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1 **The perception of permafrost thaw in the Sakha Republic (Russia): narratives, culture**
2 **and risk in the face of climate change.**

3 Natalia Doloisio^{1*}, Jean Paul Vanderlinden²

4 ^{1 2} University of Versailles Saint Quentin en Yvelines / Université Paris Saclay – CEARC Laboratory

5 *Correspondence E-mail address: n.doloisio@hotmail.com

6

7 **Abstract**

8 This article focuses on the social representations of permafrost thaw among people who were
9 born in different regions of the Sakha Republic (Russia) and live in the regional capital city of
10 Yakutsk. Our research aims to obtain a better understanding of the new risk patterns
11 associated to permafrost thaw through the collection and subsequent analysis of narratives of
12 personal experiences in order to identify the main concerns, how these are defined and which
13 coping strategies are considered by local inhabitants. Our respondents insightfully
14 characterized the nature of the multiple interrelated processes and associations that they
15 identified. According to locals' grasp, climate change and permafrost thaw's impacts exceed
16 the merely physical and material dimensions, unchaining simultaneous and deep
17 transformations in their culture. More specifically, physical degradation threatens their
18 symbolic representations, the material practices and the emotional ties that they have
19 developed in that specific land. They also expressed the need for potential mitigation
20 strategies at both a regional and local scale.

21 Key words: permafrost, climate change, Sakha Republic, narratives, risk

22 **1. Introduction**

23 Arctic regions are currently undergoing unprecedented climatic and socio-environmental
24 changes. Both scientific research and the observations and knowledge of Arctic residents
25 provide detailed information about the multiplicity of transformations (Nuttall, 2018).

26 In this paper we use a risk perception centered analysis of permafrost thaw in order to analyze
27 the situation in the Sakha Republic. We use the following definition of risk: “Risk equals the
28 two-dimensional combination of events/consequences and associated uncertainties (will the
29 events occur, what will be the consequences).” (Aven and Renn, 2009) When considering
30 permafrost thaw and climate change the risk “event” under scrutiny is the increased thawing
31 of the permafrost, and/or, the reduction of the area of permafrost (discontinuous and
32 continuous), and the associated causes (climate change) consequences. The purpose of this
33 paper is to focus on the perceptions, by the local population, of such an event, its causes and
34 its consequences. By focusing on perception we aim at capturing how locally permafrost thaw
35 is associated to causal statements, statements of salience and their justifications (Vanderlinden
36 et al., 2017). Such “risk issues” (see Renn, 2008, pp. 133 and 134) may take material forms,
37 day to day living conditions may be threatened, and non-material forms, well-being, culture,
38 values, for instance, may be threatened. While the material consequences of permafrost thaw
39 are well documented (see following paragraphs) this is not sufficient to appraise a risk
40 situation: concerns, in all their dimensions, need to be appraised (Renn, 2008, p. 74).
41 Assessing the perceptions of a specific risk contributes to such a concern assessment.
42 Furthermore, including the cultural dimension of climate change while promoting research
43 aimed at understanding communities’ perceptions of how these processes threaten their lives
44 and livelihoods is essential. The non-material processes and resources enabling people to lead
45 meaningful and dignified lives, but which are nevertheless at risk, require special attention
46 (Adger et al., 2013).

47 As a response to a warmer climate in the Arctic, two main phenomena have already been
48 observed: permafrost temperature increases of between 0.5°C and 2°C at the depth of zero
49 annual amplitude (Romanovsky et al., 2010; Kholodov et al., 2012) and an increase in the
50 active layer thickness (ALT) in the majority of the regions, especially in the Russian
51 European North (Shiklomanov et al., 2012; Romanovsky et al., 2016). The most visible
52 impacts of these phenomena have been observed in infrastructure, more specifically, the
53 detrimental of gas and oil pipelines, the associated infrastructures and roads (Hjort et al.,
54 2018; Shiklomanov et al., 2017; Streletskiy et al., 2019). Estimations of the potential costs of
55 adapting or maintaining infrastructures have also been calculated (Larsen et al., 2008; Melvin
56 et al., 2016; Hjort et al., 2018). Scientific research conducted in Yakutia revealed the
57 ecological effects of climate change on mammals: the northern pika has expanded its
58 geographical distribution; the mortality rate of small rodents has decreased; the abundance of
59 meadow voles has increased; the mean age of sables has increased and important migratory
60 changes have been observed in the Siberian roe deer - which was usually known as a
61 sedentary species- (Argunov and Safronov, 2013; Safronov, 2016). Climate change also
62 accentuates changes in Siberian vegetation, its composition, structure and productivity
63 (Tchebakova et al., 2016). Takakura (2016) also demonstrated that climate change currently
64 represents a limitation for pastoral adaptation of Sakha People depending from grassland
65 resources in river terraces and the alaa thermokarst landscape for cattle-horse husbandry.

66 Climate change exerts further pressure on cultural dimensions such as beliefs, ritual practices,
67 art forms, identity, community cohesion and the sense of place (Adger et al., 2013; Quinn et
68 al., 2015; Crate et al., 2017). Simultaneously, culture shapes the way societies perceive and
69 respond to new risk patterns associated to climate change and permafrost thaw. By assuming
70 that risk perception is a cultural construct (García Acosta, 2005; Vanderlinden et al., 2017),
71 we recognize that the notion of risk is not pre-determined, but is instead an intellectual

72 construct between the members of a society (Douglas and Wildavsky, 1982). Culture thus
73 needs to be at the core of research aimed at understanding the social impacts of climate
74 change. This is particularly relevant in the Russian Arctic, as communities have developed a
75 particular understanding and sense of place which is closely related to living in the presence
76 of permafrost and extreme climatic conditions. Furthermore, people's perceptions, definitions
77 and assessment of risks will determine whether or not they consider adaptive measures
78 necessary. Finally, taking cultural dimensions into consideration will contribute to
79 understanding the diverse range of possible responses to similar environmental changes.

80 **With this in mind, the purpose of this paper is to explore the perceptions of climate change**
81 **and permafrost thaw within the inhabitants from Yakutia by collecting and analyzing**
82 **narratives.** As illustrated by McComas and Shanahan (1999), it is only through narratives that
83 humans succeed in weaving together fragmented observations in order to construct meanings
84 and realities. Through narratives, people assign specific meaning and valuation to social and
85 environmental issues. A detailed analysis of their answers will provide us with useful
86 information in terms of how communities perceive changes, while also enabling us to identify
87 the possible differences existing between norms, definitions and expectations among the
88 scientific community and local stakeholders regarding permafrost thaw and climate change.
89 Assessing these differences at an early stage of permafrost thaw science will avoid the
90 difficulties linked to miscommunication between those impacted and the research community,
91 leading to a more fluent conversation (Kane et al., 2014).

