Managing unprecedented risk

Unstable slopes in Iceland and Greenland

Stephanie Matti

Thesis for the degree of PhD
in Anthropology

November 2022

School of Social Sciences

FACULTY OF SOCIOLOGY, ANTHROPOLOGY AND FOLKLORISTICS

UNIVERSITY OF ICELAND

Managing unprecedented risk

Unstable slopes in Iceland and Greenland

Stephanie Matti

Thesis for the degree of PhD
in Anthropology

Supervisor

Helga Ögmundardóttir

Doctoral committee

Guðfinna Aðalgeirsdóttir

Uta Reichardt

Miriam Cullen

November 2022

School of Social Sciences

FACULTY OF SOCIOLOGY, ANTHROPOLOGY AND FOLKLORISTICS

UNIVERSITY OF ICELAND

Stjórnun á fordæmalausri áhættu

Óstöðugar fjallshlíðar á Íslandi og Grænlandi

Stephanie Matti

Ritgerð til doktorsgráðu í mannfræði

Leiðbeinandi

Helga Ögmundardóttir

Doktorsnefnd

Guðfinna Aðalgeirsdóttir

Uta Reichardt

Miriam Cullen

Nóvember 2022

Félagsvísindasvið

FÉLAGSFRÆÐI-, MANNFRÆÐI- OG ÞJÓÐFRÆÐIDEILD

HÁSKÓLI ÍSLANDS

ORCID: 0000-0001-6118-8180

Reykjavík, Iceland 2022

Abstract

Climate change is contributing to shifts in the magnitude and scale of hazards, and the emergence of environmental risks in areas where they were previously unknown. In the Öræfi district of south-east Iceland, a fracture discovered by farmers gathering sheep on the Svínafellsheiði mountainside was the first indication that a large section of the slope was unstable. If the slope fails, the resulting landslide is predicted to contain 60 million cubic metres of bedrock. The debris may remain deposited on the surface of the Svínafellsjökull glacier below; however, there is a chance that the landslide could incorporate ice from the glacial surface, and cause flooding or a tsunami in the proglacial lake. The potential flooding or tsunami represents the main risk for people and infrastructure downhill. The area is a nature tourism hub with approximately 30,000 tourists visiting the glacier each year. An estimated 1,500 people spent time in the at-risk area each day in 2018.

This thesis aims to increase our understanding of how disaster risk management is conducted for unprecedented climate change-related hazards. This was done by examining the social dimensions of the unstable Svínafellsheiði slope from different angles including the contribution of local knowledge to newly emerging hazards, the effects of risk mitigation measures on psychosocial wellbeing, risk communication with affected demographics, and planning for relocation. Using grounded theory ethnography, the study incorporates semi-structured interviews, participant observation, complete participation, document analysis, and a review of the literature. Comparisons are also made with landslide-triggered tsunami risk management in Karrat and Uummannaq Fjords of Greenland. The research was conducted between September 2018 and May 2022.

This research highlights the need for official risk management processes to engage affected people as decision-makers, mitigate the psychosocial impacts of risk management policies, and ensure that all people living and working in exposed areas are informed about the risk and emergency response protocols. A key recommendation is that government authorities pivot from determining risk management and relocation options, to providing a structure to underpin and support community agency. By identifying complex patterns of exposure and vulnerability, this research establishes a nuanced understanding of the risk that can help guide the risk management and community resilience to the unstable slope. The findings can inform risk management and relocation processes in other societies facing unprecedented potentially-fatal climate change-related hazards.

Ágrip

Loftslagsbreytingar valda sífellt fleiri og alvarlegri tegundum náttúruvár og umhverfistengdar hættur koma nú betur í ljós á landsvæðum sem hafa jafnvel aldrei áður þurft að kljást við slíkt. Í Öræfasveit, í heiðinni fyrir ofan Svínafellsjökul, uppgötvuðu bændur í fjárleit sprungu í berggrunninum sem var fyrsta vísbending um að stór hluti hlíðarinnar væri óstöðugur. Skríði hlíðin af stað getur það valdið framhlaupi af allt að 60 milljónum rúmmetra af efni. Framhlaupið gæti stöðvast fyrir neðan, á jöklinum sjálfum, en það er líka hugsanlegt að það hrífi með sér ís af yfirborði jökulsins, ýti við framhlaupi frá neðrihluta hans eða valdi flóðbylgju frá jökullóninu, sem allt myndi hafa mikil áhrif á fólk og mannvirki á áhrifasvæðinu fyrir neðan. Svæðið er vinsæll ferðamannastaður og árlega koma um 30.000 manns til að skoða jökulinn. Árið 2018 komu um 1.500 manns daglega þangað sem hættan er mest.

Doktorsritgerð þessi hefur það markmið að auka skilning á því hvernig viðbragðsáætlanir og aðgerðir eru framkvæmdar þegar um er að ræða óþekktar loftslagstengdar hættur. Rannsóknin felst í því að kanna hinar ýmsu félagslegu hliðar þeirrar vár sem stafar af sprungunni í Svínafellsheiði, m.a. út frá staðbundinni þekkingu á nýjum hættum af þessu tagi, kanna áhrif viðbragðsáætlana á sálfélagslega líðan, skoða þau samskipti um vána sem eiga sér stað milli ólíkra hópa og að varpa ljósi á áætlanir um brottflutning fólks af hættusvæðinu. Notuð var etnógrafísk aðferð, með aðferðafræðilegri nálgun grundaðrar kenningar, og var gögnum safnað með hálfopnum viðtölum, þátttökuathugunum, skjalarýni, sem og víðtækri könnun á heimildum á viðkomandi rannsóknasviði. Einnig var gerður samanburður á því tilviki sem er í brennidepli rannsóknarinnar við annað sambærilegt tilvik, þ.e. viðbrögð og áætlanir sem gripið var til þegar flóðbylgjur af völdum framhlaups urðu í Karrat- og Uummannaqfjörðum á Grænlandi. Rannsóknin var gerð frá september 2018 til maí 2022.

Í ritgerðinni eru færð rök fyrir því að við gerð viðbragðsáætlana og í aðgerðum hins opinbera verði að hafa það fólk sem er í hættu með í ráðum, að það þurfi að leitast við að milda þau sálfélagslegu áhrif sem stefna hins opinbera í gerð viðbragðsáætlana hefur, og að ganga verði úr skugga um að öllum sem búa og starfa á áhrifasvæði tiltekinnar náttúruvár sé gerð ljós sú hætta sem af henni stafar og hvað neyðar- og viðbragðsáætlanir þar að lútandi fela í sér. Ein af lykilniðurstöðunum er að hlutverk yfirvalda ætti frekar að snúist um að efla íbúana sem virkan geranda í viðbrögðum og aðgerðum en einblína eingöngu á viðbragðsáætlanir og brottflutning sem slík. Rannsókn þessi sýnir fram á hve flókið það er fyrir samfélag að vera

berskjaldað fyrir náttúruvá og framlag hennar er blæbrigðaríkur skilningur á þessari stöðu sem nýst gæti til áhættustjórnunar og aukinnar seiglu samfélagsins á áhrifasvæði sprungunnar í Svínafellsheiði í Öræfasveit. Rannsóknin er einnig framlag til áhættustjórnunar og áætlana um brottflutning fólks á öðrum svæðum í heiminum þar sem í auknum mæli er tekist á við náttúruvár af völdum loftslagsbreytinga, sem oft stofna lífi fjölda fólks í hættu.

Acknowledgements

There are many people that have supported me on this PhD journey who I would like to thank. Firstly, I am grateful to the people living and working in Öræfi who were so generous with their time and knowledge. Without their valuable contributions, this thesis would not have been possible. I would also like to extend my sincere thanks to people working on assessing and managing the large landslide risk, who took time out of their busy schedules to share their experiences and knowledge with me.

I owe a deep debt of gratitude to my supervisor Helga Ögmundardóttir for her support throughout the PhD process. She has been everything I could ever wish for in a PhD supervisor. Working with Helga has been a real privilege. I am also profoundly grateful to my doctoral committee members—Guðfinna Aðalgeirsdóttir, Uta Reichardt and Miriam Cullen—for their guidance, constructive criticism, and enthusiasm. This thesis was also improved through invaluable feedback by the discussants Deanne Bird and Kristoffer Albris.

I am grateful to the University of Iceland for funding my research through the Doctoral Grants of The University of Iceland Research Fund. Finally, my heartfelt thanks go to my husband Danni, my parents, and the rest of my family and friends for their love and support.

Table of contents

List of figures

List of tables

List of articles

Article I	Matti, S., & Ögmundardóttir, H. (2021). Local knowledge of emerging hazards: Instability above an Icelandic glacier. *International Journal of Disaster Risk Reduction, 58.* https://doi.org/10.1016/j.ijdrr.2021.102187
Article II	Matti, S., Ögmundardóttir, H., Aðalgeirsdóttir, G., & Reichardt, U. (2022). Psychosocial response to a no-build zone: Managing landslide risk in Iceland. *Land Use Policy, 117.* https://doi.org/10.1016/j.landusepol.2022.106078
Article III	Matti, S., Ögmundardóttir, H., Aðalgeirsdóttir, G., & Reichardt, U. (2022). Communicating the risk of a large landslide above a glacier with foreign tourism employees in Iceland. *Mountain Research and Development. 42*(2). https://doi.org/10.1659/MRD-JOURNAL-D-21-00051.1
Article IV	Matti, S., Reichardt, U., Cullen, M., & Vigfúsdóttir, A. (n.d.). Planned relocation due to landslide-triggered tsunami risk in recently deglaciated areas. Submitted to *International Journal of Disaster Risk Reduction* (under review).

