mountainous regions of Canada. *Managing Leisure*, *12*(4), 237-250. https://doi.org/10.1080/13606710701546868

Müller-Wille, L. (1987). Gazetteer of Inuit place names in Nunavik (Quebec, Canada). *Inukjuak, Avataq Cultural Institute*.

Natcher, D., Shirley, S., Rodon, T., & Southcott, C. (2016). Constraints to wildlife harvesting among aboriginal communities in Alaska and Canada. *Food Security*, *8*(6), 1153-1167. https://doi.org/10.1007/s12571-016-0619-1

Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people's knowledge : A multi-step fuzzy cognitive mapping approach. *Ecological Modelling*, *176*(1-2), 43-64. https://doi.org/10.1016/j.ecolmodel.2003.10.027

Palsky, G. (2013). Cartographie participative, cartographie indisciplinée: *L'Information géographique*, *Vol. 77*(4), 10-25. https://doi.org/10.3917/lig.774.0010

Pearce, T., Ford, J., Willox, A. C., & Smit, B. (2015). Inuit Traditional Ecological Knowledge (TEK) Subsistence Hunting and Adaptation to Climate Change in the Canadian Arctic. *ARCTIC*, *68*(2), 233. https://doi.org/10.14430/arctic4475

Pearce, T., Smit, B., Duerden, F., Ford, J. D., Goose, A., & Kataoyak, F. (2010). Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. *Polar Record*, *46*(2), 157-177. https://doi.org/10.1017/S0032247409008602

Pedersen, C., Otokiak, M., Koonoo, I., Milton, J., Maktar, E., Anaviapik, A., Milton, M., Porter, G., Scott, A., Newman, C., Porter, C., Aaluk, T., Tiriraniaq, B., Pedersen, A., Riffi, M., Solomon, E., & Elverum, S. (2020). ScIQ : An invitation and recommendations to combine science and Inuit Qaujimajatuqangit for meaningful engagement of Inuit communities in research. *Arctic Science*, *6*(3), 326-339. https://doi.org/10.1139/as-2020-0015

Peters, E. J. (1999). Native People and the Environmental Regime in the James Bay and Northern Québec Agreement. *ARCTIC*, *52*(4), 395-410. https://doi.org/10.14430/arctic944

Pratt, K., & Heyes, S. A. (2022). *Memory and Landscape : Indigenous Responses to a Changing North*. Athabasca University Press.

Prno, J., Bradshaw, B., Wandel, J., Pearce, T., Smit, B., & Tozer, L. (2011). Community vulnerability to climate change in the context of other exposure-sensitivities in Kugluktuk, Nunavut. *Polar Research*, *30*(1), 7363. https://doi.org/10.3402/polar.v30i0.7363

Rantanen, M., Karpechko, A. Yu., Lipponen, A., Nordling, K., Hyvärinen, O., Ruosteenoja, K., Vihma, T., & Laaksonen, A. (2022). The Arctic has warmed nearly four times faster than the globe since 1979. *Communications Earth & Environment*, *3*(1), 168. https://doi.org/10.1038/s43247-022-00498-3

Rapinski, M., Payette, F., Sonnentag, O., Herrmann, T. M., Royer, M.-J. S., Cuerrier, A., Siegwart Collier, L., Hermanutz, L., & Guanish, G. (2018). Listening to Inuit and Naskapi peoples in the eastern Canadian Subarctic : A quantitative comparison of local observations with gridded climate data. *Regional Environmental Change*, *18*(1), 189-203. https://doi.org/10.1007/s10113-017-1188-3

Ready, E., & Collings, P. (2021). "All the problems in the community are multifaceted and related to each other" : Inuit concerns in an era of climate change. *American Journal of Human Biology*, *33*(4), e23516. https://doi.org/10.1002/ajhb.23516

Reid, A. J., Eckert, L. E., Lane, J., Young, N., Hinch, S. G., Darimont, C. T., Cooke, S. J., Ban, N. C., & Marshall, A. (2021). "Two-Eyed Seeing" : An Indigenous framework to transform fisheries research and management. *Fish and Fisheries*, *22*(2), 243-261. https://doi.org/10.1111/faf.12516

Riedlsperger, R. (2014). *Vulnerability to changes in winter trails and travelling : A case study from Nunatsiavut*. Department of Geography/Faculty of Arts,Memorial University of Newfoundland.

