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Rich local knowledge despite high transience in an Arctic community experiencing rapid environmental change

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Environmental monitoring and long-term research produce detailed understanding, but its collective effort does not add up to 'the environment' and therefore may be difficult to relate to. Local knowledge, by contrast, is multifaceted and relational and therefore can help ground and complement scientific knowledge to reach a more complete and holistic understanding of the environment and changes therein. Today's societies, however, are increasingly fleeting, with mobility potentially undermining the opportunity to generate rich community knowledge. Here we perform a case study of High Arctic Svalbard, a climate change and environmental science hotspot, using a range of community science methods, including a Maptionnaire survey, focus groups, interviews and cognitive mapping. We show that rich local knowledge on Svalbard could indeed be gathered through community science methods, despite a high level of transience of the local population. These insights complement environmental monitoring and enhance its local relevance. Complex understanding of Svalbard's ecosystems by the transient local community arose because of strong place attachment, enabling environmental knowledge generation during work and play. We conclude that transience does not necessarily prevent the generation of valuable local knowledge that can enrich and provide connection to scientific understanding of the environment.

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Introduction

Given the profound changes of natural environments around the world, environmental monitoring is more urgent than ever (IPCC 2022). Investments made to capture both current environmental states and changes over time are therefore substantial (Nygård et al. 2016; Caughlan and Oakley 2001). However, environmental monitoring is costly and thus can only be conducted in a limited number of localities (Lovett et al. 2007). Moreover, it typically concerns highly specific parameters and therefore lacks the more subjective understanding that fosters interpreting, relating and responding to change (Krupnik 2018). Its reliance on having to continue specific sets of measurements may also limit connecting to emerging societal needs (Wheeler et al. 2019).

Local knowledge, or local ecological knowledge, is knowledge gained through extensive personal observation and interaction with local environments (Lennert 2017). This knowledge, often shared within local communities, is the backbone and first step towards traditional knowledge about the relationship of living beings (including humans) with one another and with their environment (Pilgrim et al. 2008; Berkes 2009; Lennert 2017). Through time it gives rise to a cumulative body of knowledge, practices and beliefs, which evolves through adaptive processes and is handed down through generations by culturally embedded communication (Collignon 2006).

Local knowledge is closely related to traditional ecological knowledge (TEK), a rich place-based resource in many indigenous cultures where local land is seen as a knowledge source. TEK is increasingly being captured for inclusion in environmental monitoring and management, notably in parts of the Arctic (Kim et al. 2017)—in the world's most rapidly warming biome—with international communities attempting to institutionalise participation and inclusion of other ways of knowing in scientific knowledge production concerning climate and wider environmental change. In some places, like the Canadian territories, inclusion of TEK in monitoring even happens by default, as it is core to the wildlife co-management mandate (Peacock et al. 2020). However, the localness of TEK, as well as using local knowledge as a notion in opposition to global knowledge, has been seen as intending to keep the 'local local', thus othering local knowledge (Alsop and Fawcett 2010). It is therefore argued that we need to reconfigure the notion of place to reflect indigenous perspectives of time and space, giving TEK (and Indigenous Knowledge) a more definite status (Thompson et al. 2020). Moreover, local knowledge in many other Arctic regions continues to be ignored (Huntington et al. 2019), particularly in those parts that lack indigenous populations. In such locations the knowledge held by inhabitants is rarely captured, let alone integrated with knowledge from formal scientific monitoring and long-term research.

It is not only the climate and natural environments that are changing, but also societies including how people move, live and connect. Some call this dynamic of mobility, migration and socio-spatial interconnectedness 'translocality' (Greiner and Sakdapolrak 2013), a concept connecting various locales through a global mobility perspective. This can challenge what defines a community and thereby the prevailing perception of "community science" being based on residential location—a localist perspective (Gurney et al. 2017). Conceptualisations like these can be contested in a more connected world, changing the way humans move, settle, live, connect and explore. Gurney et al. (2017) therefore pleaded that researchers let go of rigid assumptions about place attachment, promoting a more "geographically flexible" picture of home. We ask whether such a reconceptualisation away from a localist perspective (Gurney et al. 2017) may render knowledge of people acquired through

more transient ways of bonding with places suitable for community science.

Historically, it has been common for place theorists to marginalise the experience and knowledge of 'transients' (Scherzer et al. 2020). The assumption has been that transient communities and mobile people do not develop strong attachments to their temporary residence. But place attachment theory can redefine not only the understanding of community, but also contest that mobility weakens ties and attachment to places. For example, Lash and Urry (1994) and Tuan (1980) state that mobility may actually foster greater attachment to a place because people choose places that best suit them. Place attachment is defined as the bonds people form with places and the meaning they ascribe to them. These can be of instrumental value such as achieving a desired goal or fulfilling a dream (Gurney et al. 2017). Out-of-doors experiences can play an important role as the time invested may allow for personal meanings to develop (Hutson et al. 2010). Theorists indicate that cultivating relationships with outdoor settings can also lead to heightened environmental awareness and yet stronger attachment. Learning to know and attribute value to what started off as undifferentiated 'space' allows it to evolve into 'place'. Place attachment has the potential to shape attitudes, identities, and quality of life, and thus to be an important element of human well-being (Hutson et al. 2010). Intensified interaction and relationship with a place may shape valuation of change and create "communities" that share place-based bonds, fostering a collective action, values and understanding (Williams and Vaske 2002). Within such communities' unique pools of knowledge may form.

As Scherzer et al. (2020) notes, references to location, geographical defined area and habitat have been of fundamental importance in conceptualisations of community since at least the early twentieth century. A conventional view on community is that of a group of people living in a common location or distinct geographical area, sharing a set of norms and values, interacting regularly (face-to-face), and acting collectively to achieve common goals and address common problems (Agrawal and Gibson 1999). However, in our interconnected world, such a conceptualisation risks losing knowledge, especially given the trans-locality and the way people 'now-a-days' move, live, connect and interact with their environments. A more holistic view of people's relationships to place should include how mobility, bonds, well-being and relations influence our experiences of place, identity-making, attachment to, and not the least a sense of community (Manzo and Perkins 2006). This place attachment and sense of community (built up by transient communities) play a significant role in emotional (Altman and Low 1992), connections with place and common responsibility (Brown et al. 2003), which could include contributing to community science initiatives.

Here, we investigate whether community science can play a role in highlighting value and connecting different knowledge systems. Community science—often used interchangeably with citizen science but indicating more inclusive practices such as community-based monitoring and community-based participatory research—is seen as "bridging the gap between science and practice with community-centred models" (Wandersman 2003), and "expanding the impact of citizen science" (Bonney 2021). Here, we use it as an umbrella term that has the potential to enrich science and monitoring through broadening research perspectives, help communities respond to their pressing challenges and identify what research is truly relevant for local communities. Taking community science and knowledge co-production into the arena of environmental monitoring, Eicken et al. (2021) suggest that indigenous knowledge can bridge and mediate between the observing or monitoring done by large-scale

scientific programmes and monitoring originated, implemented and managed at the local community level (Commodore et al. 2017). We believe that all types of knowledge, be this Indigenous, Traditional, local, 'transient' or scientific, are reliant on experiential processes, which include intuitive and logical thinking, empirical and experimental approaches, cognitive elements such as observing, inferring and predicting, and connect to 'place' (Lennert 2017). We therefore ask whether and how personal experiences and narratives in a place without indigenous population and subject to a high level of transience can enrich and contextualise environmental monitoring.

Focal geography

We focus on the Norwegian archipelago of Svalbard (Fig. 1), which is located in the High Arctic. Svalbard is a climate change hotspot, making it a buzzing centre of activity for polar and global

environmental research spanning all realms of the Earth (i.e., lithosphere, biosphere, hydrosphere and atmosphere). The rate of global warming in Svalbard is four times higher than the rest of the world (Hanssen-Bauer et al. 2019) and is growing at a faster pace than anywhere else (Descamps et al. 2017; Urbański and Litwicka 2022)—these changes are happening in a single person's lifetime. The importance of the fate of the Arctic and the global impacts of Arctic change are underscored in comprehensive international monitoring and assessment reports (e.g., AMAP 2021).