Co-authored articles

For all articles, the author was responsible for developing, researching, and writing. The co-authors reviewed the concepts and articles, and assisted with editing. Articles I, II, III and IV are presented in Sections 5, 6, 7 and 8 of this thesis respectively. Articles I, II and II are included as published except formatting changes to ensure consistency with the thesis as a whole, and the correction of minor errors text identified later in the PhD process. Article IV was under review at the time of submission.

List of conference presentations

Matti, S. (2019). *Adapting to emerging hazards: Instability above an Icelandic glacier.* Paper presented at International Glacier Society (Nordic Chapter) Conference, held 29 October to 1 November 2019. Reykholt, Iceland.

Matti, S. (2020). *Adapting to newly emerging climate change-related hazards: Svínafellsheiði fracture.* Paper presented at HÍ Social Science PhD conference, held 18 September 2020. Reykjavík, Iceland.

Matti, S. (2021). *Managing the risk of a large landslide onto an Icelandic glacier*. Paper presented at GLOF Conference and Workshop 2021, held 7 to 9 July 2021. Graz, Austria; online.

Matti, S. (2021). *Psychosocial response to risk mitigation measures in Iceland.* Paper presented at Nordic Network on Climate-Related Displacement and Mobility Workshop, held 16 September 2021. Copenhagen, Denmark; online.

Matti, S. (2021). *Psychosocial response to risk mitigation land use planning in Iceland.* Paper presented at International Society for Integrated Disaster Risk Management (IDRiM), held 22 to 24 September 2021. Kyoto, Japan; online.

Matti, S. (2022). *Psychosocial response to risk mitigation measures in Iceland*. Paper presented at European Geosciences Union General Assembly 2022, held 23 to 27 May 2022. Vienna, Austria; online.

Abbreviations

DCPEM	Department of Civil Protection and Emergency Management
DRRM	Disaster Risk Reduction and Management
FI	Foreign inhabitant
GG	Glacier guide
GLIMS	Global Land Ice Measurements from Space
GO	Government official
IASC	Inter-Agency Standing Committee
IMO	Icelandic Meteorological Office
IPCC	Intergovernmental Panel on Climate Change
KNR	Kalaallit Nunaata Radioa
LI	Local inhabitant
MG	Municipal government authority
RM	Risk manager
S	Scientist
T	Tourist
TE	Tourism expert
UN	United Nations
UNDRR	UN Office for Disaster Risk Reduction
UNESCO	UN Educational, Scientific and Cultural Organisation
UNPFII	UN Permanent Forum on Indigenous Issues

1 Introduction

Hammersley and Atkinson write that “sometimes, initial contacts may completely transform research plans” (2007, p. 3). It was the case with this study. Before starting my doctorate, I worked in humanitarian response for several years including with the United Nations Office for the Coordination of Humanitarian Affairs in Pakistan. In this position, I helped coordinate response to several disasters including destructive floods caused by the sudden outburst of glacial lakes in the Karakoram. Entering the PhD programme at the University of Iceland, my plan had been to gain a strong grounding in anthropological methods, risk management, and the science of glacial lake outburst floods before returning to conduct research in northern Pakistan.

In the first weeks of my PhD, I conducted an interview with a scientist about glacial lake outburst floods in Iceland. Towards the end of the interview, she described the unstable Svínafellsheiði mountainside in south-eastern Iceland, which could cause a large landslide onto the glacier below. The scientist explained how it was unlike any other risk that had been assessed or managed in the country, both due to the scale and type of hazard. I was interested, and left the interview with details of several people to contact for more information. In Liebow’s ethnographic study on the experiences of low-income males, he writes that “I decided, I would get back to my original plan – nothing had been lost. But tomorrow never came” (1967, p. 238). My first interview similarly served as an entry point into the subject matter that would end up becoming the topic of my whole PhD.

The instability in the Svínafellsheiði slope was discovered in 2014 by local farmers gathering sheep during the autumn round up. Subsequent investigation revealed that the fracture was 1.7 kilometres long, and rising up to 400 metres above the Svínafellsjökull outlet glacier. Scientists predict that the slope instability could cause a large landslide with 60 to 100 million cubic metres of material in motion (IMO, 2018a). Such a landslide could break up the surface of the Svínafellsjökull glacier below. This ice—together with water from the proglacial lake[1]—may be incorporated into the debris moving downhill, threatening inhabitants, employees, tourists, sheep and infrastructure in the area (Sæmundsson, 2018; Gylfason, 2018). Recent deglaciation and the melting of permafrost have contributed to an increase in large landslides onto glaciers in Iceland with four incidents between 1950 and 2018 (IMO, 2018; IMO 2018a; Saemundsson & Margeirsson, 2016). Icelandic people have a long history of managing environmental risks

[1] Proglacial lake refers to a body of water dammed by the glacier and rock moraines during glacial retreat.

including volcanic eruptions, glacial floods, surging glaciers and extreme weather. However, the unstable Svínafellsheiði slope represents the first time people have knowingly been exposed to this type of hazard in Iceland, and the risk managed (Helgason et al., 2018).

Glaciers cover approximately 10 per cent of the Icelandic landmass (Björnsson & Pálsson, 2008). The mass balance and coverage of these glaciers have been decreasing at an unprecedented rate in recent decades. Between 1890 and 2019, the total area covered by glaciers in Iceland decreased by 18 per cent, representing a loss of 2,200 square kilometres (Hannesdóttir et al., 2020). This is in-line with the general decline of glaciers globally due to climate change (Hock et al., 2019; Hugonnet et al., 2021). The trend of glacier retreat and permafrost decline is projected to continue in most areas of the world throughout the 21st century (Hock et al., 2019). Glacial retreat, permafrost thaw and increased water flow decrease the stability of the surrounding slopes, resulting in landslides in areas where there is no record of such events in the past (Hock et al. 2019). As the Icelandic glaciers retreat, landslides in the surrounding slopes are predicted to become increasingly frequent (Sæmundsson & Margeirsson, 2016).

Svínafellsjökull is an outlet glacier from Vatnajökull, Europe's largest ice cap by volume (Schmidt et al., 2020). Vatnajökull and the surrounding areas serve as a real-time observatory of glacial changes due, in part, to the easy accessibility of the area (Baldursson et al., 2018); it is also one of the most vulnerable areas to glacial floods, volcanic eruptions and climate change in Iceland (Sigurmundsson, 2013). The intense research interest is evidenced in the high number of peer reviewed papers published about the Vatnajökull area—some 775 papers in the last 50 years—on a range of topics including volcanism, glaciology, geomorphology, plate tectonics, and biology (Baldursson et al., 2018). Recent research on Svínafellsjökull and the surrounding area has focused on glacial geomorphology (Everest et al., 2017), geo-microbiology (Toubes-Rodrigo et al., 2016; Toubes-Rodrigo, 2017), jökulhlaup risk (Pagneux, 2016; Helgadottir et al., 2015), as well as glacier tourism (Stewart et al., 2017; Welling & Árnason, 2016; Welling & Abegg, 2019; Welling, 2020) and social history (Evans, 2016; Ives, 2007). Meanwhile, risk management research in Iceland has focused primarily on volcanic hazards (Gísladóttir & Jóhannesdóttir, 2016; Bird & Gísladóttir, 2014; Jóhannesdóttir & Gísladóttir, 2010; Bird et al., 2011), avalanches (Grímsdóttir, 2008; Margreth et al., 2014), and, to a lesser extent, flooding (Pagneux et al., 2011; Jóhannsdóttir, 2019). Social science research into the risk management of the Svínafellsheiði slope, and large landslides onto glaciers in Iceland more generally represents a gap in the literature that this thesis addresses.

Iceland is prone to a multitude of hazards including extreme weather, storm surges, floods, earthquakes, volcanic eruptions, and drift ice, however, most fatalities in the country have been attributed to rapid mass movements in the form of avalanches or landslides, which have claimed over 1,000 lives since the time of settlement in 874 AD (Van Well et al., 2018). In the 20th century, landslides and snow avalanches claimed 27 and 166 lives respectively, and caused massive economic losses (Jóhannesson & Arnalds, 2001). Two snow avalanches that occurred in Súðavík and Flateyri in the winter of 1995, represented the deadliest disasters related to natural hazards in Iceland in recent decades with 34 fatalities collectively (Nadim et al., 2008). Both occurred in areas previously considered safe (Arnalds et al., 2004). Prior to these avalanches, little effort had been put into researching and managing the risk of mass movements in Iceland (Sæmundsson et al., 2003). While avalanche research has increased significantly in the period since 1995, research into landslide risk across the country remains scarce (Sæmundsson et al., 2003).

During the study period, on 18 December 2020, a landslide fell on the town of Seyðisfjörður in eastern Iceland damaging more than 10 buildings. The landslide "ranks as the most damaging landslide to have affected an urban area in Iceland" (IMO, 2021, p. 1). A scientist at the Icelandic Meteorological Office (IMO; *Veðurstofa Íslands*) noted that they "did not expect a landslide of this magnitude" and that they "underestimated conditions at the site where the landslide fell" (IMO, 2021, p. 1). This contributed to an increased focus on research into landslide risks in Iceland, however, there still remains a dearth of funding and human resources for research on the topic.