92 **2. Methods and data**

93 Sakha Republic (Yakutia) covers an area of over 3,000,000 km² and the Arctic zone
94 represents about 52% of the territory of the republic. Different indigenous groups – mainly of
95 Turkic origin – have traditionally occupied the Russian Arctic territory (Reisser, 2016).
96 Several waves of settlement have also taken place in this area, involving the spatial allocation

97 of new populations (Heleniak et al., 2013). After the collapse of the Soviet Union, this region
98 underwent deep economic restructuring. The current regional demographic composition is
99 nowadays characterized by multi-ethnicity. Such characteristics can certainly influence the
100 way Yakutian population constructs the notion of agency and copes with undesired effects of
101 the changes they are currently facing. And therefore, should also be taken into consideration
102 when addressing mitigation policies to tackle permafrost thaw and climate change impacts in
103 the region.

104 Furthermore, climate and permafrost shape every aspect of life in the Russian Arctic, and
105 trying to understand their particularities involves exploring numerous complex systems
106 simultaneously. The effects of these factors across several spheres make this socio-
107 environmental system difficult to understand, maintain and predict (Graybill, 2016). Locals'
108 responses to change will be highly conditioned by the interrelationships between them and the
109 different spheres of the system they live in.

110 In the context of the European Nunataryuk Project, we conducted the fieldwork in Yakutsk
111 (the capital city of the Sakha republic) between June and July 2018. The goal of this scoping
112 was to meet regional authorities and research institutes that were identified as having
113 activities, or a mandate, potentially affected by permafrost thaw and climate change. We met
114 these in order to access a more precise understanding of how permafrost thaw risk issues
115 related to their mandates and concerns. In addition to this more institutional scoping, we also
116 conducted face-to-face semi-direct interviews with 24 individuals directly or indirectly
117 concerned by permafrost thaw in Sakha Republic. Interviews were conducted in English and
118 translated to Russian by a local interpreter.

119 Three interview frameworks were created in order to address different local stakes (see
120 appended Table A.1), these interviews framework were targeted at the individuals belonging
121 to the following groups, identified according to occupational criteria first, and to geographical

122 criteria afterward: governmental authorities or people working in/representing research
123 institutions; inhabitants from non-coastal areas of Sakha Republic (including Yakutsk);
124 people living in Tiksi.

125 Interviewing the first category of stakeholders aimed at increasing our understanding of how
126 the regional governmental and research structures interpret and address issues related to
127 permafrost thaw. We also aimed at accessing institutional synergies for coordinated action.
128 The purpose of meeting the individuals included in last two categories was to access locals'
129 perception concerning climate change and permafrost thaw within different geographical
130 contexts (inland vs coastal respectively).

131 Each framework consisted of questions accompanied by complimentary prompts.

132 Semi-direct interviews were designed to ensure a better understanding of the interviewees'
133 experiences, concerns, values, knowledge and ways of thinking, seeing and acting (Schostak,
134 2006) while giving them the sufficient scope to tell us about anything they considered
135 relevant or important. The challenges associated with this methodology are the difficulty in
136 expressing the results quantitatively and the need for a detailed and repeated interpretation of
137 them. Linguistic limitations due to live translations could also lead to a loss of terminological
138 precision.

139 An initial sample of key respondents, mainly from institutions and governmental authorities
140 (See appended Table A.1), was contacted as advised by our local informants. We
141 subsequently relied on the suggestions of the interviewees to contact new potential
142 respondents. This snowball sampling procedure does not represent the population in statistical
143 terms, but this was not the intended aim. Instead, we wanted to capture the diversity of
144 experiences related to permafrost thawing in the Sakha Republic - as seen from its capital
145 city.

146 On average, the interviews lasted 50 minutes with a minimum of 18 minutes and a maximum
147 of 70 minutes. In order to facilitate the interviewing process, interviews were conducted by
148 the authors accompanied by an interpreter. All interviews were recorded. A minority of
149 interviewees expressed their willingness to answer in English. Four participants who were not
150 in Yakutsk at that time agreed to answer the questions in Russian by email. These were
151 translated to English.

152 The whole body of translated interviews was transcribed to English and subjected to
153 qualitative analysis using Atlas.ti 8 (Friese, 2019). This software contributes to elicit meaning
154 from the narratives in a more organized and systemic way. In a first stage, we organized
155 information contained in locals' narratives under the form of thematic codes or categories - a
156 purpose for which atlas.ti has been designed. This forced us to refine concepts and allowed us
157 to visualize similarities and patterns among respondents (Smit, 2002). During this process, it
158 is also possible to identify contradictions and/or different points of view among locals.
159 Secondly, we used the network-building feature which facilitated visually revealing the
160 existing relationships and connections between the elements that locals mentioned - this is one
161 of the major strength of Atlas.ti (Friese, 2019) and is fundamental in risk perception analysis
162 as causal linkages are central. As an outcome of the analysis of the interviews and trying to
163 respect the order and words used by the interviewees, we created a mental map. It functions
164 as a picture of the data but also contributes to better understand the context, and associated
165 causal understanding, in which actors define, value and respond to risk situations.

166 For the final stage, we created broader categories to pool the aforementioned codes according
167 to 6 different levels of action or concerns that we identified: Impacts on natural resources
168 (section 3.1.a, for relationship with Table A2, see text in section 3.1); Impacts on
169 infrastructure (3.1.b); Impacts on health and mental well-being (3.1.c); Governance needed
170 (3.1.d); Knowledge related issues (3.1.e) and Opportunities (3.1.f)

171

172 3. Results and discussions

173 3.1 Initial thematic coding results

174 Throughout the fieldwork, it was noticeable that all the respondents were keen to tell us about
175 their life experiences related to permafrost and their environment. All the interviewees were
176 familiar with the terms “permafrost”, “permafrost thaw” and “climate change”, which were
177 mentioned in our questions and prompts. *Some differences were observed in terms of the type
178 and levels of concerns manifested by locals according to their places of origin (big cities,
179 villages or small settlements, coastal or non-coastal areas, urban or rural areas, etc.).
180 However, this does not represent a contradiction. In fact, these concerns complement each
181 other, demonstrating the wide diversity of dimensions that are currently being affected by
182 climate change and permafrost thaw. It also increases the scientific understanding of local
183 stakeholders’ perceptions regarding the complex network of non-linear and rapid changes in
184 their environment, lives and livelihoods.* All the interviewees seem to be aware of the
185 complex chain of modifications and new risk patterns created by changes to permafrost and
186 the climate in Sakha Republic (see appended Table A.2 which presents representative quotes
187 while organizing them thematically into 5 categories).