Svalbard has a long history of human use and habitation, yet it lacks indigenous communities steeped in traditions and rich knowledge of human-nature relationships built up over many generations. Instead, current society is mostly fluid, with people living on Svalbard for on average 5 years to then return to their respective home countries, to continue their former lives

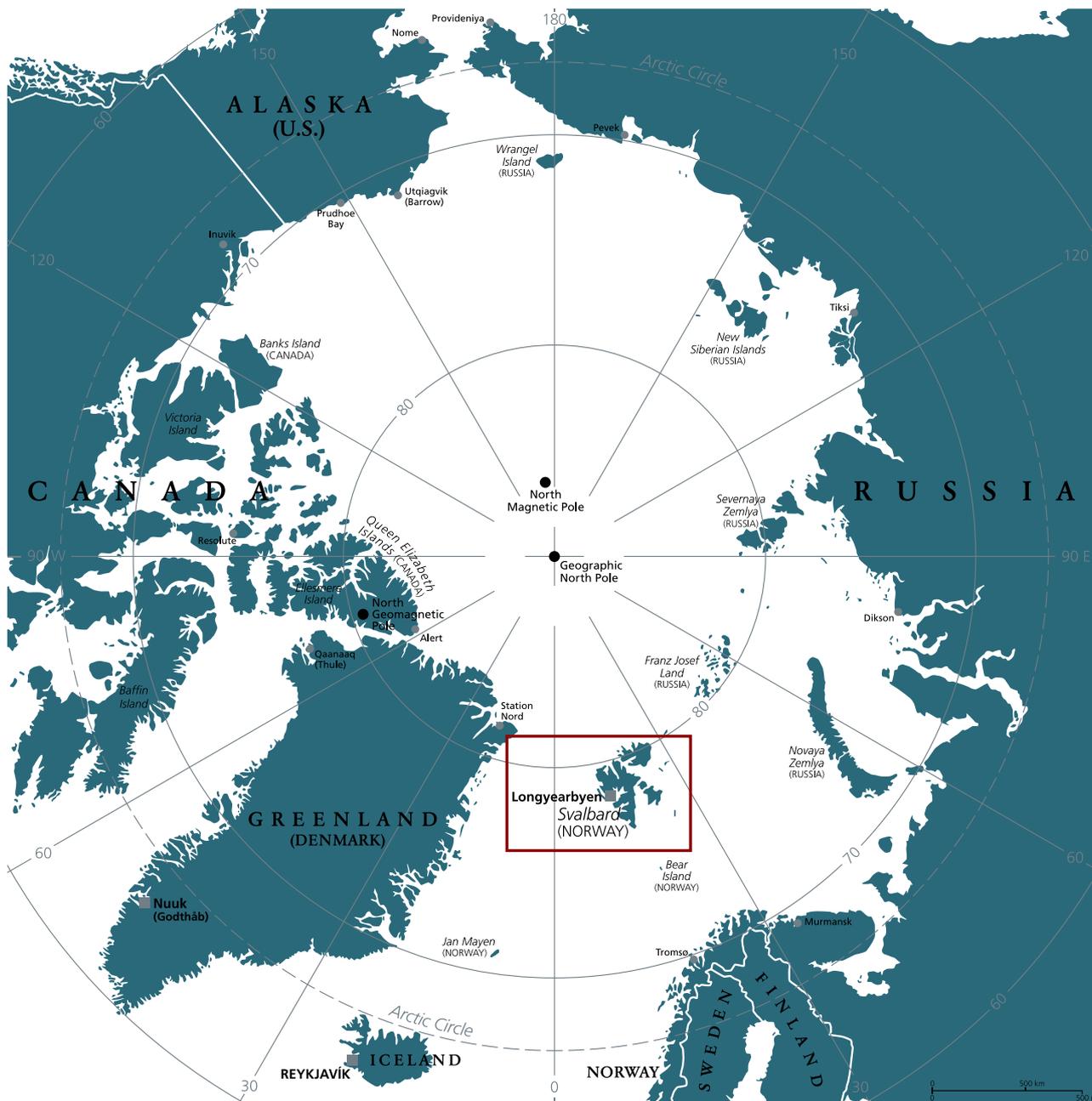


Fig. 1 The Norwegian archipelago of Svalbard in the high Arctic. This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

(Timlin et al. 2022). Its capital, Longyearbyen, has morphed from a former coal mining town into a highly modern, urban settlement with over 2000 inhabitants who do not live off the land as Indigenous communities across the Arctic do. Instead, the inhabitants of Svalbard have a strong connection and interaction with the environments of the archipelago through recreation and work (Sokolickova et al. 2023). People who chose to move here are generally fascinated by the remote archipelago and drawn to the exploring of its pristine environments (Viken and Jørgensen 1998; Nikel 2020; Timlin et al. 2022). Environmental interactions change with increasing mobility and these very interactions create nonmaterial bonds to places and environments (Lash and Urry 1994). Thus, Svalbard may be a locale where strong place attachment results in rich local knowledge, even when living or dwelling there relatively shortly.

Seen as a 'hotspot' in terms of environmental change (Meredith et al. 2019), investment in environmental monitoring and long-term research in Svalbard has been extensive. Like in other Arctic regions, environmental monitoring on Svalbard operates within natural scientific frameworks, while the multifaceted experiences and knowledge deriving from those who live, work or travel the archipelago of Svalbard are not directly captured. Through the lens of community science, we shift the focus to how even a transient society may be a productive site to enrich scientific knowledge with new perspectives, which then could make environmental monitoring more relevant to people living in and visiting the Arctic. We therefore ask the following research questions: (1) can rich local knowledge—using community science methodology—be gathered in a place characterised by a high level of transience? And (2) what is the role of place attachment therein?

Community science methods and tools

To get a broad and holistic understanding of environments in change we used a wide palette of community science methods facilitating the mutual enrichment of different kinds of knowledge. These included a Maptionnaire survey, focus groups and cognitive mapping.

Maptionnaire. To collect local knowledge and observations from a wide group of present and past residents and travellers, a digital community engagement platform was built using Maptionnaire software (Maptionnaire 2021). The online platform was designed as public participatory geographical information system (PPGIS) using Web 2.0 communication technologies, to gather location-specific information from interested publics (Hausner et al. 2015). The participants could choose to map using an English, Norwegian or a Russian version. The tool was designed to be accessible and invite anyone to report observations of environmental change (or lack thereof) starting with identifying a location on a map of Svalbard. The Maptionnaire platform allowed participants to connect text, stories, memories, images and files to specific points on a map, and proved a helpful tool for obtaining local knowledge and observations of environmental change through time. Our aim was to let people express their experiences and observations as freely as possible. To encourage people to share more than just a few observations, we included nine broad categories. These categories were based on our own analysis of environmental monitoring programmes on Svalbard and by reviewing another large-scale citizen initiative that is also using a digital platform to map unusual events, namely the Circumpolar Local Environmental Observer (CLEO; hosted by the Arctic Monitoring and Assessment Program of the Arctic Council). The resulting categories were: 'weather', 'ice and snow', 'land/landscape', 'sea and ocean', 'freshwater', 'plants and animals', 'built environment',

'littering and pollution', and 'other'—a category allowing users to map freely without using any of the above categories.

The platform was launched in mid-October 2021. Personal invitations to participate were sent to all registered residents of Svalbard, and the web-platform's link was widely shared and marketed across social media, organisations, museums, research environments, former residents lists, tourism actors and (co-) authors' personal networks. The platform also included a brief questionnaire to capture the diverse relationships people have with Svalbard (Fig. 2).

Focus groups. Focus group interviews or discussions is a qualitative technique to gain in-depth knowledge from a purposely selected group of individuals, through a moderated interaction. We identified several groups of people with whom we would like to engage to collect relevant narrative-based observations and reflections of change. Group 1 concerned the small number of long-term residents and returning residents, including seasonal workers in the tourism and other industries, who were likely to have experienced environmental changes either year-round or seasonally, but over longer periods of time. Group 2 concerned 'veteran tourists/explorers' who returned time and again and thus were familiar with larger parts of the archipelago. A series of focus groups were run, in Longyearbyen, to engage both groups of people and gather insights and the context of their experiences. We encouraged various forms of personal storytelling by using methods that gave us the opportunity to understand their experiences in different ways, while still being able to explore the underlying drivers that contributed to constructing this experience (Fig. 3). Participants were identified through social media, personal contacts and using snowball sampling. One focus group with six participants was conducted in October 2021 and three focus groups (with five, four and five participants, respectively) were conducted in January 2022. All subjects gave their written consent for inclusion before they participated in the study.

Cognitive mapping. Cognitive mapping is known as a participatory modelling technique and semi-quantitative modelling method (Van Vliet et al. 2010) that can capture representations of complex ecosystem interactions as perceived by participants; in this study these concerned relations among environmental variables seen by participants. Cognitive mapping allows for aggregate variables, complex relationships and interactions which can be hard to trace (Özesmi and Özesmi 2004). In other words, one can also see cognitive mapping as a 'mind map', a visual thinking tool used to organise information and ideas, including relationships among the noted elements. In this project cognitive mapping became a valuable analytical tool for developing a qualitative model of how people understood and connected their observations of Svalbard's environments. The map used the predefined Maptionnaire environmental categories ('weather', 'snow and ice', etc.) as well as ones emerging from both Maptionnaire entries and focus group discussions (Fig. 4). We used Kumu cognitive map software (Kumu 2022) to visualise understandings and relations of the environment observed and described by our participants. The visuals allowed us to include relationships between variables and observations perceived to impact each other in positive (+) or negative (−) ways, or merely thought of as connecting to each other and following each other's dynamic variations. The cognitive map clearly visualises the vast environmental understanding people living in and moving around Svalbard have, and how they connect, understand and perceive the variations and changes observed.