Large landslides are those with a volume of more than one million cubic metres (Bonnard et al., 2004). Between 1950 and 2018, 11 large landslides occurred in Iceland (IMO, 2018c). Four of these fell onto glaciers, the largest of which occurred on Steinsholtsjökull in 1967 and involved 15 million cubic metres of debris (Sæmundsson & Margeirsson, 2016). About half of the debris was deposited on the glacial surface, sending a huge mass of rock, air, ice, and water into the proglacial lake and causing a tsunami 75 metres high (Kjartansson, 1967). Based on current research, if the unstable section of the Svínafellsheiði slope collapses in a single event, the mass movement would be between four and seven times the volume of the large landslide that fell onto Steinsholtsjökull (Sæmundsson et al., 2019). Two other large landslides onto glaciers occurred in the Öræfi district: 4.5 million cubic metres on Morsárjökull in March 2007; and 5.4 million cubic metres on Svínafellsjökull, close to the current slope instability, in February 2013 (IMO, 2018c).

There is no record of a large landslide onto a glacier affecting people or infrastructure since the country was first settled in the 9th century (Gylfason, 2018). As the Svínafellsjökull glacier retreats, it provides less buttressing support for the over-steepened valley flanks, leaving them susceptible to failure (Ballantyne, 2002; IPCC, 2012). Typical triggers of mass movements in Iceland include heavy precipitation, rapid snowmelt, seismic activity, permafrost thaw, as well as the undercutting of mountain slopes by ocean waves or glaciers (Sæmundsson et al., 2003; Helgason et al., 2018).

This thesis also analysis the risk management of the Svínafellsheiði unstable slopes through a broader lens with reference to landslide-triggered tsunami risk in Greenland. Located less than 300 kilometres from Iceland, Greenland represents another society that has started managing climate change-related landslide-triggered tsunami risk for the first time in the past decade. On 17 June 2017, Nuugaatsiaq experienced a tsunami triggered by a large landslide 32 kilometres further into the Karrat Fjord. The tsunami left four people dead, nine injured, and destroyed or damaged most buildings in the village (KNR, 13 April 2022a; Figure 13). After the tsunami, all 75 residents from Nuugaatsiaq and 99 residents from the nearby village of Illorsuit were evacuated, and later informed that they would not be able to return due to ongoing tsunami risk (Svennevig et al., 2020; Strzelecki & Jaskólski, 2020; KNR, 20 July 2019). A scientific assessment of slopes in the area following the tsunami identified four additional unstable slopes: three close to the area that caused the 2017 tsunami, and one about 50 kilometres south (KNR, 13 May 2021b). An additional 176 residents from seven communities were deemed to be living in houses exposed to tsunami risk, and were offered support to relocate (KNR 17 June 2021a; KNR 11 May 2021a; KNR 23 May 2021). While other countries such as Norway, the USA and Canada, have a long history of managing the risk of landslide-triggered tsunamis, by examining the risk management of the Svínafellsheiði unstable slopes in relation to the Karrat and Uummannaq Fjords in Greenland, this PhD study aims to focus attention on the process of how societies manage historically unprecedented types of risk.

Understanding the challenges posed by climate change and developing appropriate responses requires input from a wide range of natural and social sciences (Barnes et al., 2013). Anthropology and other social sciences are “central to understanding how people and societies comprehend and respond to environmental changes, and are pivotal in making effective policies to cut emissions and collaborate across the globe” (Victor, 2015, p. 28). Such research draws on the discipline’s long-term in-depth fieldwork, close observation of everyday life and social relationships, and holistic examination of societies (Roncoli et al., 2009). While a focus on climate change has emerged in recent decades, anthropology has had a long engagement with relevant topics, including society-environment interactions, international development, vulnerability, communication, and risk management (Barnes et al., 2013). The overall approach of anthropology of climate change is broadly guided by political ecology theory, which explores the politicisation of human interactions with the environment (Baer & Reuter, 2015).

Victor (2015) argues that as of the fifth assessment report published in 2014, the Intergovernmental Panel on Climate Change (IPCC) had only engaged a narrow range of the social sciences—primarily economics—as part of the assessment process, while other social sciences including anthropology were marginalised. Barnes et al. (2013) came to similar conclusions about the contribution of anthropology to climate change debates more generally. Several factors make it challenging to incorporate anthropological research into climate change discussions. Anthropology tends to work on more limited time and geographical scales than climate models, making it difficult to reach broad generalisations (Barnes et al., 2013). The research also tends to be holistic rather than compartmentalised by sector, making it more unwieldy for government agencies and other decision-makers to take into account the results (Eriksen, 2020). However, Eriksen (2020) argues that, given the complex and interconnected reality of climate change-related issues, the holism and context specificity of anthropology is precisely what is needed. For example, anthropological analysis can: inform local adaptation, planning and mitigation strategies; shed light on how power dynamics affect climate change action; and examine how groups with different views and interests interact (Barnes et al., 2013).

There have been persistent calls for an expansion of anthropological research into the drivers, impacts, and responses to climate change (e.g. Crate, 2008; Jasanoff, 2010; Hulme, 2011; Barnes et al., 2013; Fiske at al., 2014; American Anthropological Association, 2015; Carey, 2012). The field has expanded significantly since Crate and Nuttall (2009) published their pioneering work on anthropology and climate change. Examples of topics covered in this diverse research agenda include: climate scientists and decision-makers (Lahsen, 2008); retreating glaciers (Carey, 2010; Orlove et al., 2010); climate change communication (Callison, 2014); carbon trading and markets (Whitington, 2016); institutions implementing early warning systems (Marchezini, 2020); the role of social media in flood governance (Albris, 2018); and relations between humans and materials/conditions, including ice (Hastrup, 2012), wind (Howe, 2015), air (Choy & Zee, 2015), and rain (Radonic, 2019).

Climate change is contributing to the magnitude, frequency and location of natural hazards (Hock et al., 2019). As a result, disaster risk management is becoming an increasingly important component of climate change response. Disasters can cause loss of life, injury, and property damage, as well as negatively affect productivity, and reduce access to healthcare, food, water and livelihoods (Marshall, 2020). Disaster risk is composed of the physical likelihood of an event occurring, as well as the exposure and vulnerability of people to the hazard (Kelman et al., 2015; Wisner et al., 2004). To examine the effect of climate change on disaster risk, therefore, the hazard, and the exposure and vulnerability of people to the hazard need to be considered (Kelman, 2015). Wisner (2020) clarifies that vulnerability is not a permanent or intrinsic characteristic; rather, people are made vulnerable by social processes, and people or institutions that wield power can reduce or increase the burden of vulnerability. Climate change affects not only hazards, but is also a driver of vulnerability, changing local environmental conditions so quickly that local knowledge cannot keep pace (Kelman, 2015).

Climate change-related hazards will increasingly emerge in areas where they were previously unknown. The exposure of people to these hazards has further also increased due to nature tourism, growing populations and socio-economic development (Baldursson, 2018). An improved understanding of community vulnerability and capacity along with community views, beliefs and behaviours can contribute to the development of more nuanced approaches to risk management in Iceland and globally.

1.1 Aim and research objectives

The main aim of this thesis is to increase our understanding of how disaster risk reduction and management is conducted for newly emerging climate change-related hazards. It focuses on understanding how local inhabitants and authorities perceive and respond to newly emerging risks before they turn into disasters. This is done by examining the case of the unstable Svínafellsheiði slope and, to a lesser extent, landslide-triggered tsunami risk in Greenland, from different perspectives including:

(a) the contribution of local knowledge to disaster risk reduction and management when a community is facing a hazard for the first time;
(b) the effect of risk management processes on the psychosocial wellbeing of people exposed to the risk;

(c) how different groups, including foreign tourism employees, are included in risk communication processes; and
(d) planning for relocation based on a comparison with communities exposed to landslide-triggered tsunamis in Karrat and Uummannaq Fjords in Greenland.

1.2 Structure of thesis

This PhD thesis is structured as follows.

Section 2 provides a description of the main field site in the Öræfi district of south-east Iceland, and a brief overview of the field site of Karrat and Uummannaq Fjords in Greenland covered in Section 8. For the main field site, this section includes information about the climate, population, economy, risks, and existing risk management processes.

In Section 3, the research design and methods underpinning this PhD study are presented. The overall research approach of this PhD study is based on grounded theory ethnography conducted between September 2018 and May 2022. The qualitative methods used were semi-structured interviews, complete participation, participant observation, document analysis, and a supporting literature review. This section also reflects on my positionality, the formulation of ideas, the process of entering and staying in the field, and ethical considerations.

Section 4 describes the conceptual background to the study. The thesis explores risk management in a location that has been heavily affected by an increase in nature tourism, and specifically glacier tourism. Specific concepts within disaster risk management that were identified through grounded theory ethnography were explored in this section, including local knowledge, psychosocial coping in the pre-impact phase, land use planning, risk communication, and planned relocation.

The article entitled "Local knowledge of emerging hazards: Instability above an Icelandic glacier” is included as Section 5. The article presents an analysis of how local knowledge of the area around Svínafellsheiði is relevant to risk management processes. While a focus on local knowledge is not new in disaster risk management, it is rarely explored in the context of developed countries such as Iceland. The analysis finds that risk managers should pay more attention to the location-specific knowledge of local inhabitants, including for newly emerging climate change-related risks.