Sarmiento, I., Cockcroft, A., Dion, A., Belaid, L., Silver, H., Pizarro, K., Pimentel, J., Tratt, E., Skerritt, L., Ghadirian, M. Z., Gagnon-Dufresne, M.-C., & Andersson, N. (2024). Fuzzy cognitive mapping in participatory research and decision making : A practice review. *Archives of Public Health*, *82*(1), 76. https://doi.org/10.1186/s13690-024-01303-7

Sarrazin, D., & Allard, M. (2024). *Climate station data from the Kangiqsualujjuaq region in Nunavik, Quebec, Canada (1988-2023).* (Nordicana D14; Version 1.5.0) [Dataset]. https://doi.org/10.5885/45264SL-AF7FDA53F9E44927

Saulnier-Talbot, É., Duchesne, É., Antoniades, D., Arseneault, D., Barnard, C., Berteaux, D., Bhiry, N., Bouchard, F., Boudreau, S., Cazelles, K., Comte, J., Corbeil-Robitaille, M.-Z., Côté, S. D., Couture, R.-M., De Lafontaine, G., Domine, F., Fauteux, D., Fortier, D., Garneau, M., … Bêty, J. (2024). Expert elicitation of state shifts and divergent sensitivities to climate warming across northern ecosystems. *Communications Earth & Environment*, *5*(1), 624. https://doi.org/10.1038/s43247-024-01791-z

Sicaud, E., Fortier, D., Dedieu, J.-P., & Franssen, J. (2024). Pairing remote sensing and clustering in landscape hydrology for large-scale change identification : An application to the subarctic watershed of the George River (Nunavik, Canada). *Hydrology and Earth System Sciences*, *28*(1), 65-86. https://doi.org/10.5194/hess-28-65-2024

Simonee, N., Alooloo, J., Carter, N. A., Ljubicic, G., & Dawson, J. (2021). Sila qanuippa? (How's the weather?): Integrating Inuit Qaujimajatuqangit and environmental forecasting products to support travel safety around Pond Inlet, Nunavut in a changing climate. *Weather, Climate, and Society*. https://doi.org/10.1175/WCAS-D-20-0174.1

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, *16*(3), 282-292. https://doi.org/10.1016/j.gloenvcha.2006.03.008

Smith, L. T. (2012). *Decolonizing methodologies : Research and indigenous peoples* (Second edition). Zed books. WorldCat.

Statham, S., Ford, J., Berrang-Ford, L., Lardeau, M.-P., Gough, W., & Siewierski, R. (2015). Anomalous climatic conditions during winter 2010–2011 and vulnerability of the traditional Inuit food system in Iqaluit, Nunavut. *Polar Record*, *51*(3), 301-317. https://doi.org/10.1017/S0032247414000151

Statistics Canada. (2021). *Focus on Geography Series, 2021 Census—Kangiqsualujjuaq*. https://www12.statcan.gc.ca/census-recensement/2021/as-sa/fogs-spg/page.cfm?lang=E&topic=1&dguid=2021A00052499090

St-Onge, P. (1996). *Transport et mobilité des résidants du village de Kangiqsualujjuaq (Nunavik) : Le cas de la motoneige* [Maîtrise en géographie]. McGill University.