188 An in-depth, cross-cutting analysis of the narratives demonstrates that interviewees not only
189 have a similar understanding of the multidimensional changes their environment and societies
190 are currently experiencing, but also that they are able to link these changes with two main
191 elements: permafrost and climate. Interviewees claim to observe modifications which take a
192 number of different forms, for example, an increase in the number of mammoth remains
193 found, an increase in the number and intensity of floods, the detrimental damage to and
194 collapse of infrastructure (buildings, routes, pipelines), landscape modifications as well as

195 changes in the composition and distribution of flora and fauna in the region. All these
196 modifications represent different facets of the same unpredictable and changing reality they
197 are living in.

198 Through this further cross cutting analysis, we identified six overarching (“a” to “f” below),
199 integrative categories (plus an extra one) bringing together the different concerns expressed
200 during the interviews (see codes of the mental map in Figure 1). These were organized into
201 thematic groups. A first general theme refers to “impacts” (“a” to “c” below). The
202 stakeholders interviewed clearly identified several negative impacts of permafrost thaw on the
203 physical elements of their environment, including:

204 **a) Impacts on natural resources:** rivers, soils, mammoth tusks, flora, fauna, etc. They
205 consider these to be closely related to the maintenance of their traditional occupations such as
206 herding, fishing and hunting.

207 “It [permafrost] affects reindeer herders because before we were moving along the
208 coastline. Now the climate has changed, big bushes have appeared and it has become
209 really hard to herd the deer. (...) Because the soil has changed, the lakes are
210 disappearing, there are landslides, insects have appeared, polar bears have started to
211 move around, everything has changed. The birds, the water, the nature, the soil and the
212 weather of course. It appears that the weather affects many things, the routes taken by of
213 birds and animals have changed and there are also migrations, animal diseases.” (quote
214 #1, for more examples see sample quotes #3, 4, 7, 12, 13 in Table A.2)

215 **b) Impacts on infrastructure** (roads, buildings and pipelines) which reduce the possibility
216 for different settlements/villages/towns in Sakha Republic to transport people, goods and
217 supplies between them.

218 “Another challenge for our people is the catastrophic flooding observed in recent years.
219 Why does this happen? Many reasons. More meltwater. More rain. Another reason:
220 maybe because the deltas of these rivers now are not dug and that’s why water can’t
221 flow. But hydrologists say that one of the main reasons for the new floods in the
222 northern rivers is the amount of water which gets accumulated in the surface (more than
223 30%) due to melting permafrost. Then, it comes to the rivers and this is another
224 challenge of permafrost melt.” (quote #2, for more examples see sample quotes #5, 7 in
225 Table A.2)

226 “Permafrost affects badly our buildings and on summer buildings that were built on
227 permafrost, when it melts, they are just going down and the walls are being destroyed
228 because of the movement. In Yakutia, the technology should be special for building
229 houses on permafrost and the materials must be of high quality. I would like to say for
230 roads as well.” (quote #8, for more examples see sample quotes #5, 7 in Table A.2)

231 Interviewees also identified other impacts linked to non-material dimensions that dignify their
232 lives and livelihoods in the region including health, mental well-being, identity and a sense of
233 belonging:

234 **c) Impacts on health and mental well-being** which conveys an holistic understanding of
235 health and its relationship to ecosystem integrity under climate change. It also conveys that
236 permafrost thaw has the double impact of reducing one’s ability to act (a) because of potential
237 health related physical weaknesses and (b) because of stress.

238 “...earlier, 2 or maybe 3 centuries ago, we had epidemics such as the black death. The
239 people and the cattle were buried in some places but we don’t know exactly where. Now
240 the permafrost is melting and they (dead bodies) are appearing during the autumn or
241 they come to the water, rivers, lakes. However, we don’t have any diseases or epidemics

242 in Yakutia yet, but the example of Yamal shows us that this is one of the big problems
243 for us and the future.” (quote #6, for more examples see sample quotes #2, 5, 11, 12, 13,
244 14, 15 in Table A.2)

245 A second theme concerns issues relating to collective action and refers to:

246 **d) Knowledge-related issues:** these refer, on the one hand, to how the new risk patterns
247 affect their traditional knowledge systems and on the other hand to the need for scientific
248 participation and research in terms of permafrost thaw and climate change processes.

249 “...because the ground is moving, changing, that’s why we have to change our
250 migration routes. Sometimes we don’t know what the best route is because everything
251 has become unpredictable. Normally we could predict the weather for one month, for
252 seasons, years! Using these predictions, we could choose routes for more comfort. Now
253 we can’t do it because we don’t know what is happening. All of our traditional
254 knowledge about the weather is being destroyed.” (quote #16)

255 “Most people don’t want to know about the conditions of permafrost. This is a topic for
256 scientists.” (quote #26; for more examples see sample quotes 1, 4, 8, 12, 13, 15, 16 in
257 Table A.2)

258 **e) Governance needed:** multidimensional and multi-scale changes to the environment have
259 created governance gaps that interviewees deemed necessary to be identified, treated and
260 filled by authorities. More specifically, they emphasized the need for new, better adapted
261 norms/regulations.