The article entitled “Psychosocial response to a no-build zone” is included as Section 6. This article examines how land use planning, and specifically how no build zones, can have adverse psychosocial effects on the people affected. There is a substantial body of literature on psychosocial effects in the post-impact emergency response phase of a disaster. The analysis draws attention to how disaster risk reduction can have psychological and mental effects on the people affected in the pre-impact phase.

The article entitled “Communicating risk in glacier tourism” is included as Section 7. The article focuses on a demographic—tourism employees—that are often overlooked in disaster risk management. The analysis highlights the tendency of government-led risk management systems in Iceland to focus on citizens as the basic unit of analysis. A key recommendation of this section is that Icelandic disaster risk management systems revise how exposure is calculated and risk is communicated due to demographic shifts stimulated by the growth of tourism in the past decade.

The article entitled “Planned relocation due to landslide-triggered tsunami risk in recently deglaciated areas” is included as Section 8. This section includes insights from the risk management of the unstable Svínafellsheiði slope, as well as landslide-triggered tsunami risk in the Karrat and Uummannaq Fjords of Greenland. The analysis focuses on how planned relocation efforts can be prepared, managed and communicated in ways that are more inclusive of local perspectives.

The final section presents the overall findings of this PhD thesis, outlines key recommendations, and draws attention to avenues for further research.

2 Field site

2.1 Öræfi district, Iceland

This thesis focuses on the settlements of Freysnes (63.9907° N, 16.8969° W), Svínafell (63.9792° N, 16.8913° W), and Skaftafell (64.0704° N, 16.9752° W), as well as the surrounding areas, in the Öræfi district of south-eastern Iceland (Figure 1). The district spreads around the base of the ice-capped Öræfajökull stratovolcano, which extends south from the massive Vatnajökull ice cap. The landscape is marked by steep outlet glaciers that plunge from the ice cap, and their meltwater rivers. The settlements of Freysnes, Svínafell, and Skaftafell are located nearby Svínafellsjökull glacier (64.0186° N, 16.8215° W). Svínafellsjökull and the surrounding Svínafellsheiði mountainside (Figure 2) are part of the Vatnajökull National Park, established in 2008 (Baldursson et al., 2018; Parliament of Iceland, 2007).

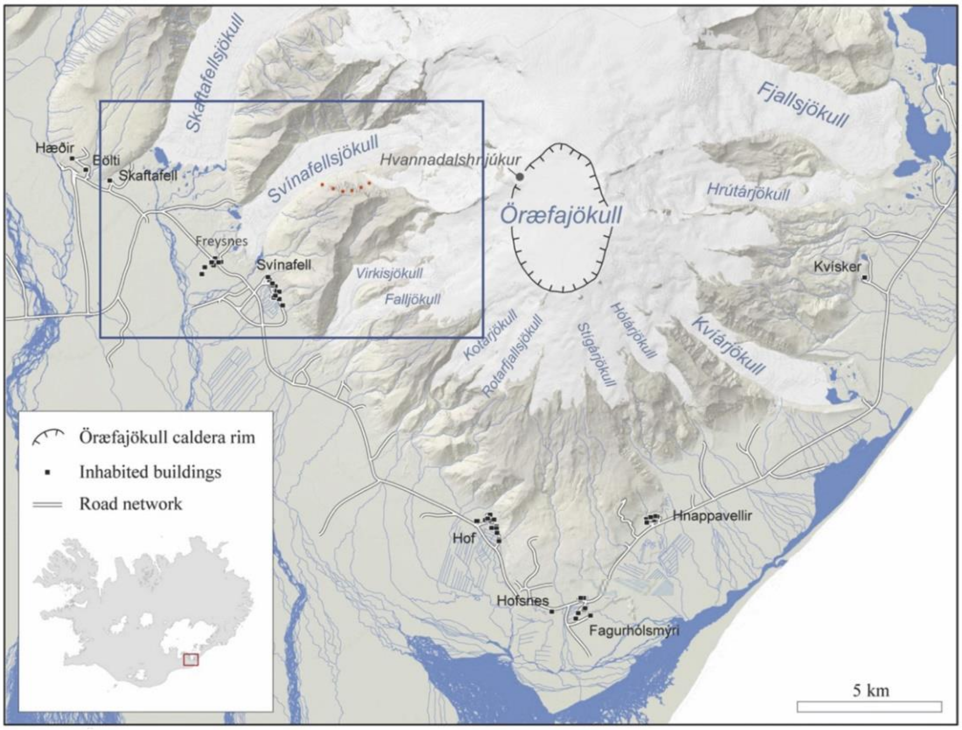


Figure 1: Location of the Öræfi district (Base map Roberts and Guðmundsson, 2010). The rectangle indicates the area covered by Figure 2.

Thompson et al. (2017) observed that the unpredictability of disasters related to natural hazards, often precludes the collection of pre-disaster data for research purposes. This particular field site was chosen because it represented a rare opportunity to study risk management in a community facing a large-scale existential climate change-related risk for the first time. The chosen field site is geographically bounded, limited to areas potentially exposed to the risk and adjacent settlements.

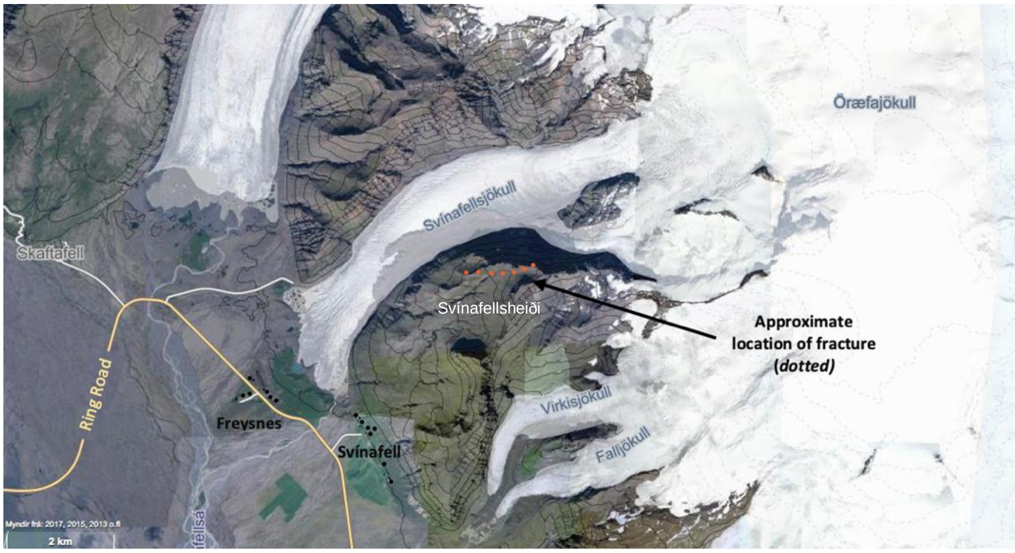


Figure 2: Location of Freysnes and Svínafell settlements in relation to Svínafellsheiði (Base map: map.is with detail added by Stephanie Matti)

Historically, settlements in Öræfi were among the most inaccessible in Iceland—with large glacier-fed rivers blocking access routes. This changed with the bridging of the Skeiðará river in 1974 (Baldursson et al., 2018). According to the 2018 census, the Öræfi district had 151 permanent inhabitants with 77 males and 74 females (Statistics Iceland, 2020). Of these seven per cent were 10 years or younger, 11 per cent were aged between 11 and 20 years, 34 per cent between 21 and 30 years, 17 per cent between 31 and 40 years, seven per cent between 41 and 50 years, 10 per cent between 51 and 60 years, and 15 per cent were over 60 years (Statistics Iceland, 2020). These figures do not take into account over one hundred foreigners living in the area on a temporary basis, primarily working in the tourism sector. Of the 151 people registered as living in the Öræfi district in 2018, an estimated 30 local inhabitants—both adults and children—were living in Svínafell and Freysnes, the two communities potentially at risk from the unstable Svínafellsheiði mountainside (personal communications with local inhabitant, 7 October 2022).

Recent decades have seen dramatic changes as the sparsely populated community has shifted from a dependence on agriculture and fishing to large-scale tourism (Welling & Abegg, 2019). Several of the outlet glaciers—including Svínafellsjökull—have become significant tourist attractions. In the period from 2010 to 2017, tourism to Iceland increased from 448,000 foreign visitors per year to over 2.2 million people per year representing an almost five-fold increase (Icelandic Tourist Board, 2018). This rapid growth in tourism nationally also translated into a huge increase in the number of visitors to glacier sites in Öræfi. For example, visitors to Svínafellsjökull increased from 16,208 visitors in 2015 to 27,455 in 2018 (Þórhallsdóttir & Ólafsson, 2020 cited in Welling, 2020). Some 37 per cent of tourists who visited the area, participated in a guided glacier tour, while 76 per cent of visitors viewed the outlet glaciers at a "short distance" (Welling et al., 2020).

During the COVID-19 pandemic, global tourism virtually ceased, and Iceland was no exception. The number of foreign visitors to Iceland dropped 96 per cent from 231,681 departures in September 2018 to just 10,126 departures in September 2020 (Icelandic Tourist Board, 2020). At the time of writing in 2021 and 2022, mass tourism had returned to Iceland and the Öræfi district. The number of foreign departures in September 2021 rose once again to 108,276 people (Icelandic Tourist Board, 2021). There has been a growing understanding in Öræfi that the recent tourism boom is likely a permanent, rather than passing, phenomenon (Baldursson et al., 2018).