Tratt, E., Sarmiento, I., Gamelin, R., Nayoumealuk, J., Andersson, N., & Brassard, P. (2020). Fuzzy cognitive mapping with Inuit women : What needs to change to improve cervical cancer screening in Nunavik, northern Quebec? *BMC Health Services Research*, *20*(1), 529. https://doi.org/10.1186/s12913-020-05399-9

Tremblay, M., Furgal, C., Larrivée, C., Annanack, T., Tookalook, P., Qiisik, M., Angiyou, E., Swappie, N., Savard, J.-P., & Barrett, M. (2008). Climate Change in Northern Quebec : Adaptation Strategies from Community-Based Research. *ARCTIC*, *61*(5), 27-34. https://doi.org/10.14430/arctic99

Tremblay, M., Furgal, C., Larrivée, C., Savard, J.-P., Barrett, M., Annanack, T., Enish, N., & Etidloie, B. (2006). Communities and Ice : Bringing Together Traditional and Scientific Knowledge. *"Climate Change: Linking Traditionnal and Scientific Knowledge" Edited by Rick Riewe and Jill Oakes. Aboriginal Issues Press. University of Manitoba.*, 289 p.

Veilleux, S., Decaulne, A., & Bhiry, N. (2021). Snow cornice and snow avalanche monitoring using automatic time lapse cameras in Tasiapik Valley, Nunavik (Québec) during the winter of 2017–2018. *Arctic Science*, *7*(4), 798-812. https://doi.org/10.1139/as-2020-0013

Watt-Cloutier, S. (2016). *The Right To Be Cold : One Woman's Story of Protecting Her Culture, the Arctic and the Whole Planet*. Penguin Canada.

Wenzel, G. W. (2004). From TEK to IQ : Inuit Qaujimajatuqangit and Inuit Cultural Ecology. *Arctic Anthropology*, *41*(2), 238-250. https://doi.org/10.1353/arc.2011.0067

Wenzel, G. W. (2009). Canadian Inuit subsistence and ecological instability—If the climate changes, must the Inuit? *Polar Research*, *28*(1), 89-99. https://doi.org/10.1111/j.1751-8369.2009.00098.x

Wilson, K. J., Arreak, A., Itulu, J., Ljubicic, G. J., Bell, T., & Giguère, N. (2021). "When We're on the Ice, All We Have is Our Inuit Qaujimajatuqangit" Mobilizing Inuit Knowledge as a Sea Ice Safety Adaptation Strategy in Mittimatalik, Nunavut. *Arctic*, *74*(4), 525-549. JSTOR Arts & Sciences IX Collection.

yWorks. (2025, décembre). *yEd Graph Editor*. https://www.yworks.com/products/yed

Ziegler, J. A., Lantz, T. C., Overeem, T., Proverbs, T. A., Lord, S., Aklavik Hunters and Trappers Committee, Gwich'in Tribal Council Department of Culture and Heritage, & Inuvik Hunters and Trappers Committee. (2024). "All the rivers we used to travel by" : Indigenous knowledge of hydrological change and its impacts in the Mackenzie Delta Region, Canada. *Regional Environmental Change*, *24*(2), 66. https://doi.org/10.1007/s10113-024-02209-4

ANNEXE A

GUIDE D’ENTREVUES

INTERVIEW AND PARTICIPATORY MAPPING GUIDE

We are researchers working on the snow quality and climate change impacts on winter activities around the northern village of Kangiqsualujjuaq. In this 60 min. interview, we will discuss the experience and observations of individuals who hunt and travel on the land during the winter season in your community. Our focus will be on changes associated with winter travel and activities and their consequences.

OPENING

1. What does winter mean to you ?

PART 1: AREAS USED FOR WINTER ACTIVITIES, TRAVELING CONDITIONS

In this part, I want to learn about the activities you do in winter and where you practice them.

2. How often do you go out on the land in winter?
3. What are the main activities you do when you go out on the land in winter (hunting, fishing, trapping, or other activities)? Can you show areas that are important for your activities on the map?

PART 2: CHANGES IN THE WINTER ACTIVITIES AND SAFETY

In this part, I want to learn more about the changes and your experience traveling in your lifetime.