262 “...all our life is regulated by the official laws, orders and others decrees, for example,
263 period of the year when we can catch fish. But these laws were for the past, now
264 everything has changed and people are losing their harvest (...) And the procedure for
265 changing this regulation is very hard, very bureaucratic. The fish spawning time has

266 changed and all the laws and directives regulated this but now everything has changed
267 and people can't do anything. And if they go to fish during the real spawning time, this
268 might be considered illegal (...) Three years ago, people raised the question of traps for
269 wolves because wolf traps are banned, but now wolves are becoming an epidemic for
270 us. This is a big challenge because every year they take 5-10 thousand reindeer from us”
271 (quote #18 in Table A.2)

272 **f)** An additional category, entitled “**Opportunity**”, was included. Throughout the interviews,
273 people expressed concern about the negative character of perceived changes while only one
274 opportunity was identified, referring to the commercial opportunities that an increase in the
275 number of mammoth tusk finds – sold at impressively high prices in the Asian markets –
276 represent for local inhabitants. However, this is not entirely positive, as it was identified to be
277 an activity that goes against the traditional beliefs of indigenous peoples. With this in mind,
278 one representative of the people of the North said:

279 “In the minds of traditional Northern Peoples, the mammoth is the God of the
280 underworld. And it was a taboo to pick and collect bones. We believe that if, for
281 example, we take this bone or tusk, it opens the door to the underworld. And it will
282 bring us many troubles. It is one of the strongest taboos in our culture. Sometimes,
283 however, some people try to sell them (...) and now we see that collecting mammoth
284 bones is one of the biggest businesses in the North and many people get involved in
285 this business. I see big changes in our traditional life or traditional worldview, because
286 it destroys our traditional beliefs and the connections between older and younger
287 generations. I can say that we are losing our traditional ecological worldview because
288 if you can pick the land ground, you collect these bones, it means that you have
289 stopped believing in our traditions. “

290 **3.2 On causality, values at risk and uncertainty**

291 We further analyzed the causal statements that were associated with these multidimensional
292 impacts, sticking closely to the respondents' stories of permafrost thaw. In doing so, we
293 identified five categories of operators linking permafrost thaw to its perceived origin and
294 impacts: "threatens," "is the cause of", "is associated with," "requires," and "is part of."
295 "Threatens", "is part of" and "is the cause of" are unidirectional operators. "Associated with"
296 and "requires" are bidirectional - which is quite unusual for the latter. These relationships, as
297 observed in our interviews, are mapped in Figure 1.

298 Insert Figure 1 about here

299 Impacts are identified along causal chains which jointly find their origin in permafrost thaw.
300 A fine distinction is made in our corpus: the "is the cause of" and "threaten" distinction.
301 Actual observations are required for the respondent's explicit causal statements (that we
302 associate with the "is the cause of" operator) to be expressed - these observations are
303 expressed as verbs describing (unwanted) impacts. A series of permafrost thaw risks have
304 already been identified and their causal origin is, in the respondents' eyes, quite clear. These
305 impacts and associated causal statements are erosion, floods and forced displacement;
306 mammoth tusk poaching, cultural erosion; damage to pipelines and buildings; and changes in
307 the migration routes of wild and domestic animals.

308 The "threaten" operator refers to causal statement loaded with uncertainty that are associated
309 with objects / values at risk, either directly or indirectly, including cemeteries, health, water
310 quality, underground storage, infrastructures, hunting, reindeer herding, fishing, flora and
311 fauna, roads (see Figure 1).

312 The "associated with," and "requires" bidirectional operators show that the respondents
313 believe that the impacts of permafrost thaw are part of complex interrelated phenomena.
314 Some of these could be expected, such as associating a threat to flora and fauna with a threat

315 to reindeer herding. Some indicate a grasp of climate change and its specific place in the
316 changes observed. For instance, climate change is jointly associated with permafrost thaw and
317 the future. It also allows a threat to be linked to cultural heritage (cemeteries) and health
318 through potential diseases. The “requires” operator reflects the identification of a call to
319 action within the respondents’ narratives. Most of these solutions refer to some sort of
320 collective action be it through state institutions, science, regulation or administrative
321 responsibility.

322 Finally, the “is part of” operator captures causal statements where an initial impact on part of
323 a greater ensemble has an impact on this greater ensemble. This operator is particularly
324 important here as it captures multiple impacts, in the form of threats to hunting, fishing and
325 migratory routes that lead to a general threat to the greater ensemble of local culture.

326 **3.3 Furthering the analysis of the “requires” operator - looking for risk-mitigation** 327 **options through collective action**

328 In order to cope with the new non-linear changes and impacts, respondents explicitly
329 mentioned the need for further action

330 “[...] we can say that the permafrost is really melting and this can only worry the
331 inhabitants of Tiksi. Something has to be done.” (quote #20, for more examples see
332 sample quotes #19, and 21 in Table A.2)

333 and identified the government and the scientific community as being responsible for
334 developing adaptive measures related to permafrost and climate change

335 “Roads cannot be of very good quality because in spring or summer you can take very
336 good roads but then, in winter they can be broken because winters are too cold. We need
337 new methods but it is very expensive. And for me, honestly, the government doesn’t
338 pay attention to roads in Yakutia. As you know, our city is very small so I think that the

339 government can try to create some new methods in our city” (quote #24 for more
340 examples see sample quotes #23, 25, 26 and 27 in Table A.2)

341 They also mentioned the need to update the norms and laws, as in some cases they are no
342 longer adapted to the current changing environment people are living in (see sample quote
343 #17 above). Finally, they also highlighted the importance of defining the administrative
344 responsibility for some new resources resulting from changes to permafrost such as mammoth
345 tusks, as they are being found more frequently. In this respect, a representative of the
346 Melnikov Permafrost Institute said:

347 “In Yakutia now, there have been long discussions with Moscow and the central part of
348 Russia concerning the status of the mammoth tusks. Is it a national resource or not? The
349 issued is raised because all national resources are subject to a special law. They all
350 belong to the central federation, not to the local governments. The Yakutsk Academy
351 for Sciences has a Department of mammoth fauna that is partly working on these issues
352 (...) It is very chaotic and unknown, but very important for making a point on the
353 permafrost economy in coastal areas and climate impacts.”

354 From the analysis of this operator, we can infer that collective action is essentially conceived
355 as something that can only be achieved through the intervention of “upper external” actors. In
356 this respect, the notion of agency could – a priori – be related to a vertical and hierarchical
357 relationships. This confirms some of the findings in Kennedy et al. (2018), including a case
358 study from Sakha Republic. In that case study, agency, or the lack thereof, is identified as
359 limiting local adaptation to climate change.

360 **3.4 Furthering the analysis of the “is part of” operator: when material impacts threaten**
361 **culture**

362 The unidirectional “is part of” operator reflects how changes might lead to physical and
363 material impacts but also represent a threat to cultural dimensions, including the three main
364 traditional activities practiced in Sakha Republic: hunting, fishing and reindeer herding. These
365 are not only economic activities but are also strongly linked to the identity and the worldviews
366 of indigenous people.