The cognitive mapping also contributed as an inductive data analysis. The map connected the observations, narratives and

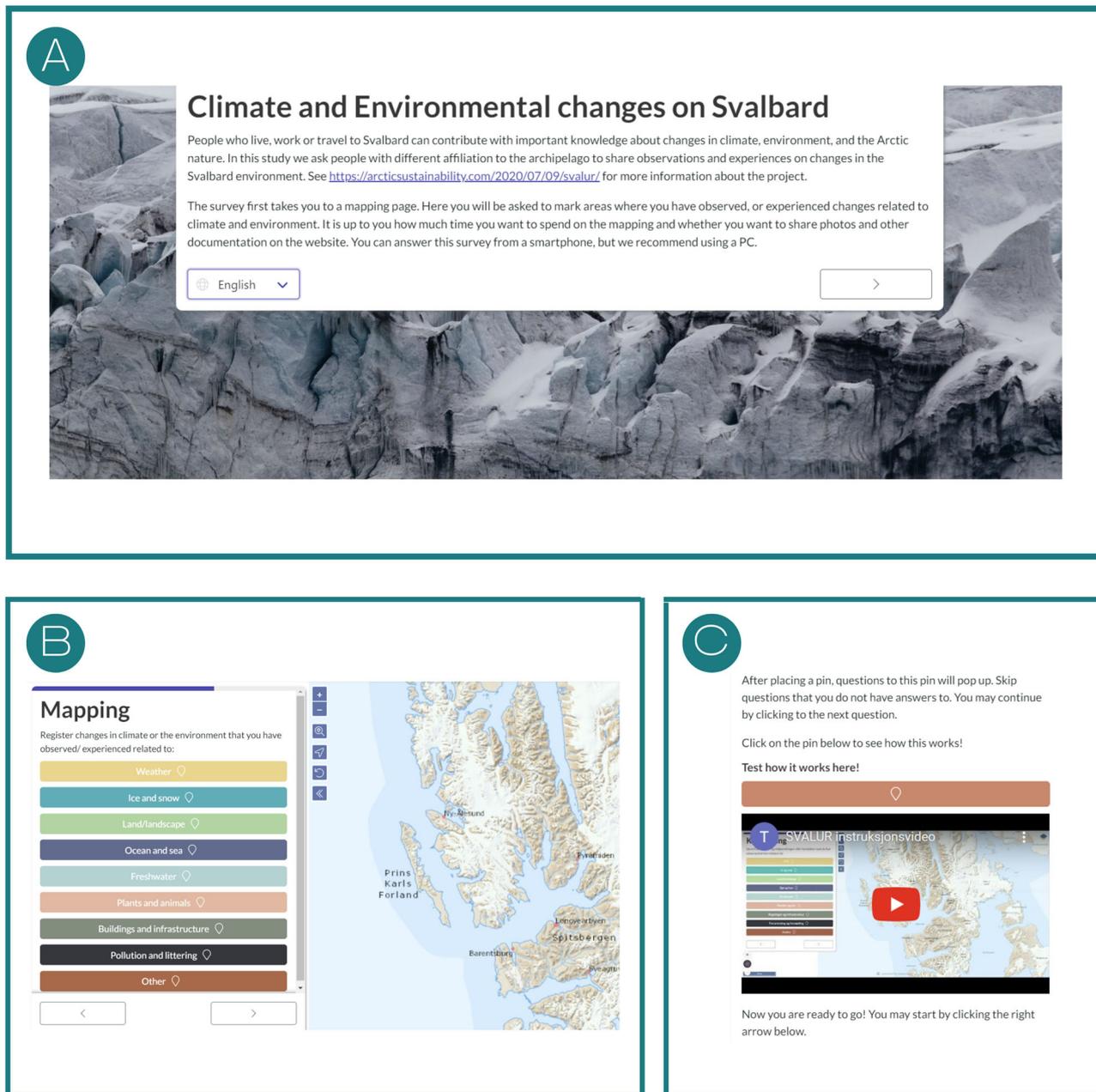


Fig. 2 The Maptionnaire platform. Our Maptionnaire platform used to obtain local knowledge. **A** Nine different categories could be chosen by users (**B**). An instruction video was included to help participants contribute in an easy and meaningful way (**C**). This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

captured uncertainties and integrated environmental and social aspects. It gave a bird’s eye view of the data (Blackstone 2018; Hines 2000). Here, the collected set of observations and relations among the variables moved from being individual observations to a more general set of propositions about those observations, developing these into specific patterns (Hines 2000). In short, the cognitive maps contributed to identifying patterns, forming new theories, hypotheses and the identification of monitoring needs.

Community science approaches often share the features of locality, local community and local knowledge. But in a transient place such as Svalbard, we needed the set of different community science methods to ensure a wide response from the local community and a more qualitative understanding of complexity of Svalbard’s changing ecosystems. Combining these different observations and data did not only integrate and connect the

largely fragmented variables and indicators, but also shed light on otherwise invisible experiences and knowledge contributing to insight of the stories behind data that can provide the context of knowledge produced of the Svalbard archipelago (Fig. 5).

Results

The contents of the different accounts on environmental change collected via different community science methods show complementary characteristics in terms of their quality, quantity and dimensions. Together, they gave a unique insight into both the richness of knowledge and place attachment that this transient community holds, reflected as general observations (Section “General observations”), and a specific case focusing on mobility-related results, the role sense of place and place attachment (Section “Case: mobility, monitoring and sense of place”).

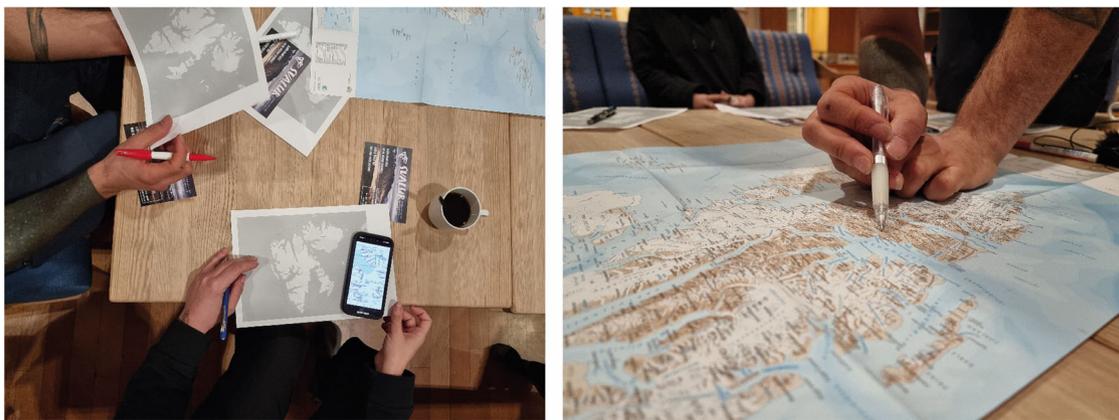


Fig. 3 The focus group interviews. The project team identified several groups of participants for focus group workshops, with whom we wished to engage to collect relevant narrative-based observations of environmental changes. The focus groups included a small number of long-term residents and returning residents, including seasonal workers. These photos are covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