4. Do you think traveling on the land in winter changed during your lifetime? If so, how? And how does it compare to your parent’s experience?
5. Have you ever had to cancel a trip because of bad weather conditions? Have you ever gotten stuck while traveling? How long were you stuck and how did you cope with it?

6. Have any areas become more dangerous to travel? Why are they dangerous? Can you show them on the map? When is it mostly dangerous?
7. How do you predict good winter conditions for traveling? Are there any parameters you use to evaluate travel conditions during the winter?
8. What specific weather forecast data and tools do you think you would need for safer travels (e.g. Information on ice thickness, wind direction, and speed)?

PART 3: IMPACTS OF THE CHANGES, SOLUTIONS OR BARRIERS

In this part, I want to learn more about the impact of the changes in winter traveling on your life.

9. Does winter travel conditions have an impact on your country food access? Have you ever had to buy more food from the store, because the trails were not in good condition and harvest was not sufficient ? Which month/season was this? How has this changed over time?
10. Does winter travel conditions have an impact on the amount of fuel you buy to go to the same place? If so, how?
11. Does winter travel conditions have an impact on the equipment you buy?
12. Are you satisfied with the amount of time you spend on the land? Do you wish you could spend more time? What would have to change? How does it make you feel?
13. How did you learn about winter travel routes and hunting areas? How do youth (18-30 years old) learn about winter travel routes and hunting areas today?

Nakurmiik! This project has been funded by ArcticNet and Polar Knowledge Canada. It has been approved by Université du Québec à Trois-Rivières Ethics Committee. Licence number: CER-21-273-07.21

ANNEXE B

LIVRET DESTINÉ À LA COMMUNAUTÉ

REPORT

CHANGES IN WINTER TRAVEL AND HARVESTING ACTIVITIES IN KANGIQSUALUJJUAQ

March 2025

Université du Québec à Trois-Rivières

POLAR POLAIRE

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Université du Québec à Trois-Rivières

POLAR POLAIRE

About the project

In recent years, Kangiqsualujjuamiut and Nunavimmiut have expressed concerns regarding their access to land and travel, particularly during the winter months (Gérin-Lajoie et al. 2016, Tremblay et al. 2008). Changes in ice and snow conditions are compromising the safety of hunters navigating the trails.

This research is part of the **Caring for our River** initiative, mainly funded by Polar Knowledge Canada. It's a collaborative project co-developed by university researchers and the community of Kangiqsualujjuaq. This report focuses on the second component of the project, which aims to assess landscape and land use changes (part of Anne-Laure Morin MSc).

What we did

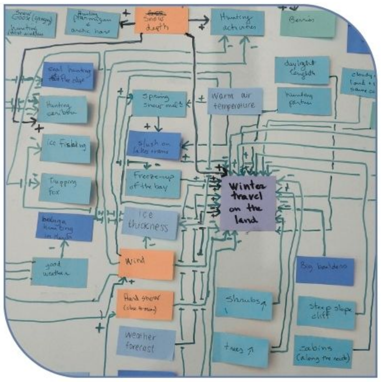


Figure 1 : Example of a knowledge map

Map of knowledge

In a first workshop, participants engaged in discussions and shared experiences about the various factors that influence "winter travel on the land" in February 2023. These factors, represented by colorful sticky notes, were connected and organized on a whiteboard to illustrate their relationships.

Figure 2 : Example of participatory mapping workshop

Participatory mapping

The second workshop took place in December 2023 and involved participants, either in duo or individually. They worked with large maps to mark their harvesting sites and draw trails, all while answering guided questions. Maps were produced with the information and were shared with local organisations.

Participants

A total of 19 community members, including Elders and hunters who regularly travel on the land during winter, participated in the study.

Knowledge maps	Participatory mapping	Both	Total
14	10	5	19

Results

This word cloud (Figure 3) highlights the 30 more frequently mentioned themes in the verbatims from the workshops and interviews with the community, such as snow, ice, hunting and caribou.