According to Sigurmundsson et al. (2013), the Öræfi district is one of the most vulnerable areas to glacial floods, volcanic eruptions and climate change in Iceland. In 1362, the prosperous farming district was devastated by a large eruption of Öræfajökull, with further damage caused by the smaller 1727 eruption and numerous jökulhlaup (glacial flooding) in the Skeiðará river (Þórarinsson, 1958; Höskuldsson & Þórðarson, 2007; Roberts & Guðmundsson, 2010; Þórarinsson, 1974). The 1362 eruption was the most powerful explosive eruption in Iceland, destroying up to 40 farms and presumably killing all inhabitants of the district, estimated to be between 240 and 400 people (Þórarinsson, 1958; Höskuldsson & Þórðarson, 2007; Roberts & Guðmundsson, 2015). After the 1362 eruption, the name of the district was changed from Litla Hérað, meaning the small shire, to Öræfi, meaning wasteland. In summer 2016, seismic activity began to steadily increase in the area surrounding Öræfajökull, which was followed by the formation of a cauldron in the ice-filled summit crater. The unrest suggested that the stratovolcano was starting to reawaken, however, in the period since, there have been no further reports of heightened activity (Baldursson et al., 2018; IMO, 2022).

An emergency evacuation plan for an eruption of Öræfajökull was developed by the Department of Civil Protection and Emergency Management (DCPEM), and disseminated following public information sessions with both the local population and tour operators in the area (IMO, 2018b; DCPEM, 2017). The emergency evacuation plan outlines that in the event of an eruption without warning, a text message will be sent by DCPEM to all mobile phones in the area,[2] and the National Crisis Coordination Centre will be activated (DCPEM, 2017). Key roles for the main emergency response personnel are outlined (DCPEM, 2017). People in the area are instructed to take the fastest route to three nearby towns outside the district, to wait in their car for further instruction, and seek shelter indoors if volcanic ash or tephra starts to fall (DCPEM, 2017). Preparedness actions also included telecommunications operators improving mobile reception coverage in the area (DCPEM, 2018b).

The area has a subpolar maritime climate that is highly affected by atmospheric circulation in the North Atlantic. The Öræfi district is one of the warmest and wettest regions of Iceland (Hannesdóttir et al., 2015). As a result, the glaciers are among the most sensitive in the world to changes in the climate including temperature and precipitation (Baldursson et al., 2018). Glaciers in the area have been retreating and thinning since 1890, and at an unprecedented pace since the 1990s with climate change playing a major role (Hannesdóttir et al., 2015; Schmidt et al., 2020; Aðalgeirsdóttir et al., 2020; Aðalgeirsdóttir et al., 2006; Adger et al., 2014). Numerical models of glacier mass balance indicate that under the scenario in which the average worldwide temperature increase is limited to 2° C by the end of 2100, Vatnajökull is set to lose 40 to 70 per cent of its volume by 2300; a scenario of 4° C warming in the same period will result in almost complete loss of glacier mass by 2300 (Schmidt et al., 2020).

2.2 Uummannaq and Karrat Fjords, Greenland

Section 8 of this thesis explores risk management of the Svínafellsheiði unstable slopes through a broader lens, bringing in analysis of landslide-triggered tsunami risk in Greenland. The Greenland case study focuses on communities in the Uummannaq Fjord system (70.8637° N, 52.8178° W), which includes Karrat Fjord (71.4478° N, 53.8853° W) and Uummannaq Fjord (70.8637° N, 52.8178° W), in central-western Greenland. The inlet to the fjord system is approximately 50 kilometres wide, it then branches into

[2] The text message will read "Emergency message from the Police. Volcanic eruption is imminent in Öræfajökull. Evacuate to Svínafell, Hof or Hnappavellir, Höfn or Kirkubæjarklaustur depending on your location." (DCPEM, 2017, p. 1).

several smaller fjords, which extend approximately 150 kilometres eastwards towards the inland icecap.

The largest town in the Fjord system, Uummannaq had a population of 1,407 people in 2020 and is the eighth largest town in Greenland (StatBank, 2022). The Uummannaq Fjord system is part of the Avannaata municipality; the most northern municipality in Greenland it covers 522,700 square kilometres and has a population of 10,729 (StatBank Greenland, 2022). The main economic sectors in the area are fishing, hunting, administration and tourism (Strzelecki and Jaskólski 2020). The climate of the area is high Arctic, with long cold winters and short cool summers.

3 Research design and methods

3.1 Research design

3.1.1 Ethnography

The research design of this thesis is based on the ethnographic approach to empirical research. The research design relied primarily on qualitative methods, supplemented by quantitative data including statistics. Contemporary ethnography is defined as an:

> iterative-inductive research (that evolves in design through the study), drawing on a family of methods, involving direct and sustained contact with human agents within the context of their daily lives (and cultures), watching what happens, listening to what is said, asking questions, and producing a richly written account (O'Reilly, 2005, p. 3)

Activities and narratives of participants are observed to gain a deeper understanding of how groups operate (DeWalt & DeWalt, 2002). Hammersley and Atkinson note that ethnography entails participating in people's daily lives for an extended period of time, and "gathering whatever data are available to throw light on the issues that are the emerging focus of inquiry" (2007, p. 46). Within the framework of ethnography, the research design underpinning this thesis involved grounded theory ethnography guided by foreshadowed problems.

A criticism often levelled at ethnography is that because it examines a single case, the representativeness or generalisability of the findings is in doubt (Hammersley & Atkinson, 2007). The case of the unstable Svínafellsheiði slope is of intrinsic interest, as it represents a case of a large-scale risk that people in Iceland have not been knowingly exposed to previously. It represents a rare opportunity to study the pre-impact disaster risk management phase for a new type of climate change-related hazard. The novel themes that emerge from this case—including the effects of risk mitigation on psychosocial wellbeing, and the role of tourism employees in risk communication—draw attention to features of risk management that may be at play in other contexts. In addition, this thesis also explores the case in comparison with landslide-triggered tsunami risk in Greenland.

Foreshadowed problems take the form of "concepts, ideas, theoretical perspectives and even common-sense notions ethnographers take into the field" (O'Reilly, 2009, p. 1). For this PhD study, foreshadowed problems broadly orientated the research towards risk management processes, the involvement of people in risk management, the role of local knowledge, and the psychosocial effects of crises. These foreshadowed problems were rooted in my prior professional experience working in humanitarian response and disaster management, including with the United Nations Office for the Coordination of Humanitarian Affairs in Pakistan. Hammersley and Atkinson (2007) point out that it is common for research to be stimulated by previous professional experience. These foreshadowed problems represented broad interests rather than fully-fledged research hypotheses.

3.1.2 Grounded theory ethnography

The specific lines of enquiry pursued during the research emerged through grounded theory ethnography. Despite the title, grounded theory is a method for ethnographical work rather than a theoretical lens used to analyse the results. Glaser and Strauss (1967) developed grounded theory as a general stance towards the development of ideas, concepts and theories generated through a close exploration of data, rather than relying on pre-existing theory. Grounded theory ethnography provides a systematic process for digging into the scene and probing beneath the surface (Charmaz & Mitchell, 2001). Different definitions of grounded theory ethnography have emerged in the period since it was first proposed, but all include the following strategies:

1. Data collection and analysis are conducted simultaneously;
2. Themes that emerge through early analysis are pursued;
3. Basic social processes are discovered within the data;
4. Abstract categories explaining these social processes are constructed through an inductive approach; and
5. These abstract categories are integrated into a theoretical framework that specifies causes, conditions and consequences of the process(es) (Charmaz & Mitchell, 2001).

Charmaz and Mitchell explain that while ethnography often relies on developing a full description of a group of people, and tends to lift "stock concepts from their disciplinary shelves" (2001, p. 160), grounded theory ethnography moves the research and researcher towards the development of novel concepts through systematic empirical investigation. From the start of fieldwork, grounded theory ethnographers study what is happening in the setting and undertake a conceptual rendering of the collected data (Charmaz, 2006).

Grounded theory ethnography can be applied to a range of qualitative data including interviews, participant observation, field observations, and documentary analysis; meanwhile, ethnography emphasises studying people's actions and accounts in everyday contexts. In-line with grounded theory ethnography, the research design of this thesis was not fixed and detailed from the start, rather the methods used and categories for interpreting the data were generated through the process of data analysis (Hammersley & Atkinson, 2007). The following methods were ultimately implemented: semi-structured interviews, participant observation, complete participation, document analysis, and literature review. The data collection process was iterative, with further information gathered to shed light on salient aspects identified through the analysis. These research methods are described in further detail in Section 3.2.

Funding for this thesis was acquired through the Icelandic Research Fund, and started after the first year of the study. I was not recruited to investigate a particular issue, nor was the research designed to meet any institutional strategic priorities. This high degree of freedom paved the way for grounded theory ethnography, as I was given full flexibility to investigate the themes and processes that emerged from the data.

In the remainder of this section, I explain in more detail how the research was conducted. I discuss fieldwork, the main methods implemented, and how I analysed the data. The final sub-sections discuss the formulation of ideas, my positionality, the process of entering and staying in the field, and ethical considerations.

3.2 Methods

3.2.1 Semi-structured interviews

According to Brinkmann (2013), semi-structured interviews are the most common form of interview in the social and human sciences. A semi-structured interview is a qualitative data collection method whereby a researcher asks interviewees a series of pre-determined open-ended questions, rather than following a strict, formalised list of questions (Given, 2008). Brinkmann and Kvale describe semi-structured interviews as "an interview with the purpose of obtaining descriptions of the life world of the interviewee in order to interpret the meaning of the described phenomena" (2015, p. 6). Semi-structured interviews are a powerful research method as they have the potential to explore areas of people's lives—such as their subjective experiences and attitudes—that would otherwise remain invisible (Kvale, 1996; Peräkylä & Ruusuvuori, 2011; Skinner, 2012).