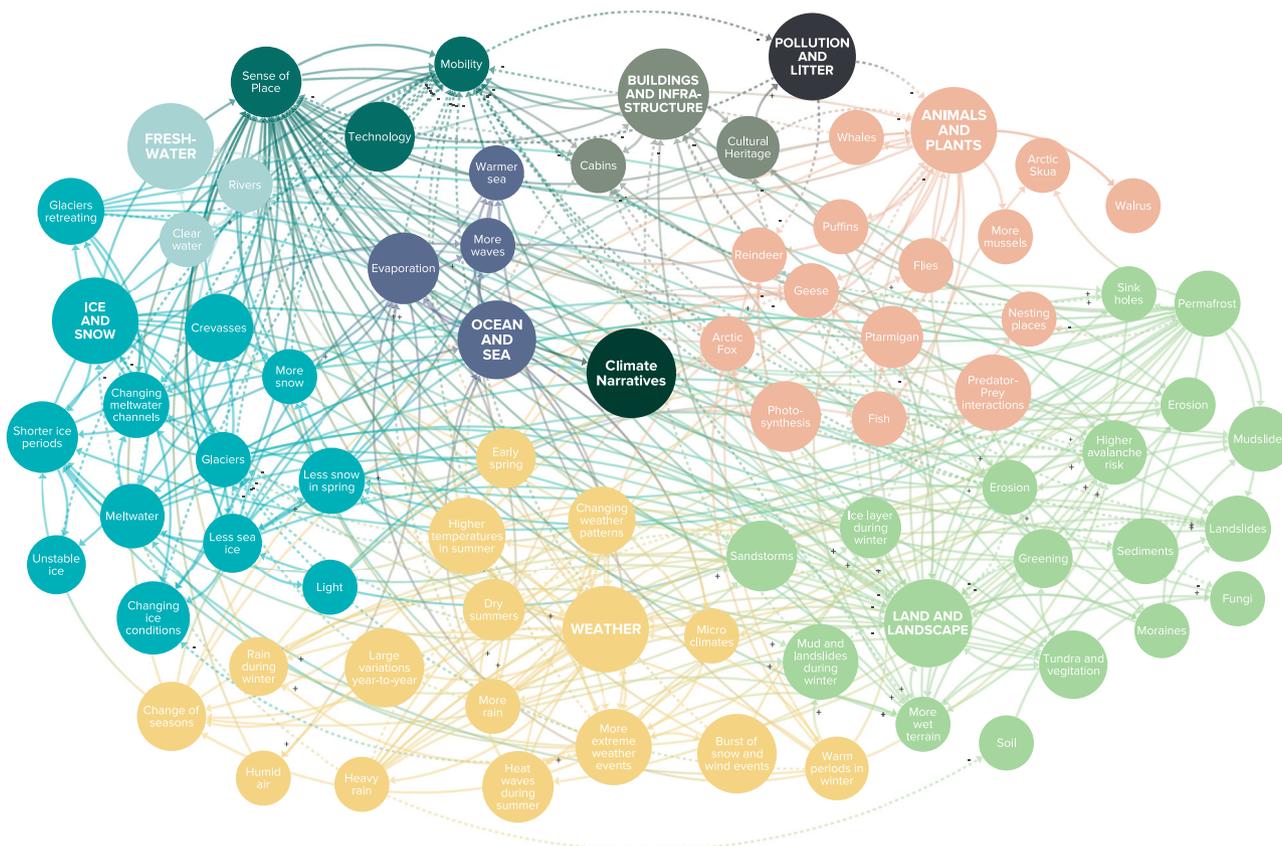


Fig. 4 Cognitive map demonstrating rich environmental system understanding based on local knowledge. We used the categories from the Maptionnaire (the largest bubbles in the figure: ICE AND SNOW, WEATHER, etc.) and identified keywords (smaller bubbles; their size determined by the number of characters of the text) and connections (solid lines representing the presence thereof in the empirical material; solid line with a plus (+) where the relationship between variables are perceived to impact each other positively; dotted lines with a minus (-) negatively). This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

Demographic profile. The Maptionnaire and focus groups supplement each other with respect to notably age, affiliation (i.e. tourist guide) and nationality (Table 1). The collective sample of participants to this study had good representation of both men and women, younger and older, and the various duration of residency categories. The participants covered a broad set of

affiliations, though unsurprisingly—given Svalbard as a place and the focus of our study—many were connected to outdoor interests (e.g. hunter/fisher, outdoor organisation, tourist guide). The majority of participants were not Norwegian but from other nationalities, which—together with the residency variables—emphasise the transiency of the community.



The Reindeer starve and die because of ice cover during winter, which then impacts the number of Arctic foxes that increase in numbers which in turn impact the geese – because more foxes eat the eggs etc.

–Resident of Svalbard

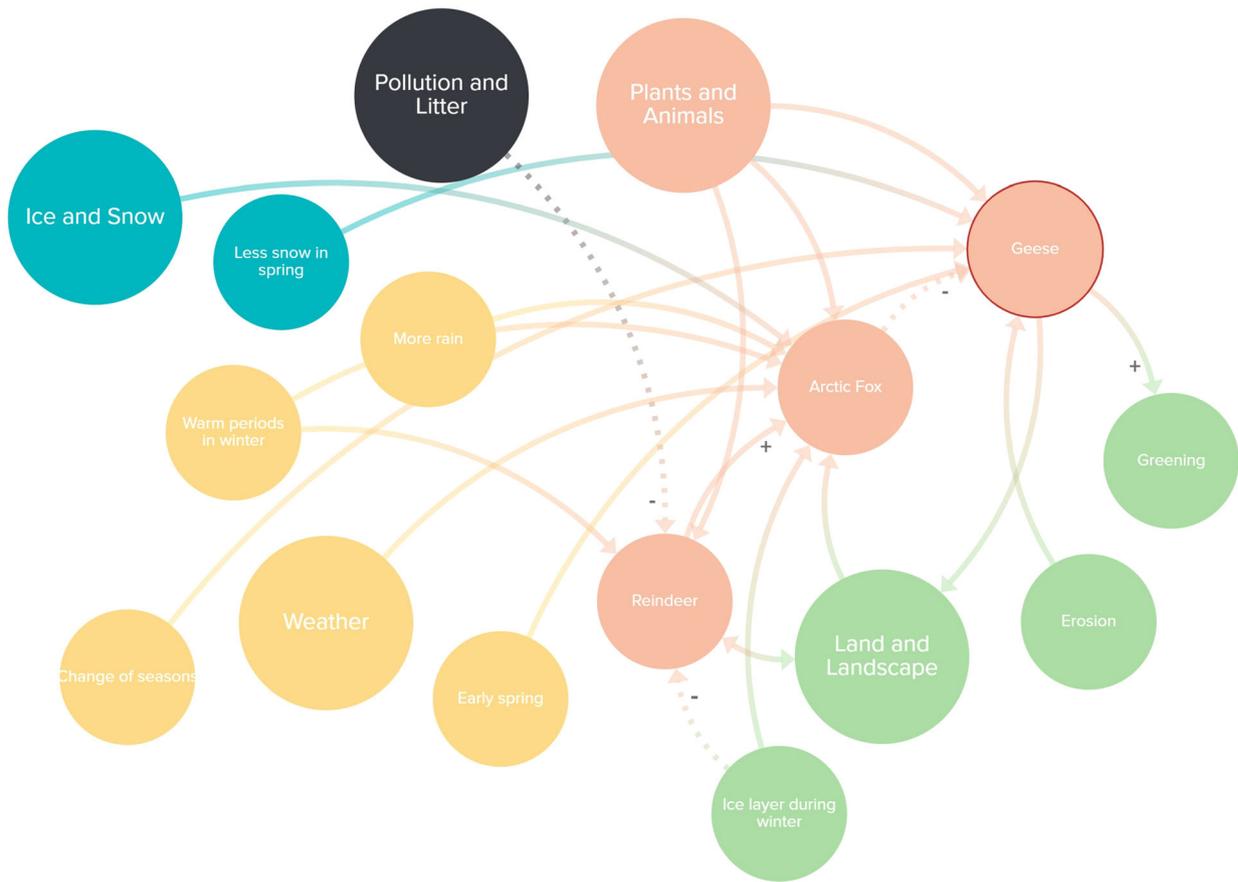


Fig. 5 An example of the system understanding generated from local knowledge connected to the Arctic fox. The system understanding visualised through cognitive mapping, connecting the Arctic fox to changes in weather, notably snow and ice; elements of the landscape; and animals such a reindeer and geese. This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved. The photo is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Jonatan Pie; copyright © Jonatan Pie, all rights reserved.

General observations. By the 3rd of November 2022, the web-based survey Maptionnaire had resulted in 460 separate observations (Table 1). Compared to ongoing environmental monitoring on Svalbard, this tool contributed with observations from a large number of different locations, collectively covering a large part of Svalbard (Fig. 6). This was despite the fact that more than 80% of those participating were residents of Longyearbyen.

Where environmental monitoring brings together quantitative scientific data, the Maptionnaire gathers rich and diverse qualitative local knowledge and their meanings based on personal accounts of environmental change in Svalbard. Each point on the map in Fig. 6 represents a narrative about changes observed or experienced, often unfolding complex relationships and sometimes including cascading impacts—insights that are difficult to

Table 1 Demographic variables.