367 “...because the ground is moving, changing, that’s why we have to change our
368 migration routes. Sometimes we don’t know what the best route is because everything
369 has become unpredictable. Normally we could predict the weather for one month, for
370 seasons, years! Using these predictions, we could choose routes for more comfort. Now
371 we can’t do it because we don’t know what is happening. All of our traditional
372 knowledge about the weather is being destroyed. You can say the same about each of
373 our traditional occupations, fishing, hunting too. Not only infrastructure.” (excerpt of
374 quote 16 in Table A.2)

375 The increasingly unpredictable environmental and climatic conditions put these traditional
376 occupations at risk of disappearance, and with it, the potential loss or degradation of their
377 traditional knowledge and culture.

378 A deeper analysis of the elements mentioned by respondents appearing in the mental map also
379 reveals an interconnection between the physical and the cultural dimensions

380 “We started to feel these (climatic) changes a very long time ago. In 1995, at the
381 meeting of reindeer herders in the Itum Kalinsky region, we spoke about it. And we
382 spoke about the need to change the migration routes of the reindeer herders because
383 some changes have been observed. This is why the melting of permafrost has a major
384 impact on our traditional lifestyle.” (excerpt of quote #19, see sample quotes #16 and 19
385 in Table A.2)

386 More specifically, physical changes represent a threat to their culture. This is the case of
387 forced displacements, the destruction of underground caves traditionally used by reindeer
388 herders and hunters during migrations, the erosion of places of cultural value such as
389 cemeteries, and the shorter periods of winter roads on which several communities depend to
390 obtain goods and supplies.

391 **3.5 What did we learn in terms of permafrost thaw risk perception**

392 As stated in the introduction and method sections, we accessed perceptions through the
393 narratives told by our respondents. As has been explored in other settings, we did this through
394 the identification of different categories of claims: evidence claims, causal statements;
395 salience claims, statements pointing toward what matters to the respondent; and normative
396 claims, in the form of statements judging the moral dimensions associated to a risk issue
397 (Touili et al., 2014; Vanderlinden et al., 2017).

398 Our results indicate that the causalities associated with permafrost thaw in the interviewees'
399 narratives are quite aligned with current scientific knowledge: climate change is causing
400 annual and seasonal average temperatures changes, which affects permafrost, which in turn
401 affects things that are of interest to humans. This seems to be a relevant result. When
402 envisioning permafrost thaw risk mitigation, there might not be a need for knowledge-
403 centered interventions as our respondents do know what is going on.

404 Furthermore, our results point to the fact that their knowledge and associated causal
405 statements go beyond simple linear causal relationships. Our respondent qualify quite finely
406 the nature of the associations at hand - this was unexpected to us. The various operators that
407 we identified indicate/reveal intervention points. For instance, the “threaten” or “requires”
408 operators point to a quite precise intervention uphill in the causal chain. Alternatively, the “is
409 part of” operator points to larger scale, multiple benefits interventions. These results indicate

410 the complementary nature of scientific knowledge (elucidating the nature of causalities) and
411 layperson narratives (embedding these causalities in everyday observations). The complex
412 fabric of life in a changing environment is better ascertained through local narration and may
413 allow for a better identification of salient issues. Individuals in the Sakha republic perceive
414 permafrost thaw regularly, in context. They understand what is involved, in many dimensions.
415 Their perceptions may inform scientists and policymakers alike.

416 The salience claims that we observed are also informing us on the specifics of permafrost
417 thaw and associated knowledge systems. Our respondents shared the interest that scientists
418 have for infrastructure, biological and non-biological resources and associated economic
419 dimensions (see introduction). Yet they also expressed interest in their culture, their minority
420 status, their cultural reliance on a quite unique environment. When considering the current
421 scientific interest into permafrost thaw (see introduction) there seems to be a discrepancy
422 between what scientists find salient (material dimensions) and what our respondents find
423 salient (a mix of material and non-material concerns). Again, this illustrates the importance of
424 accessing locals' perceptions when envisioning permafrost thaw risk issues. The
425 complementarity of scientific knowledge and locals' perception includes bettering the
426 identification of what matters, to who, and why.

427 Finally, our respondents' narratives include risk mitigation. This stresses the fact that when
428 laypersons perceive permafrost thaw risks, they connect it to its mitigation options. As our
429 respondents appraised the risk situation, they simultaneously imagined potential permafrost
430 thaw risk mitigation avenues. On this dimension, our respondents seem to hold quite a
431 monolithic view: intervention should originate and be conducted from the outside world. This
432 results allows us to ascertain a supplementary dimension of permafrost thaw risk perception
433 analysis. The narratives of the respondents do not only talk about permafrost thaw, but also
434 talk about who they are, in the face of permafrost thaw, and how they construe their ability to

435 face the associated risks. This final result is of critical importance, as action will be needed,
436 and these actions will call for local agency. Our results point to a genuine need for further
437 research into the determinants of local agency in Yakutia.

438

439 **4. Conclusion**

440 Using a series of interviews and coding them thematically, we explored how, when relating
441 their experiences, the inhabitants of Sakha Republic express their understanding of permafrost
442 thaw. During this process, we uncovered key elements such as a high level of awareness
443 regarding permafrost thaw and its impacts - permafrost thaw is a salient issue in Yakutia; an
444 explicit understanding of the complex causal webs that permafrost thaw entails; and the
445 expressed need for potential mitigation strategies that seems to reflect an agency deficit and
446 an associated reliance on external authorities.

447 In this paper, we also clarify how, through the intermeshing of ordinary life experiences,
448 material and cultural impacts are connected and need to be taken into account simultaneously
449 in order to understand precisely how permafrost thaw is taking shape within Sakha Republic.
450 Ordinary life and everyday concerns, both practical and symbolic, ranging from personal to
451 local, regional and national levels, are interconnected and, according to our respondents,
452 should remain so. The material and cultural dimensions of permafrost thaw are two sides of a
453 single coin and are strongly interrelated. The analysis of narratives demonstrated that for
454 locals, geo-physical processes unchained by changes in climate and permafrost undoubtedly
455 transform landscape and alter ecological patterns. But these transformations exceed the
456 physical and material dimensions, and also exert supplementary pressure on the northern
457 culture. Physical degradation (manifested under different forms: as thawing cemeteries,
458 increasing mammoth tusks appearing on permafrost or forced displacements, among others)

459 threatens their symbolic representations, the material practices and the emotional ties that they
460 have developed in that specific land. For locals living in the North, their land is filled with
461 memories, life experiences, and contributed to develop a site-specific way of interpreting and
462 valuating events. Forced restructuring of their cultural features caused by climate change and
463 permafrost thaw might lead to an occasional or irreversible inner fragmentation and socio-
464 cultural rupture.