I conducted a series of 50 semi-structured interviews with 52 people (25 female; 27 male) between August 2018 and April 2021. The interviewees included 14 local inhabitants (10 female; 4 male), nine glacier guides (2 female; 7 male), nine tourists (2 female; 7 male), seven foreign inhabitants (4 female; 3 male), three risk management experts (2 female; 1 male), three scientists (1 female; 2 male), two municipal government officials (2 female), two tourism experts (1 female; 1 male), two search and rescue coordinators (1 female; 1 male), and one national park ranger (1 male) (see Annex 1). Of the glacier guides interviewed, eight were from overseas and one was from elsewhere in Iceland. Three of the foreign inhabitants interviewed had lived in the area for less than one year, and the remaining four had lived in the area for longer. Of the glacier guides interviewed, two had lived in the area for a total of less than a year, and the remaining seven had lived in the area for longer. All interviewees were aged between 20 and 75 years old. The foreign inhabitants and glacier guides were generally young, typically aged between 20 and 40 years old. Meanwhile, local inhabitants came from a more diverse spread of younger and older age groups. In 2018, an estimated 30 local inhabitants were living in Svínafell and Freysnes, the two communities potentially at risk from the unstable Svínafellsheiði mountainside (personal communications with local inhabitant, 7 October 2022). Of these, 12 people were interviewed for this PhD thesis. The remaining two local inhabitants interviewed work in the area but reside in neighbouring settlements.

Most of the participants were recruited either during risk management briefings or through snowball sampling (Bernard et al., 2016). Snowball sampling involves a small group of initial informants who then nominate other participants who meet the eligibility criteria of the study (Given, 2008). This sampling approach was appropriate given the relatively small number of local inhabitants, risk managers and scientists involved. Interviewees were typically contacted by email, telephone or in-person to arrange the interview. Tourists were selected through convenience sampling, which included all tourists that visited the Svínafellsjökull lookout during a three hour time period in the afternoon of 28 November 2019.

While most interviews were conducted with individuals, five were conducted with two interviewees at the same time, and one interview was conducted with a group of four local women together at their request. Interviewing more than one person at a time was productive, with interviewees triggering ideas and thoughts among others. One potential pitfall was that participants may not feel comfortable to express some opinions in a group setting. In one case, one interviewee who participated in an interview with others, requested a follow-up session to expand on a sensitive topic raised by another participant. Five participants were interviewed twice during the course of the research to shed light on a particular angle of the research in-line with the iterative grounded theory ethnography approach, and two participants were interviewed three times. In four of cases (LI.14, RM.4, S.3, and S.4) the subsequent interviews focused on clarifying or updating the information provided in the initial interview. As a result, the interviews were typically less formal, less structured and shorter in duration. While included in Annexe 1 with an explanatory note, these interviews were not included in the tally of 50 interviews.

All interviews were conducted in English except one conducted in Icelandic with the assistance of an interpreter (see Section 3.2 Positioning for further information about language competency). The interviews typically took between 60 and 90 minutes, and were conducted either face-to-face (with 49 interviewees) or online to comply with COVID-19 regulations (with 3 interviewees). All interviews were audio recorded and were typically transcribed within a week of being conducted. This short interim period facilitated analysis during transcription—with analytical notes included in comments—as the experience of the interviews and the thoughts they prompted were still recent.

The interviews were semi-structured, with a basic guide of example interview questions developed for each demographic (see Annex 2). This was used to loosely structure the flow of the interviews; there was no fixed sequence to the topics; rather the approach was flexible, allowing the discussion to flow in a way that seemed natural (Brinkmann & Kvale, 2015; Hammersley & Atkinson, 2007). For example, the guide for people living and working in areas exposed to the risk included topics such as their role in the community, understanding of the hazard, perception of risk communication, and involvement in risk management. The questions were open-ended to allow important issues, perceptions and ideas to be raised and discussed (see Annex 2 for examples of interview questions asked).

Understanding the dynamics and connections between community members represented a challenge during the research. Many of the initial interviews were conducted with people that speak English and were involved in tourism, which represents the main sector of employment in the area. At one stage in my research, I felt I had interviewed most local inhabitants in the immediate vicinity. However, I was unaware of the familial connections between many of my interviewees until it was pointed out by a participant: “we are all of the original family in this area, we are all of the family who grew up with education” (LI.14). She noted that there were some people living in the area who did not have close familial ties with this group, and that it was important to include their perspective. Based on the information provided, I was able to reach out to and conduct interviews with some people from this other group including one interview conducted in Icelandic through an interpreter.

3.2.2 Complete participation and participant observation

Important data for this thesis were gathered through both participant observation and complete participation covering a range of activities.[3] Anderson (2011) defines complete participation as situations in which the researcher becomes a complete member of the social world under study. As such, the researcher inhabits the dual role of both participant and observer. Anderson argues that complete participation confers the most compelling type of “being there” for an anthropologist (2011, p. 303). Researchers can become complete participants through different routes including recreation, occupation or lifestyle (Anderson, 2011). According to Hammersley and Atkinson (2007), ethnographers often have some choice over whether or not to take on one of the existing roles in the field. I took on several roles throughout this study including tourist, foreign glacier guide, scientific monitoring mission member, and Icelandic search and rescue team member.

I was employed and lived in Öræfi as a glacier guide starting mid-way through the first year of my research for seven months (from April till October 2019). During the study period I worked as a guide for the company Icelandic Mountain Guide for approximately 650 hours equating to 16 weeks of full time equivalent employment. This was conducted according to the shift-work approach of the company. In this role, I guided groups of up to 12 clients on a 3.5 hour glacier hike. I also completed both the beginner level Hard Ice 1 and professional level Hard Ice 2 training courses for glacier guides accredited by the Association of Icelandic Mountain Guides.

I specifically pursued this work with the goal of developing greater insight into how people understand and live with the risk associated with the Svínafellsheiði slope instability. This field work included informal discussions with and observations of both clients and other glacier guides. Most other glacier guides were of a similar age, race and background to

[3] In Sections 5 to 8 of this thesis, complete participation and participation were conflated and termed participant observation. The methodological distinction between these types of data collection was only recognised in the final stages of this PhD, and therefore only appears in Sections 1 to 4, which were written last.

myself, which helped neutralise my influence as a researcher (Hammersley & Atkinson, 2007). I was able to immerse myself in the life of a relatively inexperienced foreign glacier guide; this represented a very particular position within the society and risk management processes. As Anderson points out, “even complete membership confers only a partial vantage point for observation of the social world under study” (2011, p. 304). Participating as a glacier guide did not equate to being, for example, a local inhabitant with a family history in the area.

I conducted complete participation while gathering sheep on Svínafellsheiði with local farmers (August 2020; Figure 3), and as a tourist on a glacier hike (January 2018). It should be noted that each of these activities were less than one day in duration, and did not involve the adoption of a lifestyle over a long period of time. Gathering sheep, I gained first-hand experience of how veteran farmers direct less experienced members around the mountains. I saw and experienced how gathering sheep engenders a different interaction with the land compared with hiking or other mountain activities. During the preparatory phase of my PhD in January 2018, I joined a commercial glacier tour of Svínafellsjökull as a paying tourist/client. At that stage, I had identified glacial hazards, climate change, and local knowledge as broad themes that I was interested in researching as part of my PhD with an Icelandic institution. However, the glacier hike was conducted before I had decided upon the specific topic, and before I was aware of the unstable slope on Svínafellsheiði. Joining the commercial glacier tour gave me the opportunity to experience Svínafellsjökull from the perspective of a client with limited experience on glaciers, to receive the safety briefing for the first time, and depend on the guide for risk assessment and advice while on the ice. This took place approximately five months before commercial tours on Svínafellsjökull were stopped due to the risk stemming from the unstable slope.

I gathered data through participation in two scientific monitoring missions to the site of the fracture on Svínafellsheiði (October 2018 and August 2019; Figure 4, Figure 5). During the scientific monitoring missions, I assisted hauling gear to the site, setting up monitoring equipment, and taking measurements along with other participants. Most participants were also not natural scientists, which helped to neutralise my influence on the group. However, being the only foreigner and non-Icelandic speaker on both missions, drew attention to my distinct role as an outsider and a researcher. During these missions, I gained insight into the experience of travelling to the fracture to conduct scientific research, I was able to observe the behaviour and attitudes of other members on the mission, and, as a result, was able discern more about the context in which scientific investigation was conducted. While these observations and lived experiences are not directly referenced in this study, they played an important role in deepening my understanding of the relevant risk management processes.

Finally, during my research I undertook an 18 month two-year training programme to become a member of the Hjálparsveit skáta í Kópavogi (Kópavogur Search and Rescue Team). The team is part of the Icelandic Association for Search and Rescue, an independent association that aims to prevent accidents, save lives and property (Landsbjörg, 2022). Across Iceland, thousands of people volunteer for about one hundred teams that form the association. The training involved participation in 15 courses on different aspects of search and rescue operations (e.g. avalanche rescue, first aid, search techniques etc.), as well as fundraising activities, ensuring the upkeep of the team base, and additional field trips. While the team is based in Kópavogur, in the Greater Reykjavík area, the team is part of Landsbjörg, the national association for search and rescue teams. This umbrella organisations helps to standardise training among teams across the country including in the Öræfi district. During the training, I had many informal discussions with other volunteers, observed their conduct, and participated as a volunteer trainee. While field observations were not recorded during this search and rescue training, the experience helped me develop a deeper understanding of the risk management and disaster response environment in Iceland.