Maptionnaire	Focus groups	
Gender		
Male	35% (n = 63)	55% (n = 11)
Female	24% (n = 44)	45% (n = 9)
Not answered	41% (n = 75)	
Age		
<40	23% (n = 41)	55% (n = 11)
>40	37% (n = 67)	45% (n = 9)
Not answered	40% (n = 74)	
Residency		
<6 months	10% (n = 18)	
1–2 years	16% (n = 30)	20% (n = 4)
3–5 years	18% (n = 32)	25% (n = 5)
6–10 years	13% (n = 23)	15% (n = 3)
11–20 years	18% (n = 32)	10% (n = 2)
>20 years	14% (n = 26)	20% (n = 4)
Visitor	9% (n = 16)	10% (n = 2)
Not answered	4% (n = 5)	
Affiliation		
Tourist guide	14% (n = 25)	75% (n = 15)
Hunter/fisher	26% (n = 47)	25% (n = 5)
Local politician	2% (n = 4)	
Environmental organisation	6% (n = 11)	
Outdoors organisation	19% (n = 35)	
Management/Planning	14% (n = 25)	5% (n = 1)
Researcher/Consultant	8% (n = 14)	
Student (Higher education)	10% (n = 18)	
Teacher		5% (n = 1)
Resource extraction		5% (n = 1)
Service industry		5% (n = 1)
Note: A person can belong to more than one affiliation		
Nationality		
Norwegian	46% (n = 84)	20% (n = 4)
Other	54% (n = 98)	80% (n = 16)
Total mapped points	460	126

capture through standard (scientific) monitoring of a more limited number of variables.

As said, the majority of the registered points were made by residents in Longyearbyen, all reflecting the extensive experiences with climate change around the Svalbard archipelago. The most used category was ‘Snow and ice’, with 48% of the survey participants reporting experiences of cryospheric changes, such as glacier retreat, deepening permafrost, appearing crevasses, expanding meltwater channels and changing snow conditions. Participants described how glacier retreat combined with milder winters, and how more rain in the snow-free seasons has increased the risks of landslides and slush avalanches. Reports also concern old mountain-side trails that have been washed away and higher flow and variability in river courses changing accessibility. Further down the river, spreading into deltas, people described how wetter and warmer weather has resulted in lush vegetation and more insects. Instabilities in the active permafrost layer have impacted buildings and roads, but land collapses have also affected nesting grounds of birds (Fig. 7). There were fewer reindeer close to Longyearbyen than in the past, but—critically—more of them in other areas of the archipelago. Additionally, more polar bears are attracted to areas nearby settlements. Some participants noticed a delay of flowering in plants, whereas crowberry was reported to flower early in the unusually warm summer of 2020. Geese are arriving earlier because of change in the onset of spring and associated earlier snowmelt, contributing to greening. Diminishing sea ice and coastal erosion were also observed by several participants.

The focus group interviews provided a further 126 accounts of environmental changes (Table 1). These drew on observations from activities-based experiences, weekend outings, other recreational outdoor activities and guiding. Accounts were often general observations that correspond to those from scientific reports, i.e., rising temperatures in winter, summer and autumn; greener tundra and earlier flowering in plants; increasing populations of animals such as reindeer, various birds and marine mammals; increasingly unpredictable weather and more precipitation in summer and winter; patches of thawing permafrost; less ice in the fjords and retreating glaciers; more avalanches and landslide events; and changing behaviour of reindeer and polar bears. Together with the Maptionnaire and cognitive mapping, all these personal experiences and narratives enrich and contextualise environmental monitoring, contributing to a more holistic understanding of the environmental changes happening, and—importantly—how people are experiencing, feeling and understanding these changes.

Case: mobility, monitoring and sense of place

Mobility. Analysing the observations from the Maptionnaire and connecting these with the narratives and observations shared through the interviews and adding those to the cognitive map, it became clear how the observations were connected to movements through landscapes, resulting in clusters of observations at specific places. How important moving through landscapes—exploring—was to our participants is clear from the great number of observations and dimensions of environmental change that were seen to hinder mobility (Fig. 8). These notably concerned ‘winterscape’ and cryospheric changes, including less and unstable sea ice, crevasses, changing (land) ice and snow conditions, retreating glaciers, and changing meltwater patterns, all impacting how people can move through and interact with their surrounding environments.

Connecting these observations to mapped GPS routes used by local people for recreational and work purposes, it became more obvious that changes are observed along a web of routes (Fig. 9). This shows at least two immediate potentials: (1) the network of routes as mobility infrastructure illustrates geographical possibilities that can add to science or citizen science data collection or observations; (2) comparing these routes with existing locations of monitoring that monitors land-fast sea ice, sea-ice extent and thickness and glacier mass balance can lead to identification of monitoring needs when thinking of movement, safety and well-being.

Scientific monitoring sites covering ice and glaciers are mainly clustered around the Longyearbyen/Adventdalen area and especially the Ny-Alesund/Kongsfjorden area. They are also associated with snowmobile routes but only a few of them. This means that there is a partial mismatch between where scientific monitoring of ice and glaciers takes place and where locals go.

Safety monitoring.

“One can never predict which way one can drive. We are so used to driving certain routes like to the east coast or even to Pyramiden, like -oh I will just go the way from Longyearbyen, to Adventdalen, to Sassendalen and then I drive over the sea ice to Tempelfjorden. But then I could not do that, a) because it is closed or b) because there is no ice so we cannot drive. So we will be starting to drive over all these glaciers and all these ice caps which is very dodgy because the glaciers are changing, there are more crevasses, there is less snow in the summer so they are starting to melt, the surface is changing. So, it is not only the extent of the glaciers and their retreat. Every year you need to start

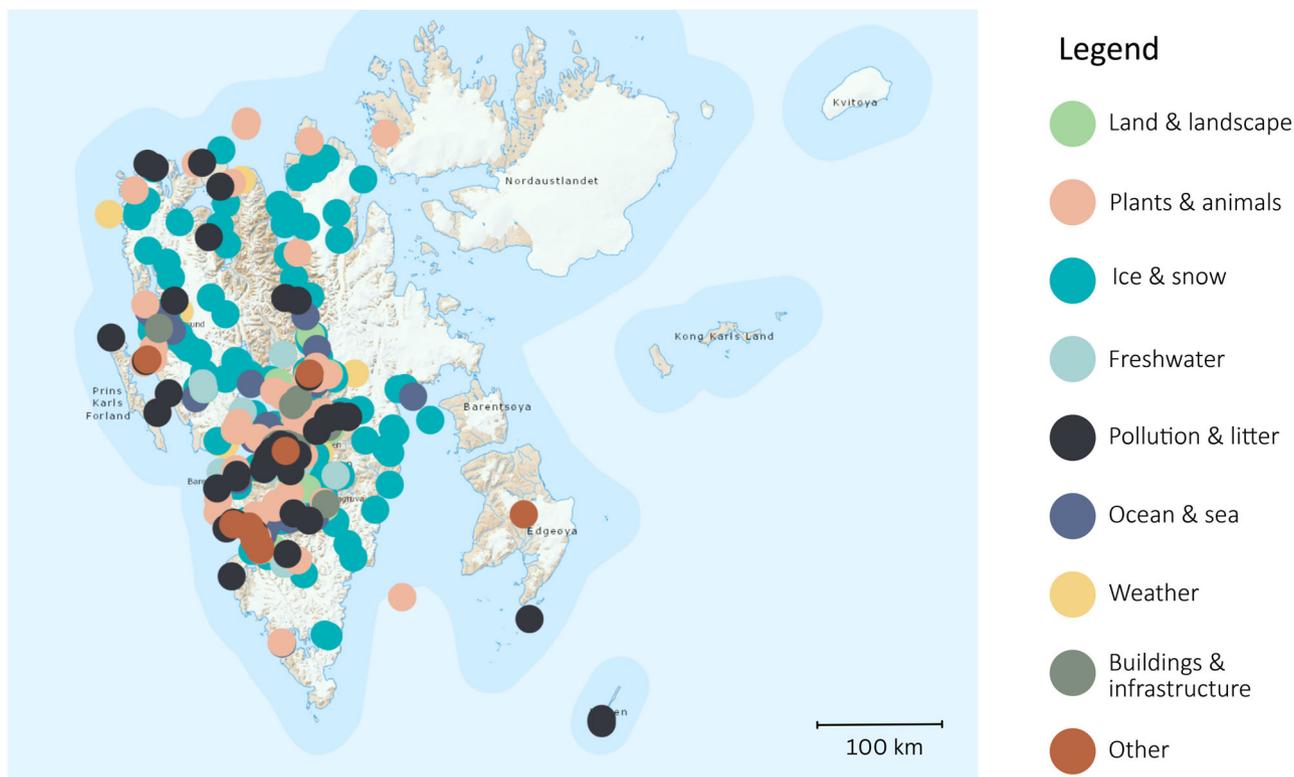


Fig. 6 Spatial distribution of the Maptionnaire entries, demonstrating that local knowledge could be gathered from across a large geographical area. This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.



The plain below Road 238 has changed "structure", ie the active layer of the permafrost has changed on the plain. For many years, there were Arctic Skuas, who had a permanent nesting place here, on a small elevation on the plain. A couple of years ago, they changed their nesting place, moved a little north on the plain (closer to the Research Park). The reason was that the elevation they used as a nest was suddenly "gone", ie it had collapsed.