465 This is why, maintaining a focus on both material and cultural dimensions while conducting
466 research in Siberia may be quite a formidable challenge. This is even more important as our
467 results show that science is understood, by our interviewees, to be one of the central sources
468 of solutions with regard to permafrost thaw. Science-based solutions seem legitimate to our
469 respondents. In this conclusion, we argue that maintaining this close association of material
470 and cultural dimensions while conducting research may help to support this legitimacy.

471 Our results successfully map out permafrost thaw and its impacts, using local interests as an
472 entry point. Furthering this analysis, outside of the capital city, would facilitate a much-
473 needed finer analysis that goes beyond the scope of this paper. Finally, the translation of these
474 results in terms public policies in the face of climate change would appear to us, and we hope
475 to our readership, to be something of a necessity.

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Appendices

Category	Interviewee
Representative of ethnic minorities	Office of the Northern Arctic People's Culture Institute for Humanitarian Research and Indigenous Issues Ex-representative of the Indigenous People in Parliament
Educational authorities	Upper Authorities from the North Eastern Federal University of Yakutsk
Governmental authorities	Minister of Nature Protection
Cultural institutions	Mammoth Museum
Research institutions	The Melnikov Permafrost Institute

	Office of the Arctic 4 researchers in the medical field
Students	Journalism student from Tomponsky District Law student from Yakutsk History student from Tiksi Financial economics student from Anabarsky District 2 students from Tiksi Financial economics student from Vilyuysky District
Traditional occupations	Reindeer herder Seamstress
Other occupations	Entrepreneur from Momsky District Biologist from Kazachie (Ustiansky District) Power supply worker from Siktyakh (Bulunsky District)
TOTAL INTERVIEWEES	24

Table A.1: List of interviewees from the scoping fieldwork in Yakutsk

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(1) Samples associating changes with both permafrost thaw and climate change	Interviewee	Quote #
“It (permafrost) affects reindeer herders because before we were moving along the coastline. Now the climate has	Reindeer herder from	1

<p>changed, big bushes have appeared and it has become really hard to herd the deer. (...) Because the soil has changed, the lakes are disappearing, there are landslides, insects have appeared, polar bears have started to move around, everything has changed. The birds, the water, the nature, the soil and the weather of course. It appears that the weather affects many things, the routes taken by of birds and animals have changed and there are also migrations, animal diseases.”</p>	<p>Kolimskoie</p>	
<p>“Another challenge for our people is the catastrophic flooding observed in recent years. Why does this happen? Many reasons. More meltwater. More rain. Another reason: maybe because the deltas of these rivers now are not dug and that’s why water can’t flow. But hydrologists say that one of the main reasons for the new floods in the northern rivers is the amount of water which gets accumulated in the surface (more than 30%) due to melting permafrost. Then, it comes to the rivers and this is another challenge of permafrost melt.”</p>	<p>Representative of the Institute for Humanitarian Research and Indigenous Issues</p>	<p>2</p>
<p>“Actually, there was an article maybe a month ago. They found a huge glacier that broke away from the shore and the main reason I read in the article was because of permafrost, the weather is getting hotter and today is close to 19°C – a week ago it was -2°C. When I was studying there (Tiksi), the weather was not like that. Maybe we got a few days which were very hot in the middle of July and afterwards it was always very foggy and under 2 degrees. I was really surprised</p>	<p>Student #2 from Tiksi</p>	<p>3</p>

by the news.		
<p>“People living in Tiksi are concerned about climate change and permafrost thaw. (...) For example, I know that students of the Arctic Gymnasium (High School) conduct their own research to identify changes in climatic conditions. (...) Changes in permafrost affected the flora and fauna most severely. New plants are appearing in the tundra, which are more common in the western and southern regions of Yakutia. The animal world has changed habitat. (...) Local hunters also agree with the fishermen and believe that animals traditionally being hunted (deer, arctic foxes) have changed their habitat and moved further away from old places.”</p>	Student #3 from Tiksi	4
(2) Samples associating changes solely with permafrost thaw	Interviewee	Quote #
<p>“...in the houses built on permafrost, the permafrost will soon melt and the building will be destroyed so we need another place to build the houses. Such cases are in villages (...) The special areas for fishermen are being eroded and they need to move their houses in order to survive. And even technology cannot move that.”</p>	Seamstress from Saskylakh	5
<p>“...earlier, 2 or maybe 3 centuries ago, we had epidemics such as the black death. The people and the cattle were buried in some places but we don’t know exactly where. Now the permafrost is melting and they (dead bodies) are appearing during the autumn or they come to the water, rivers, lakes.</p>	Representative of the Institute for Humanitarian Research and	6

<p>However, we don't have any diseases or epidemics in Yakutia yet, but the example of Yamal shows us that this is one of the big problems for us and the future.”</p>	<p>Indigenous Issues</p>	
<p>“I think yes (people are concerned about permafrost) because permafrost thaw begins the erosion process. People start losing their houses which are destroyed. And in the tundra, it creates holes.”</p>	<p>Biologist from Kazachie</p>	<p>7</p>
<p>“Permafrost affects badly our buildings and on summer buildings that were built on permafrost, when it melts, they are just going down and the walls are being destroyed because of the movement. In Yakutia, the technology should be special for building houses on permafrost and the materials must be of high quality. I would like to say for roads as well.”</p>	<p>Student from Yakutsk</p>	<p>8</p>
<p>(3) Samples identifying a weak relevance of permafrost</p>	<p>Interviewee</p>	<p>Quote #</p>
<p>“...people in our city and in our Republic don't usually think about permafrost. We don't care. We only care about winter and I guess people from villages must care about the weather in winter because sometimes they get food for themselves by fishing or hunting and they need to understand when they can go outside and how to get dressed. So, nobody cares about permafrost, we don't think about this.”</p>	<p>Law student from Yakutsk</p>	<p>9</p>
<p>“...most people don't want to know about the conditions of permafrost (...) People are interested in knowing about the conditions of the land under Tiksi because there are seismic</p>	<p>Student #1 from Tiksi</p>	<p>10</p>