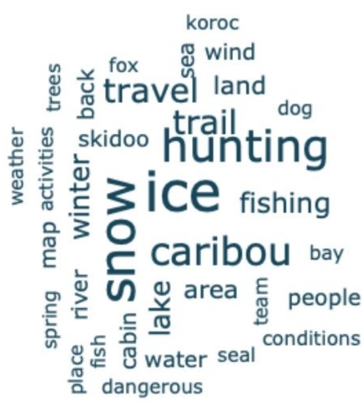


Figure 3 : Word cloud of all the interviews and workshops

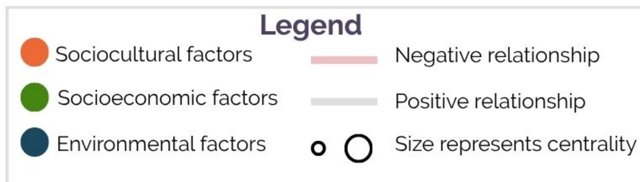
In the next section, a collective knowledge map follows and offers a visual representation of the elements to consider when traveling on the land (Figure 4). Afterwards, a table summarizes participants' observations of changes in the environment in winter (Table 1). Finally, adaptation strategies that are being implemented, or suggested by participants are detailed below.

These results were presented for validation in Kangiqsualujjuaq on two occasions, including at the Parnasimautik assembly in March 2025.

Map of Knowledge

The map (Figure 4) illustrates the combined exercises of two groups, who identified what might affect their ability to travel on the land in winter. The 61 different factors mentioned by participants were then grouped into the following categories : sociocultural, socioeconomic or environmental factors. Among them, four factors stood out for having the most outward connections to other factors and were considered to be drivers of change : Wind, Spring snowmelt, Snow depth and Ice layers in snow.

The size of the circles indicates the importance of the factors, as determined by the number of connections that they have with other elements.