-Resident of Svalbard

Fig. 7 Observation of breeding Arctic Skuas and permafrost instabilities. This photo is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of nikpal; copyright © nikpal, all rights reserved.

reassessing where you go, what you do, how you can drive and what is safe. So, that is very interesting because I feel like just a few years ago you did not really think about it that much and now it has become where you ask yourself: where can I actually go.”

- resident of Svalbard

Some of the most pertinent observations and narratives of environmental change were in connection to safety. These brought out how such change impacts not just mobility itself

but also the sense of safety associated with movement. In this regard, these statements and mobility patterns strongly indicate a wish and need for ‘monitoring for safety.’ Such monitoring is also crucial when speaking of risk management, risk reduction and rescue response throughout the year. Research examining disasters and disaster risks in Svalbard has mainly focused on two aspects, namely Norwegian efforts in and for the main settlement of Longyearbyen (Duda et al. 2022) and expedition cruise activity during the summer season. Considering Svalbard’s geographical location; the great mobility of people living, visiting and exploring Svalbard; the environmental characteristics; the big

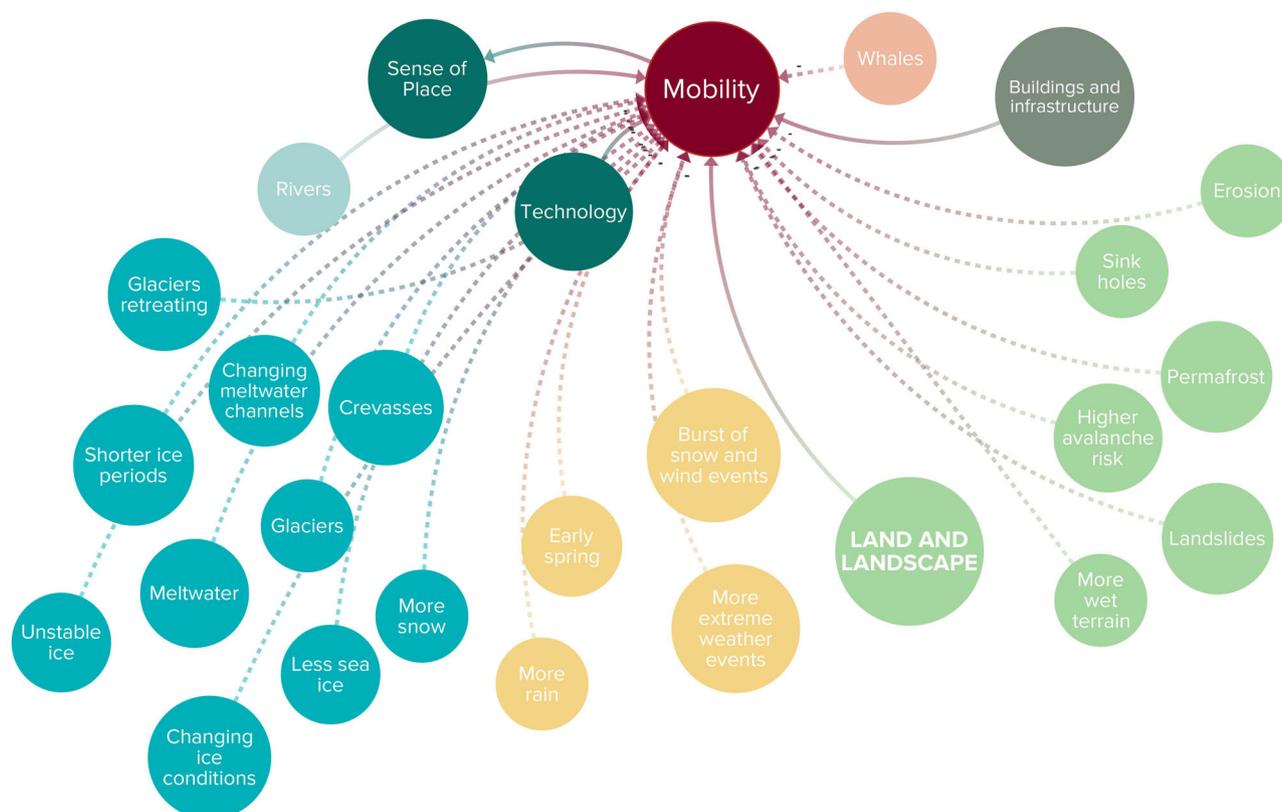


Fig. 8 Cognitive map of how observations connected to mobility. Note the predominance of dotted lines, representing elements that impact mobility negatively. This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

environmental variations throughout the year (e.g. extreme weather events, warming periods, rain bursts in winter, increasing precipitation); and the great transformations of glaciers (e.g. change in mass, retreat, crevasses, melt water channels), landscapes (e.g. thawing permafrost, landslides and erosion) and ice bridges over fjords (e.g. less sea and fjord ice, black ice, thinner ice, severe micro climates impacting the ice); these truly call for more monitoring to secure safe movement across the archipelago and to contribute to risk management as well as safety.

“Larsbreen moraine has changed significantly during the last years. The ground has slid off the ice cored moraine and the old route up is now totally gone.”

- resident of Svalbard

While long-term scientific monitoring of glaciers has been conducted for more than a dozen major glaciers in Svalbard in Kongsfjorden and more remote areas on the archipelago (Hanssen-Bauer et al. 2019), there are however no decadal-scale measurements of glacier mass balance for Larsbreen or Longyearbreen. These readily accessible glaciers are proximal to Longyearbyen, and define an important route for people travelling out of town. This monitoring gap is well complemented by the experiential observations shown in the Maptionnaire and mapped by the focus groups.

Analysing the Maptionnaire and focus group data, it was evident that there generally was a feeling of decreased safety and security. This was not only in connection with travelling during winter but also to other natural hazards, such as avalanches, rockfalls, unstable mountain slopes and mudflows, putting both people and infrastructures at risk.

The role of sense of place in rich local knowledge. The cognitive map in Fig. 10 not only visualises how ‘Sense of Place’ and the observations and narratives (Maptionnaire and focus group data) are connected through clusters of connections, but also they also largely relate to movement and interactions with nature. The focus group conversations unfolded while looking at maps, and narratives were typically told as travel through landscapes. The narratives related to the observations were also connected to emotions, thoughts and feelings, whereas the Maptionnaire contributed with observations connected to specific places. The cognitive map brought together the narratives and observations, hereby illustrating how people have developed meaning and knowledge to these environments through these interactions, movement and generating a place attachment. These bonds people form with places, the meaning they ascribe to them, evolve through moving, interacting and engaging with one’s surroundings. This contributes to setting the foundation of the rich local knowledge gathered in a place characterised by a high level of transience.

“So it’s like walking in a field, or in Northern Svalbard, what it used to be. It used to be dry and hard. But it’s not anymore. And also the smell. It used to be so dry air here, that you couldn’t really sense anything. But now you have almost normal range of scents in the air.”

-resident of Svalbard

The cognitive map connected the narratives, captured uncertainties and integrated environmental and social aspects. Visually, the maps show relations among variables. Additionally the cognitive maps demonstrates that behind the scientific data