During complete participation activities, I gathered fieldnotes either jotting down information by hand, typing notes on a computer immediately after observations were made, or through voice recordings on an audio device that were later transcribed. My fieldnotes ranged from short notes to detailed descriptions—up to several typed pages—depending on what had occurred during the day. For example:

> When I cross the fracture for the first time, I step on a small bridge of earth over the fracture. One of the other members cautioned me against this and said that I should try to jump over it, because you never know how strong the bridge is. I can see what the scientists say about feeling trepidation about going across for the first time. Is it a foolish thing that I'm doing? I know that given the conditions and lack of rainfall at the moment, it's unlikely to collapse now. I still feel the risk as I jump over to the other side. The section of mountain in motion is larger than I expected, and the fracture is wider. In some places it looks about a metre across on the surface. I ask one of the

> scientists about this, and how it's possible when the fracture is only moving apart at a few millimetres per year. He explains that the measurements are made from the bedrock not from the surface, and that on the surface it can often look larger than it actually is (fieldnotes, 25 October 2018).

I remained analytical while documenting these fieldnotes, even when my experiences had become somewhat routine, as was the case with glacier guiding. I took photographs of sites, tour activities, infrastructure, people, and equipment, which complemented the fieldnotes. As I recorded and organised these fieldnotes, I began to identify issues, themes and connections emerging from the data that helped shape the analysis and direction of my research (Hammersley & Atkinson, 2007).

In addition, participant observation was conducted during several specific time-bound activities that were considered particularly relevant for the research. These included three formal risk briefings conducted on the same day to different audiences (October 2018; Table 1). The first risk briefing was a scientific briefing and response planning workshop with the members of the immediate local community. The participants were 12 local residents, as well as 12 people who were either government risk management employees, scientists, or local government authorities. The second was a civil protection committee meeting to coordinate disaster risk management attended by 19 planning and response personnel. The third was a town hall meeting about both the unstable slope and potential Öræfajökull volcanic activity. The town hall meeting was attended by approximately 100 local inhabitants ranging in age from teenagers to elderly.

Table 1: Svínafellsheiði risk management meetings in research period

Date	Type of meeting	Format	Location
24-Oct-18	Residents in the immediate vicinity	Workshop	Öræfi
24-Oct-18	Civil defense committee	Planning	Öræfi
24-Oct-18	Open residents meeting	Town hall	Öræfi
5-Nov-19	Open residents meeting	Town hall	Öræfi
24-Jun-	Open residents meeting	Town hall	Öræfi
1-Oct-20	Civil defense committee	Planning	Online
22-Oct-20	Residents in the immediate vicinity	Workshop	Online
22-Oct-20	Tourism businesses in the area	Briefing	Online
22-Oct-20	Open residents meeting	Town hall	Öræfi

I recorded the aims of the meetings, the body language of those who attended, how people contributed, and other reactions. I had informal discussions in English with 29 people before and after the meetings conducted on 24 October 2018. These people were mainly local inhabitants, but also included some informal discussions with scientists, risk managers and local authorities. The three meetings were conducted in Icelandic, the informal discussions I conducted were in English (see Section 3.2 Positioning for further information about language competency).

Figure 3: Local inhabitants gathering sheep on Svínafellsheiði (Photo: Stephanie Matti, 2020).

Hammersley and Atkinson (2007) reflect that common challenges experienced when conducting complete participant data collection include feeling too at ease in the setting and failing to understand the orientations of participants. During the course of this research, these challenges were mitigated by: taking on multiple roles; remaining reflexive, critical and analytical throughout; and triangulating information with data collected through other methods. At no point did I feel that my rapport with one group—e.g. local inhabitants, scientists or glacier guides—led to problems with other participants (Miller, 1952). If anything, the in-depth knowledge of other demographics was typically valued and sometimes queried towards the end of interviews by participants, for example, scientists interested in how the situation was perceived by locals, and foreign inhabitants requesting further information about scientific updates.

3.2.3 Document analysis

Document analysis draws on diverse forms of text in written, audio, visual, or electronic formats either as the primary methodological basis for a project, or to supplement data gathered through other research methods (Botterill & Platenkamp, 2012). For the risk management of the Svínafellsheiði unstable slope, documentary analysis supplemented data gathered through interviews, complete participation, and participant observation. The main types of written documents used were national laws and regulations, warning signs erected on access roads to Svínafellsjökull, information signs at Svínafellsjökull viewing areas, tourism statistics, tourism brochures in the area, historical accounts of eruptions, poetry written by local residents about the local environment, data collected by the road authority on the number of cars passing Freysnes, websites providing information for tourists visiting the area, websites of risk management authorities, and tourist blogs.

A risk assessment was conducted by the Icelandic Meteorological Organisation during the study period. The risk assessment process was considered complex as it represented a new type of risk, not previously managed in Iceland (S.5; see Sections 6.4.2 and 6.4.3). While some results of the risk assessment were presented orally by authorities during a risk briefing conducted in October 2020, as of April 2022 when Article IV (Section 8) was finalised, the risk assessment document was not publicly available (see Section 8.4.1). As such, the risk assessment was not included in the document analysis for this PhD thesis.

The Greenland case study was based on data collected through an analysis of 55 articles published online on Kalaallit Nunaata Radioa (KNR), Greenland’s government-funded public service radio (KNR n.d). The articles were selected by examining all entries under the search “Karrat” on the KNR website after the tsunami on 17 June 2017 (see Annex 3 for a list of articles used). The reports were translated from Danish into English using online translation software, with quality checks by a bilingual research assistant. Articles published through other news sources were used to verify the information provided. The articles cover the development and reception of official risk management strategies and include many quotes from affected people and policy makers at the municipal and national level. A review of the relevant government, academic and press outlets revealed that KNR had the most extensive selection of documents on the case, and that the information presented incorporated different points of view. The data collection focused on existing data sources rather than direct interviews due to ethical considerations and resource limitations (see Section 3.6 Ethical Concerns).

For both the Icelandic and Greenlandic cases, documents were used as primary sources of data—as distinct from a literature review—that contributed towards developing a more holistic view of the subject matter. Hammersley and Atkinson caution that official documents and enumerations should be treated as social products and "must be examined, not relied on uncritically as a research resource" (2007, p. 130). A cautious and critical approach underpinned the document analysis. For example, statistics on the number of people living in the Öræfi district, focused on Icelandic inhabitants while omitting most foreign tourism employees. This helped deepen my understanding of how this particular demographic was taken into account by the authorities. The exclusion of foreign tourism employees in residence statistics for the area was also confirmed during the interviews.

3.2.4 Supporting literature review

When conducting grounded theory ethnographic research, Glaser and Strauss recommend conducting a literature review after developing an independent analysis of the gathered data (Glaser & Strauss, 1967; Glaser, 1978; Strauss, 1987). Rather than approaching the data equipped with specific concepts and theories, the researcher should allow the key themes and categories to emerge from the data first, then try to explain these by drawing on the literature. This is conducted with the aim of using any available resources that help make sense of the data (Hammersley & Atkinson, 2007). Before conducting fieldwork, I started my thesis by reading broadly about glacial hazards and environmental anthropology. However, it was only after themes and categories began to emerge from the data, and I began to draft individual articles, that I conducted a thorough literature review about the specific themes and concepts that had emerged. This included, reviewing the literature on local knowledge (Section 5), Icelandic sheep gathering practices (Section 5), psychosocial wellbeing in the pre-impact phase (Section 6), coping mechanisms (Section 6), land use policy for risk management (Section 6), risk communication (Section 7), planned relocation (Section 8), urbanisation trends (Section 8), and issues stemming from the relocation of indigenous people and communities (Section 8). Given the wide range of potential topics that could have come to bear on research about

Svínafellsheiði, this approach was both practical and targeted, while enabling the analysis to emerge from the data.

3.2.5 Data analysis

The data of this thesis was analysed according to a grounded theory ethnographic approach. Key to grounded theory is allowing the codes and connections to arise from the data, rather than applying concepts and theories from earlier works (Charmaz and Mitchell, 2001). Data generation and analysis took place concurrently throughout the research process. When gathering data, I was actively making connections, trying to understand the information presented, and taking notes on my analysis. The lengthy process of transcribing the interviews provided an opportunity to increase my familiarity with the data, and continue reflecting on and analysing the content (Taylor et al., 2015). During these stages, I recorded my reflections, impressions, interpretations, initial analyses, and connections to other data alongside my fieldnotes and interview transcripts. These comments and memos formed something of a journal (Taylor & Bogdan, 1998). The final phase of data analysis occurred during the process of writing up the articles presented later in this thesis (Creswell, 2007).

To manage the large amount of data from the interviews and fieldnotes, I imported the transcripts and files into the computer software QSR NVivo 12. NVivo was primarily used to code and retrieve data. One of the key benefits of the software was that I was able to attach different codes to a section of data, with overlapping segments, and with codes nesting within one another (Hammersley & Atkinson, 2007). I initially used open coding to facilitate the identification of new themes and categories that emerged from the data (Esterberg, 2002). I read each interview transcript in detail, and assigned codes to the text that captured the main ideas that were being communicated (Charmaz & Mitchell, 2001). Once different categories and themes began to emerge, I used focused coding to review the data in order to collect further examples (Esterberg, 2002).