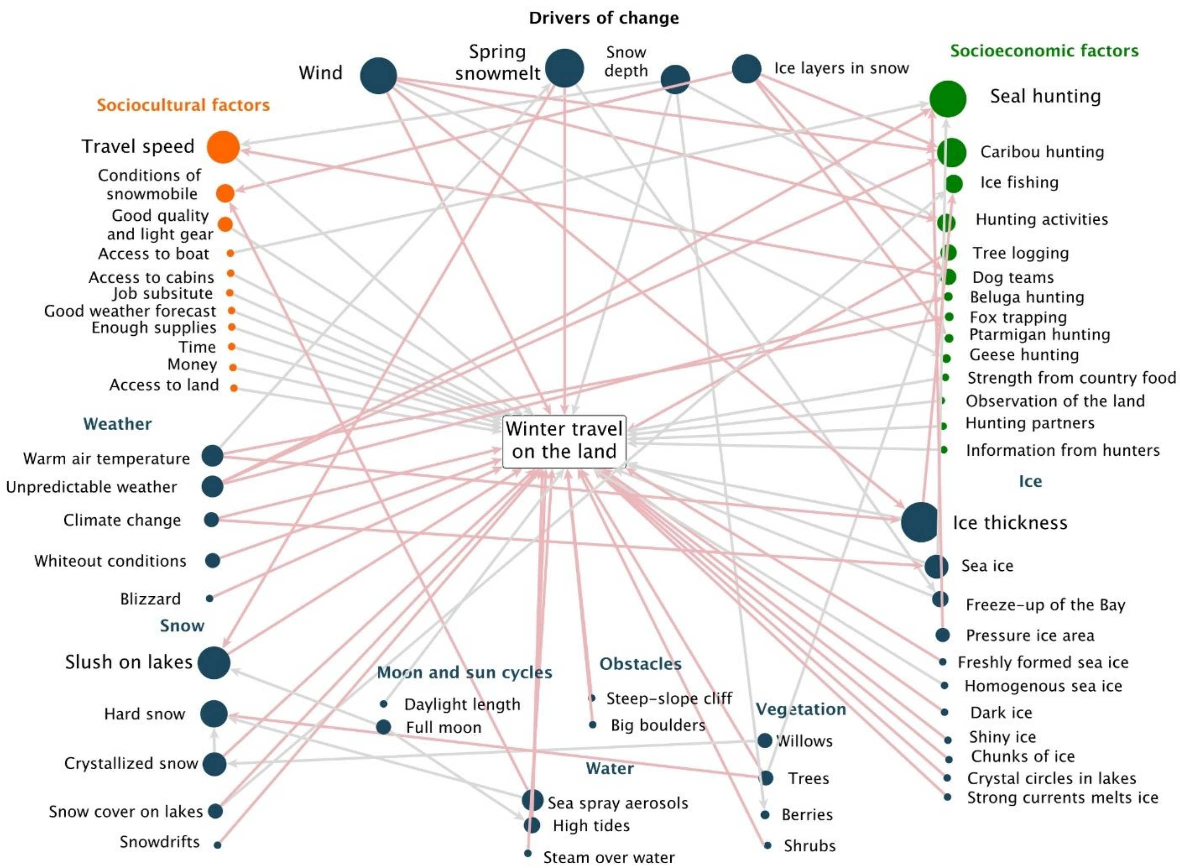


Figure 4. Factors affecting winter travel in the context of environmental change

Observations of changes

SNOW, WATER & ICE

Table 1a. Observations and impacts of environmental changes in Kangiqsualujjuaq

Observation	Impact	Knowledge holder's voice
Snow		
Shorter winter	Multiple (e.g. harvesting season, wellbeing)	"In the end of April, we can lose the snow in one day now. We never used to see that. It used to be a nice long May." "Climate change has had a great impact on our traveling on the land, because in October 1990, we used to be able to go on skidoo"
Softer snow	Difficult igloo building	"About 15 years ago, the snow suddenly changed. It used to be all hard, all solid. In one winter, it was all crystals. (...) After that, the snow was always soft. We are not able to make snow blocks for igloo or tent blocks."
	Improved skiing conditions	"My friend told me that, [in] 2000, it's the first time he noticed snow was more powdery. Now, it's like heaven, skiing on powder snow."
Less snowdrifts	Smoother travel Harder for navigation	"Nowadays, we see less *qimutjuk* (snow drifts), those very long snowdrifts. They used to be very hard to ride on. Maybe this year there will be some".
Water and ice		
Shorter ice season	Increased search and rescue operations	"It's different now. It's hard to describe. A long time ago, it used to freeze up real fast, but now, global warming is affecting the freeze up, by slowing it down. Right now, maybe in January or February, sea ice is going to freeze."
Warmer seawater	Northward expansion of aquatic species	"Our salt water is getting warmer and animals that usually live in the south are moving further north. We even saw a great white shark in Killiniq."

WEATHER, VEGETATION, ANIMALS AND SOCIETY

Table 1b. Observations and impacts of environmental changes in Kangiqsualujjuaq

Observation	Impact	Knowledge holder's voice
Weather		
Unpredictable weather	Multiple (more complex decision-making, food access)	"If it rains in winter, the rain will freeze and the caribou will not be able to find their food, lichen."
More wind		"When I was a kid, winter was nice and steady, now it has a lot of wind. The weather is more unpredictable."
Vegetation		
More willows	Softer snow texture	"Since there are a lot of willows now, the snow is mostly soft. It used to be harder but (...), it's like *pukak* (crystallized snow) everywhere.''
Animals		
Flight patterns of birds	Potential hunting opportunities	"In the last years, snow geese are changing their flying pattern and coming more north."
Northward expansion of species		"Black bears are moving further north." "I heard there was a moose sighted in Kuujjuaq River."
Society		
Generations, weather	Inuit way of living	"It changed a lot, our way of living. By weather and across generations.''

Adaptation Strategies

IMPROVING SAFETY AND TRANSPORT

Change in transportation mode
Shifting from a snowmobile to an alternative transport mode (eg. boat, airplane, etc.)