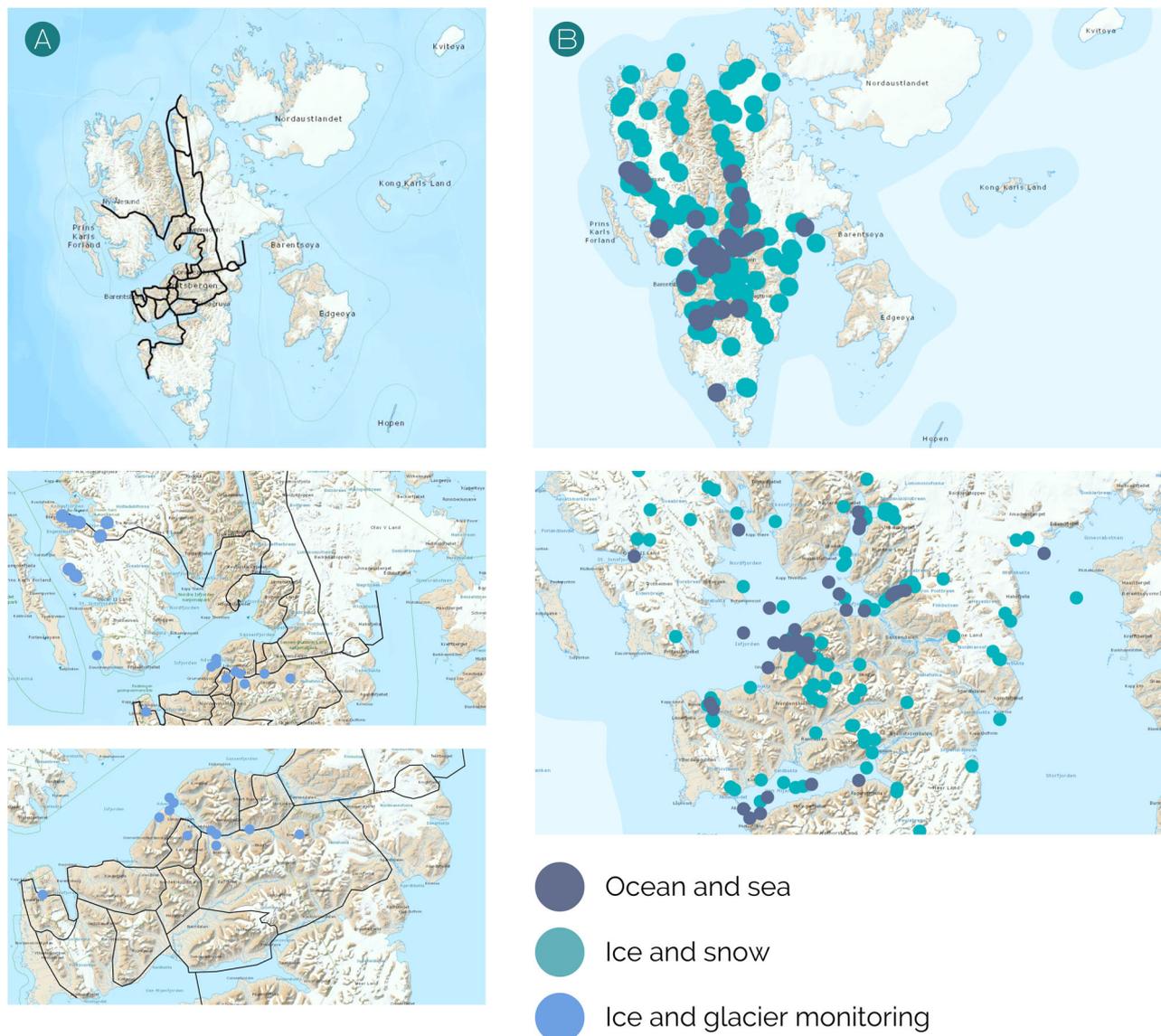


Fig. 9 Comparing snowmobile routes, observations and scientific monitoring sites. A Snowmobile routes in different areas of Svalbard. GPS routes from Eirik Hellerud and areas of monitoring on ice and glaciers (SVALUR survey on monitoring stations and programmes of ice and glaciers). **B** Maptionnaire observations of ‘ice and snow’ and ‘ocean and sea’ (which observations were only of sea ice and fjord ice conditions). This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

and environmental observations there are always stories that can contribute with holistic understanding.

The way that people ascribed their observations and the connections with the environment, also illuminated the values and emotions connected thereof. Some were emotions of feeling changes being big and unpredictable (and therefore a threat) and not being able to mitigate or adapt in the same pace as the changes were happening. These were feelings of uncertainty and in various situations feeling unsafe. But it was not only the difficulties, uncertainties and threats that were mentioned, but also linkages to why these were occurring and how awareness and knowledge was important to mitigate these (“Mobility” and “Safety monitoring”). Not least, these were also emotions and a feeling of having a responsibility towards the surrounding environment in all its fragility.

“So I read the landscape differently. I recognise wet areas from far away, and I can alternate my route that I wanted to walk with the guests, already in time, before all of a sudden

having a wet area in front of me. You want to avoid wet tundra, because you will damage the tundra, even if you have your rubber boots on. If you are stepping on wet tundra you will damage it. So you want to walk in dry areas because of comfort for the guests, but mainly to not destroy anything.”

-resident of Svalbard

Future monitoring. The observations from the different sources also made clear where societal interest in the environment lies and what they would like to see being monitored. These perspectives and interests were by-and-large about environmental monitoring that is relevant to the local community and residents of Svalbard and generally linked to elements of safety. This contrasts with a lot of the monitoring happening which typically serves international interests. In some cases, identified monitoring needs actually already happen. Here, those responsible for

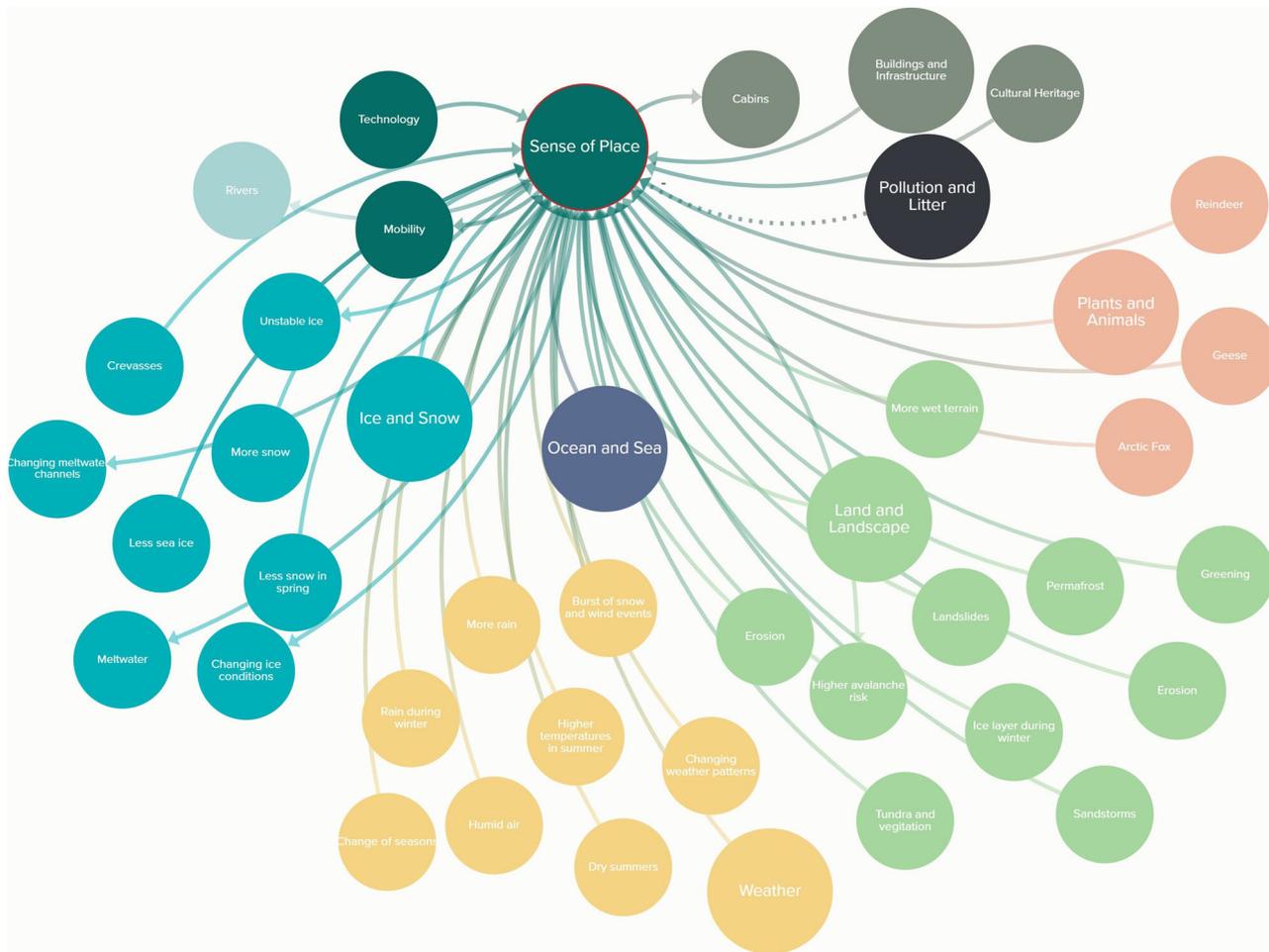


Fig. 10 Sense of place is largely connected to human-nature interactions “Ice and Snow” and “Land and Landscape”. Weather (and climate) also plays an important role in the system understanding, being the main factor that impacts all the other categories. This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

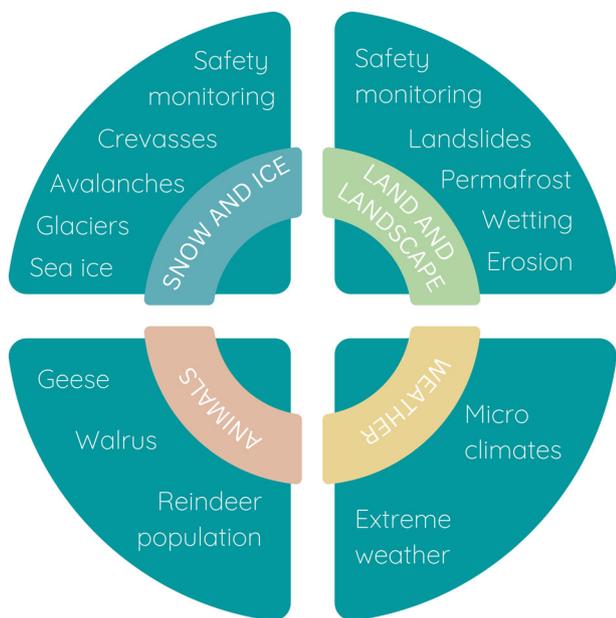


Fig. 11 Identified lacking monitoring identified from the Maptionnaire and focus groups. This figure is covered by the Creative Commons Attribution 4.0 International License. Reproduced with permission of Ann Eileen Lennert; copyright © Ann Eileen Lennert, all rights reserved.

monitoring programmes may want to reflect on how to ensure that their insights and ‘translated’ data are available to local publics (Fig. 11).