<p>movements.”</p>		
<p>“I can’t say whether it (permafrost) is important or not, because permafrost is part of our lives. The entire territory of Yakutia is covered by permafrost and our traditional lifestyle is connected with this, it depends on it.”</p>	<p>Representative of the Institute for Humanitarian Research and Indigenous Issues</p>	<p>11</p>
<p>(4) Samples identifying a strong relevance of permafrost</p>	<p>Interviewee</p>	<p>Quote #</p>
<p>“Our culture, or circumpolar civilizations, is based on these territories where there is permafrost or a cold climate. And that is why each change to permafrost or our climate has an impact on our culture. We started to feel these changes a very long time ago (...) when reindeer herders or fishermen come to a place, they have like a storage place. They put their meat and fish one or two meters deep, but now this is disappearing because the permafrost is melting. All these places are destroyed. However, we still try to make them, but they will be destroyed every time.“</p>	<p>Former representative of the Indigenous People in the Parliament</p>	<p>12</p>
<p>“I cannot speak on behalf of the whole population of Sakha Republic, but for our district it is definitely very important because our entire life is related to it (...) I think that all our life depends on the permafrost so we wouldn’t exist without it. We get food from the reindeer, so if there are no reindeer</p>	<p>Seamstress from Saskylakh</p>	<p>13</p>

<p>we cannot survive, and we also obtain fish.”</p>		
<p>“First of all, it (permafrost) is a visiting card, an image of Yakutia. Secondly, permafrost is really cold and people who live in the cold have a long life expectancy. And thirdly, it’s our culture.”</p>	<p>Young entrepreneur from Momsky District</p>	<p>14</p>
<p>“That (permafrost) is our outstanding special point and that is why we are in a unique place in the world. In earlier times, people just got used to living in such conditions and dislike the heat.”</p>	<p>Financial Economics student from Anabarsky District</p>	<p>15</p>
<p>(5) Samples asserting that traditional knowledge and occupations are being threatened by changes in their environment</p>	<p>Interviewee</p>	<p>Quote #</p>
<p>“...because the ground is moving, changing, that’s why we have to change our migration routes. Sometimes we don’t know what the best route is because everything has become unpredictable. Normally we could predict the weather for one month, for seasons, years! Using these predictions, we could choose routes for more comfort. Now we can’t do it because we don’t know what is happening. All of our traditional knowledge about the weather is being destroyed. You can say the same about each of our traditional occupations, fishing, hunting too. Not only infrastructure.”</p> <p>“...the young generation is not interested in our traditional occupations like reindeer herding, hunting, fishing, because</p>	<p>Representative of the Institute for Humanitarian Research and Indigenous Issues</p>	<p>16</p>

<p>they understand that they are not comfortable: “they don’t give us enough profit for our life”, but this is the base of our traditional lifestyle and knowledge! If these young people find one tusk, the price of this tusk is more than the money from one-year’s work as a reindeer herder or hunter. This is why we can now say that our traditional occupations – reindeer herding, fishing and hunting – are in crisis because people involved in these are very old. They are over 50. If we sustain this situation for a long time, it means we might lose these traditions.”</p>		
<p>“...all our life is regulated by the official laws, orders and others decrees, for example, period of the year when we can catch fish. But these laws were for the past, now everything has changed and people are losing their harvest (...) And the procedure for changing this regulation is very hard, very bureaucratic. The fish spawning time has changed and all the laws and directives regulated this but now everything has changed and people can’t do anything. And if they go to fish during the real spawning time, this might be considered illegal (...) Three years ago, people raised the question of traps for wolves because wolf traps are banned, but now wolves are becoming an epidemic for us. This is a big challenge because every year they take 5-10 thousand reindeer from us”</p>	<p>Former representative of the Indigenous People in the Parliament</p>	<p>18</p>

(6) Samples identifying a need for further action	Interviewee	Quote #
<p>“We started to feel these (climatic) changes a very long time ago. In 1995, at the meeting of reindeer herders in the Itum Kalinsky region, we spoke about it. And we spoke about the need to change the migration routes of the reindeer herders because some changes have been observed. This is why the melting of permafrost has a major impact on our traditional lifestyle. Today it is a reality and every year, on the northern river, Alezeyya, there are floods. This is the result of changing permafrost. Not long ago, the members of the local parliament were interested in this question, and at the beginning of June they organized parliamentary discussions about the impact of climate change on the traditional lifestyles and traditional occupations of indigenous peoples in the North. Now, scientific expert groups and authorities examine the system to make research on this process in order to face this challenge and think about the changes we need. (...) Many changes... We have never paid too much attention to this but now it is urgent. (...) (People) always try to adapt to these changes just as they happen. And they try to raise these questions with their officials to fight against wolves and bears, to help them in flood situations, etc. When we speak about this during parliamentary discussions, I say we don't have a normal program or plan on how to mitigate this, we</p>	<p>Former representative of the Indigenous People in the Parliament</p>	<p>19</p>

<p>only act with the results, not to mitigate or to prevent, only after something happens (...) We must do something to prevent it. We must adapt. We must understand where we are going. All these global questions are for all mankind, we must all work on them.”</p>		
<p>“People living on the coast feel climate change. For example, the winters are very short and almost windless. Strong winds no longer reach the maximum level, as they did 10 years ago.</p> <p>The summers have become mild, the temperature has increased. The reservoirs of ice have changed in the autumn. (...) we can say that the permafrost is really melting and this can only worry the inhabitants of Tiksi. Something has to be done.”</p>	<p>Student from Tiksi #3</p>	<p>20</p>
<p>“Yes, there are several conflicts. It is commonly known that where there it is legal to obtain (mammoth tusks) there is also illegal trade. And the point is that the tusks are going to China. It is the imperfection of the laws that regulate how to obtain these tusks. I hope for your next visit, everything will be clearer.”</p>	<p>Guide from the Mammoth Museum</p>	<p>21</p>
<p>(7) Samples identifying key potential stakeholders associated with the implementation of responses related to permafrost thaw and climate change impacts</p>	<p>Interviewee</p>	<p>Quote #</p>
<p>“The influence of climate on the population is not an issue for the Ministry for Nature Protection. It thinks you should look</p>	<p>Minister of Nature</p>	<p>22</p>