"In the spring, when we want to go fishing, we're using helicopters and airplanes these days, because the route to fishing spot is already melted and it's not accessible."

Sharing resources and equipment
Collaborating to share tools and resources to improve accessibility and reduce costs

"If the hunters are short on gas, there is some available [on land]. (...) We're sharing. If they can afford it, they will return what they were using. It's part of our way of life."

Trail visibility
Installing markers on the land for navigation (e.g. reflectors, trees, *inukshuk*)

"The reflectors are main points, because some Inuit don't have good observation. They're just zooming on the trail. (...) And they're only looking for colored reflectors."

Traditional and alternative trails
Knowing when to use traditional trails or alternative trails depending on environmental conditions

"If there's water flowing, and you have to cross the river, there's an alternative route."

SHARING INFORMATION

Devices
Having access to a device, such as a GPS or a phone

"Nowadays, I would not travel without my device"

"When we say the ice condition in the spring is not safe, we have a public announcement that [says] it's no longer accessible."

Communication tools for warning
Public announcement (radio, Facebook) to inform the public about dangers

Data availability
Improving weather forecasts, community-based monitoring of ice and snow conditions

"I think there should be some website for youth to get information about snow conditions and ice formation. It should be public."

"Growing up, with my father's knowledge (...). He was teaching me: we can go on this route, but here's an alternative route. It's longer, but it's more safe (...)."

Intergenerational knowledge transfer
Sharing skills and knowledge with younger generations (e.g. navigation, landscape, animals, hazards, etc.)

Conclusion

This project illustrates the interconnexions of environmental, social, and economic factors and how they affect travel and hunting practices. Participants identified several changes in the winter landscape, including a shortened snow season, delayed ice formation, changes in snow texture, shifting snowdrifts, and unpredictable weather. Finally, a variety of strategies and methods, both already being employed and newly suggested, have been noted to improve access to land and travel safety.

By documenting these changes in collaboration with the community, we hope to provide insights for decision-makers and contribute to future research, such as improving models for safer travels in winter.

Key lessons

- The winter season favors a large number of land-based activities, yet this season is strongly affected by actual changes.
  - More research is needed on transitional periods (spring, fall) to better understand these changes.
- Improving resilience and adaptation capacities is essential.
- Knowledge maps can promote co-production of knowledge (Local & scientific knowledge).
- Community-based monitoring should be prioritized.
  - Information and research must be brought back to communities.

Thank you!

We are extremely grateful to all of the participants who shared their knowledge and ideas with us, especially to our interpreter Sophie Keelan.

Claude St-Aubin	David Snowball	Elijah Kelly Annanack
Felix St-Aubin	Henry Ittulak	Jack Annanack
Jaiku Arnatuk	Jamie Annanack	Kenny Arnatuk
Leevan Etok	Lucassie A. Etok	Nedlidd Annanack
Sammy Unatweenuk	Sarah-Pacha Annanack	Susie Morgan
Tommy Assevak	Tommy Unatweenuk	Tuumasi Annanack

This research was approved by the Ethics Commitee of Université du Québec à Trois-Rivières (CER-21-273-07.05). Thanks to all funding organizations who made this project possible :

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Cover pages : José Gérin-Lajoie, 2023
Page 1 : Pexels.com
Page 2 : Anne-Laure Morin, 2023

References

Gérin-Lajoie, José, Alain Cuerrier, and Laura Siegwart Collier. 2016. "The Caribou taste different now: Inuit Elders Observe Climate Change." Nunavut Arctic College Media.

Tremblay, Martin, Christopher Furgal, Caroline Larrivée, Tuumasi Annanack, Peter Tookalook, Markusi Qiisik, Eli Angiyou, Noah Swappie, Jean-Pierre Savard, et Michael Barrett. 2008. « Climate Change in Northern Quebec: Adaptation Strategies from Community-Based Research ». ARCTIC 61 (5): 27-34.