‘Snow and Ice’ had many entries in the Maptionnaire regarding observations of changing winterscapes, crevasses, sea ice conditions, avalanches and glaciers, revealing a strong interest in safety monitoring. Narratives of focus group participants, repeatedly capturing aspects to do with moving through snow and ice confirmed the need for monitoring of such dimensions. The same held for ‘Land and Landscape’, where 10% of the entries in the Maptionnaire concerned observations connected to landslides, erosion, permafrost and wetting, and those aspects played a predominant role in the narratives of focus group participants too. In relation to ‘Weather’, the need for better predictions of extreme weather events and the occurrence of microclimates was emphasised strongly, as was monitoring to assess the high number of reindeer, expanding nesting areas of geese and their impacts on environments, and new howling areas for walrus. Observations of different categories were often clustered, thereby pinpointing geographical areas where possible future monitoring currently may connect best to local interests and needs.

At the same time, some of the mentioned ‘monitoring needs’ are already extensively monitored. A case in point is the Svalbard reindeer, which is emphasised that it should be monitored, but actually already is subject to extensive monitoring (Albon et al. 2017; Le Moullec et al. 2019; Ravolainen et al. 2020). A similar discrepancy could be possible for monitoring of glaciers in cluster

areas of the Maptionnaire. Our findings therefore identify both geographic and topic areas for which researchers and monitoring programmes should ensure their data and interpretations are visible, accessible and relevant for local publics.

Discussion

The Svalbard community is currently finding themselves in the midst of rapid environmental changes, particularly concerning glacial melt and associated river flows, and instabilities resulting from thawing permafrost impacting plants, wildlife and built environments. Importantly, many of these changes heighten risk for people moving through the—slowly defrosting—landscape. Our study demonstrates that rich local knowledge can be captured about environmental changes experienced by a community characterised by a high degree of transience. The transient community of Svalbard has a strong connection and interaction with the environments of the archipelago through recreation and work (Timlin et al. 2022). People who chose to move here are generally fascinated by the remote archipelago and drawn to the exploring and living the ‘true Arctic experience’ (Kaltenborn 1998; Viken and Jørgensen 1998; Timlin et al. 2022; Sokolickova et al. 2023). As indicated by our data, residents spend considerable time and efforts exploring, moving and re-visiting different locations in the Svalbard archipelago, developing a strong bond to the environment; from that position they are able to contribute with rich knowledge of environmental change taking place at a broad scale. We therefore agree with Gurney et al. (2017) that a “communities of attachment” approach that acknowledges mobility as a key feature of today’s human-environmental relationships is useful for understanding environmental change and associated knowledge production. More specifically, we found a large geographical dispersion of observed environmental change and events, indicating that the contributions were made by a community that explores widely. Our results underscore the need to think beyond a localist perspective in community science, so that local knowledge can include knowledge generated from people’s interactions with and attachment to the environments they live in, move through, visit recurrently and explore.

Community science in ‘transient communities of attachment’ can benefit from using a wide palette of methods. We combined three tools: digital survey, focus groups and cognitive mapping. Our digital survey platform (Maptionnaire), was able to capture observations of environmental change across a remarkably large geographical area—notably concerning the western half of the archipelago—because people in this transient community explore widely. This means that observations of environmental change can be made in many more place than where formal monitored takes place. This demonstrates the tool’s potential as an additional infrastructure that science could possibly utilise for environmental monitoring. The digital platform could provide crucial information on where changes are taking place, affecting vulnerable habitats and wildlife; but also which kinds of human activities are mostly affected by environmental changes and where. The spatial data mapped by the participants provide valuable information for researching cryosphere change, such as changes in snow conditions, glacier melt and permafrost thawing, that could be combined with earth observation. Place-based observation and knowledge derived from community observation platforms have been shown to be both scalable and transferable for use in climate change research (Reyes-García et al. 2019). Mapping areas that are remote and inaccessible by use of community-based observation platforms is particularly valuable in data-scarce areas such as the Arctic (Peacock et al. 2020), assisting larger science initiatives as well as demonstrating where and what kind of monitoring data is needed by these communities. The latter was also made visible through our Maptionnaire.

A further community science tool, focus groups, were found to be truly valuable for collecting qualitative data concerning participants’ insights and the context of their experiences (Dilshad and Latif 2013). Importantly, As Gorman and Clayton (2005) identified, there were several strengths of the focus group interviews. Not only was a rich pool of qualitative data collected, but it encouraged interaction and offered opportunity for immediate feedback or clarification of viewpoints and observations. One characteristic of the resulting materials was that it extended timelines due to inclusion of experiences further back in time. Likewise, it added a more in-depth understanding of the data drawn out from the Maptionnaire, as we encouraged various forms of personal storytelling. This gave us the opportunity to understand experiences in different ways, while still being able to explore the underlying drivers that contributed to constructing these experiences.

Lastly, cognitive mapping helped us collate, connect and visualise the knowledge gathered from the Maptionnaire and focus groups, demonstrating the incredible system understanding that the transient community has of the environment. This included the ability of people to reflect on, e.g., how weather impacts not only landscapes, but also wildlife, seasonality and mobility; and to sense numerous interconnections such as how the number of geese is influenced by the onset of spring, the abundance of arctic foxes and how moist parts of the tundra are.

Our study confers with Albagli and Iwama (2022) who argue for integrating knowledge from different systems, using community-based online platforms for mapping risks associated with environmental change and disasters combined with social cartography methodologies where people are also involved in co-creation processes of understanding and responding to climate change. Similar to their study, the place-based knowledge we have gathered has not been combined and synthesised with the scientific monitoring of environmental change and disasters at this high-Arctic island. On the one hand, combining knowledge systems could enhance the multiple evidence base for understanding ‘what is happening’, but the process itself could help to empower and democratise science to learn more efficiently, to build trust and to find effective governance strategies on ‘how to adapt’ to the rapid environmental changes currently observed in the Arctic (Tengö et al. 2014).

Finally, we highlight the fact that scientific knowledge from environmental monitoring exists alongside knowledge and experiences held by various transient mixes of people that reside in or travel to Svalbard. Svalbard serves as an interesting case study for investigating whether such different kind of knowledge can further identify and strengthen environmental monitoring of Svalbard. While many long-term monitoring programmes on Svalbard are linked to government agency directives at the national or international levels, there are also personal endeavours that derive from individual researchers’ interests. In a similar manner, Svalbard’s transient community may have created a dynamic exchange of knowledge across public-private sectors as well as initiatives that derives from how one views ones surrounding world. We demonstrated that a rich local knowledge—using community science methodology—can be gathered in a place characterised by a high level of transience. Here, the role of place attachment played a significant role. It was evident that peoples’ outdoor interactions and experiences played an importance to the bonds, knowledge, values and meaning people ascribed to the environments. Thus, heightening an environmental awareness and yet a stronger attachment.

We conclude that transience does not necessarily prevent the generation of valuable local knowledge that can enrich and provide connection to scientific understanding of the environment.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request. Access to the original dataset is restricted due to personal data protection requirements, data will be anonymized and freely available when the project is finalised in the Norwegian Dataverse Repository (dataverse.no).

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Author contributions

Conceptualisation: all authors contributed equally to this work. Methodology: AEL, RVDW, JZ, and VHH. Conducting community science methods and work: AEL and JZ. Data analysis: AEL, FJAM, JZ, and VHH. Visualisation and graphics: AEL. Writing—original draft: AEL. Writing—review and editing: all authors contributed equally to this work. Project administration: AEL.

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Competing interests

The authors declare no competing interests.

Ethical approval

The questionnaire, methodology and for this study was approved by SIKT, Norwegian Agency for Shared Services in Education and Research (ethics approval number: 703522).

Informed consent

Informed consent was obtained from all participants and/or their legal guardians before every PPGIS and focus group interview.

Additional information

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