<p>at the research done by the Institute of Health. You should get in contact with the Ministry of International Relations of our region because it is in charge of the research related to health, ecology, life etc..”</p>	<p>Protection</p>	
<p>Now it is the Federal Authorities (responsible for fixing quotas and dates). It’s very hard to change because they are for the whole Russian territory. They don’t think that maybe each territory is different. And the procedure for changing this regulation is very hard, very bureaucratic. The spawning time for fish has changed and all the laws and directives regulated this, but now everything has changed and people can’t do anything. And if they go to fish during the real spawning time, they might be considered illegal. We need to think about regional conditions. For example, three years ago, people raised the question of traps for wolves because you know wolf traps are banned, but now wolves have started to become an epidemic for us. This is a big challenge because every year they take 5 or 10 thousand reindeer from us. This question was only raised when we brought experts from the European Union to this Arctic area four years ago, and they prepared a special document to start treating this problem. However, you see that it is not only a federal responsibility but also an international responsibility!”</p>	<p>Former representative of the Indigenous People in the Parliament</p>	<p>23</p>
<p>“Roads cannot be of very good quality because in spring or</p>	<p>Law student</p>	<p>24</p>

<p>summer you can take very good roads but then, in winter they can be broken because winters are too cold. We need new methods but it is very expensive. And for me, honestly, the government doesn't pay attention to roads in Yakutia. As you know, our city is very small so I think that the government can try to create some new methods in our city"</p>	<p>from Yakutsk</p>	
<p>"I think the main actor must be the government: federal, local, regional government. They must implement special programs on how to mitigate the effects of this climate change or melting permafrost. But we must understand that all that I say is measured by the results. We must think how to prevent and how to support (people from Yakutia)."</p>	<p>Representative of the Institute for Humanitarian Research and Indigenous Issues</p>	<p>25</p>
<p>"I think that the industrialists will cope with the problems (of permafrost thaw) because they do all their business on the permafrost. In permafrost there is oil, natural resources, precious resources, the entire periodic table is there, and of course there are so many people interested in the Arctic in terms of business."</p>	<p>Seamstress</p>	<p>26</p>
<p>"Most people don't want to know about the conditions of permafrost. This is a topic for scientists."</p>	<p>Student from Tiksi #1</p>	<p>27</p>

612 Table A.2: sample quotes representative of the 7 central initial results that were identified:
613 awareness of permafrost thaw (1) linking it to climate change and (2) not linking it to climate
614 change; judgment on the (3) weak and (4) strong relevance of permafrost thaw; (5) expression

615 of the threat to traditional activities represented by permafrost thaw; (6) need for further
616 action; and (7) key stakeholders for implementing adaptive measures related to climate and
617 permafrost

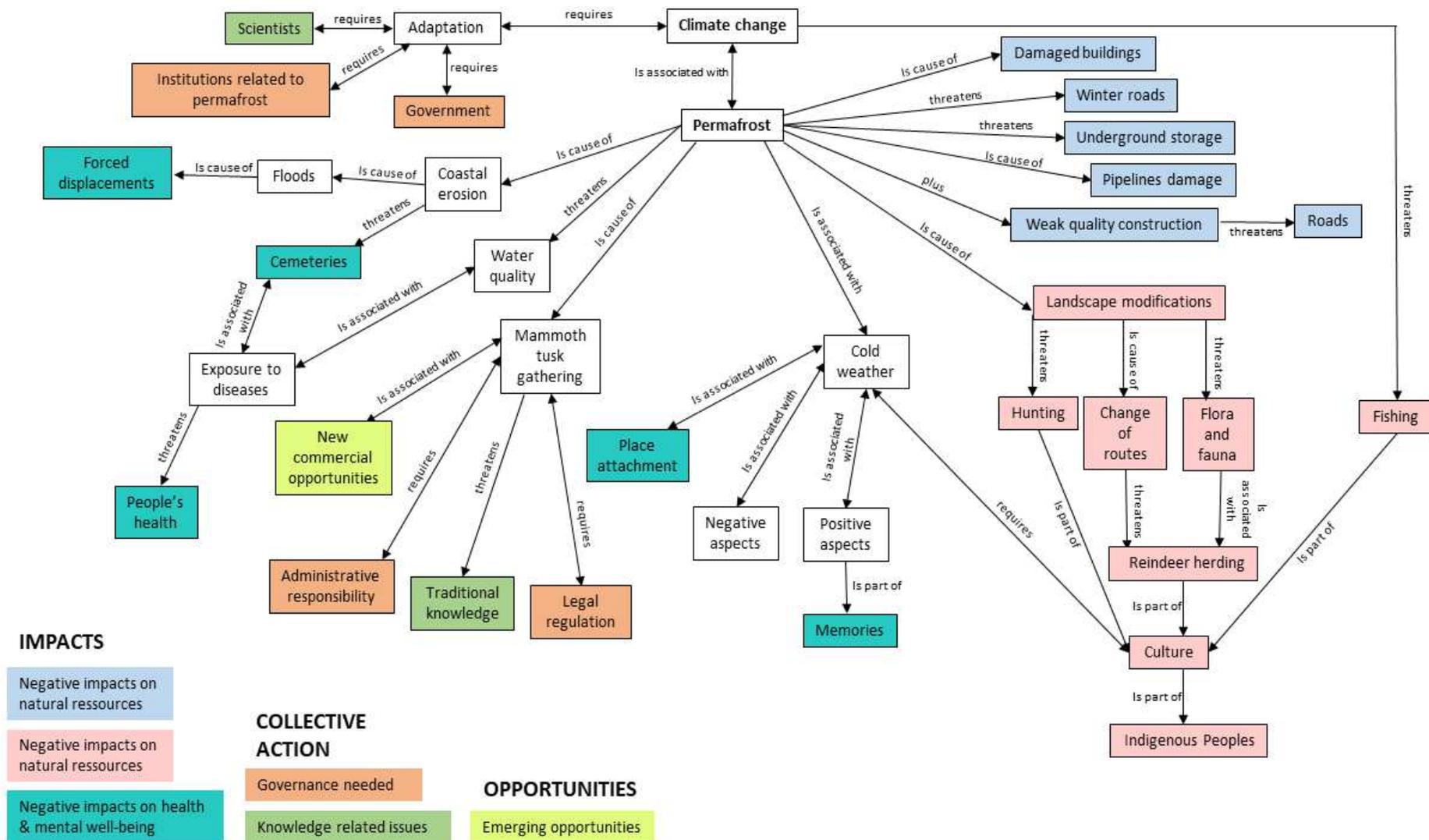


Figure 1: Mental map created with Atlas.ti 8. It shows the relationship between the issues associated to climate change and permafrost thaw, organized in 6 broad categories according to the operators that are described in the text. (PLEASE KEEP COLOURS)