My analysis of documents for the Greenland case involved a more manual process of grouping sections of the articles in a word processing programme first into themes and then categories. As with the data analysis of the interview transcripts, the themes and categories were identified first through open coding, followed by focused coding to collect further examples. Reflections about the case were captured in comments included in the document. This approach was employed, rather than coding in NVivo because the data was going to be used for a single article, and thus could be captured through the more manual process. My analysis of documents related to the Svínafellsheiði slopes (see Section 3.1.3 Documentary

Analysis) was not included in the NVivo coding, instead it was added when drafting articles in response to the specific lines of enquiry that I chose to pursue.

The collection of data, analysis of data, and writing of the articles for this thesis was not a single, linear process. Richardson and St Pierre's description of a "seductive and tangled method of discovery" (2005, p. 967) is more apt. Charmaz and Mitchell explain that "theoretical sampling means going back to the field to gather specific data to fill gaps within categories to elaborate the analysis of these categories, and to discover variation within and between them" (2001, p. 168). This was the case with my research. At times, I undertook further data collection to shed light on a specific aspect in order to gain a more comprehensive understanding of the topic or in order to 'saturate' various categories that had been identified. In this way, data analysis fed into the research design and data collection through the iterative process central to grounded theorising (Hammersley & Atkinson, 2007). This process necessitated lengthy withdrawals from the field to process and analyse data before returning to collect further data.

3.3 Formulation of ideas

In the months after I identified Svínafellsheiði as a topic of interest, I began to explore the broad topic of local knowledge in risk management. I had been aware of, and interested in, questions of local knowledge and risk management prior to starting the PhD. Based on initial discussions with Icelandic scholars at the University of Iceland, I thought this would include significant coverage of folklore. However, other concepts and themes emerged from the data, which would ultimately guide the direction of my research (Priest et al., 2002). Interviewees indicated that, unlike other areas in Iceland, there was not a strong tradition of folklore in Öræfi. Instead, when people talked about how they interact with the mountainous environment, they regularly referred to sheep gathering and a potential eruption of Öræfajökull. I pursued these themes through further interviews, and by joining locals gathering sheep. This yielded further information and new categories such as how people interact with the land while collecting sheep. The resulting detailed analysis formed the basis of the first article.

Section 5 was originally drafted in early 2019 using semi-structured interviews and informal discussions conducted in 2018. During this period, most people were generally positive about their inclusion in risk management processes. However, over time, local inhabitants became more critical of risk management processes, especially when people were affected by the no-build zone, and when the follow-up risk briefing was delayed by several months. This shift towards a more critical approach was also reflected in the analysis presented in Section 5, vis-à-vis Sections 6, 7 and 8.

The theme of the second article about the effect of the no-build policy on the psychosocial wellbeing of people in the area first emerged through written correspondence with a local inhabitant, and was developed further in interviews. Hammersley and Atkinson note that “time may seem a dimension of obvious importance in social life, but it has often been neglected” as “attitudes and activities frequently vary over time in ways that are highly significant for social theory” (2007, p. 35). The second article was very time specific. At the beginning of my fieldwork, the no-build policy was not yet established; at the end of my fieldwork, the policy had been changed and no longer had such a significant impact on the daily lives of people. As a result, this dynamic was only valid for a limited period of time during my fieldwork. When gathering this information, I reflected that there may be different motivations for interviewees to share their views on the matter with me, including to vent frustrations or use my research to advocate for change.

The lack of inclusion of foreign tourism employees was a theme that emerged early in the study through discussions and participant observations. These themes were reinforced throughout the research. It was apparent at the risk briefings conducted on 24 October 2018, that the information presented was only accessible to Icelandic speakers. In interviews, glacier guides drew attention to their lack of inclusion in official risk management processes, and their perception that foreign inhabitants represented a demographic that was poorly understood by risk management authorities. In my training and employment as a glacier guide, neither my colleagues nor I were informed about the risk of the unstable slope by our employer or the authorities, or given any indication of how to respond. That said, some limited information was passed on informally by colleagues who had been present when operations shifted from Svínafellsjökull to the neighbouring glacier. However, this communication depended on ad hoc interactions on a personal level. A local inhabitant confirmed this during an interview, and drew attention the fact that foreign inhabitants living and working in areas potentially exposed to the risk represented a demographic that was also overlooked by official risk management processes. Subsequent interviews were conducted with this demographic, and the results informed the article presented in Section 7.

The theme for the fourth and final article of this thesis, presented in Section 8, developed from the idea of positioning the ethnographic research of this

PhD study in a broader context. Different cases of tsunamis triggered by landslides were explored in countries including Norway, the US, and Canada. These represented societies with a long history and detailed risk management processes for dealing with this type of hazard. Ultimately, given the focus of this PhD study on newly emerging climate change-related risk, the decision was made to examine the Uummannaq and Karrat Fjords in Greenland. Part of this decision was made due to the almost total lack of social scientific attention paid to the risk management of the 2017 tsunami. The initial focus was on the response to the 2017 tsunami and relocation of communities, as one of the authors had previously conducted several semi-structured interviews with people involved in the response. Further research using newspaper articles revealed the subsequent discovery of additional landslide risk, and planned relocations from other communities in the area. The KNR articles represented the most detailed sources on the risk management processes that were able to find after conducting an extensive review of scientific journals and internet search engines both in English and Danish. The analysis represents an initial examination and description of the case, that can guide future research. Further research should involve the affected community and be conducted in-line with recommendations by Rink and Reimer (2019) about how to conduct community-based participatory research in Greenland.

3.4 Positioning

Scheper-Hughes (1995) argues that every ethnographer is biased, while Esterberg (2002) explains that the personal qualities of the ethnographer shape how people react to the researcher and what data is made available. Critical scholars have drawn attention to how the identity, social and historical position of the researcher shapes the study (Abu-Lughod, 2006; DeWalt & DeWalt, 2002; Sylvain, 2005; Hammersley & Atkinson, 2007). The principle of reflexivity calls for researchers to acknowledge and reflect on how their race, gender, background and other power dynamics situate them in relation to the people studied (Loftsdóttir, 2012b; Taylor & Bogdan, 1998). I am a white woman in my mid-30s from Australia and Switzerland. For the rest of this sub-section, I reflect on my position in relation to the community context of the study.

Historically, being a woman would likely have had a greater impact on my research compared with the current period. Interviewees mentioned that it was uncommon for women to assist with gathering sheep a hundred years ago, or to become glacier guides even 10 years ago (LI.10). However, by the time I was conducting my research, this had largely changed. For example, on my second shift as a glacier guide, one of the guides took a photograph because it was one of the first times that nearly all of the guides on shift were female. Throughout my research, I felt that I was able to participate in outdoor activities regardless of my gender rather than as a result of it. I did not feel that being a woman conferred any particular advantages. Many of my first contacts with happened to be with women. However, many of these initial participants were glacier guides or participants in the scientific monitoring mission. I feel that these shared experiences created more of an opening for interviews, however, I cannot not rule out that my gender played a role. Hammersley and Atkinson (2007) argue that being a woman doing research can have its advantages, including that men may be more willing to discuss vulnerability and weakness to female researchers than a fellow male. In this research, at no point did I feel that I had access to information that would not have been available to a man.

Figure 4: A local member of the scientific monitoring mission to the slope instability hammers a metal stake into the ground. The exact GPS position of the stake is one of several methods being used to measure changes in the width and position of the slope (Photo: Stephanie Matti, 2018).

Being in my early thirties placed me within the normative age range for glacier guides. This facilitated the development of working relationships and building a rapport with some participants, especially glacier guides and foreign tourism employees. Furthermore, even among local inhabitants, many of the participants who were most active in the research process—

including being available for interviews, suggesting other potential participants, and responding quickly to my queries—were of a similar age to myself.

At the beginning of the PhD process, I completed two Icelandic language courses. As a result, I was able to understand some of what was said in Icelandic during meetings, in the fieldwork, and when examining documents. While my language competency increased throughout the study period, I did not acquire a sufficient grasp of Icelandic, Slovak, Polish, Kalaallisut or other languages to converse freely with participants or read documents directly. I felt that participants were almost always able to convey their ideas adequately in English during interviews, however, it is likely that conversations would have flowed more easily if they were conducted in the participant's native language. This was mitigated by several factors including the generally good level of English spoken among members of the community, English being the language of operation in the tourism sector in Iceland, and the use, in one case, of an interpreter to assist interviewing. For documentary evidence, including the press reports used for the Greenlandic case, I translated the reports into English using online translation software, with quality checks by a bilingual research assistant.

Having an adequate level of fitness represented an important condition of entry to participate in various data collection activities including glacier guiding, joining the scientific monitoring missions and gathering sheep. In the case of the monitoring missions, participation required being able to haul heavy scientific equipment up the steep route to the fracture representing approximately a thousand metres of elevation gain. Similarly, participation in sheep gathering demanded the physical condition required to assist—or at a minimum, not burden—the team of farmers gathering sheep over the rough mountainous terrain of Svínafellsheiði. The activity involved running up the mountainside, then changing course quickly to intercept the sometimes erratic route taken by the sheep as they descend from higher slopes.

Understanding the workings of class in the study was complicated by class being rarely discussed in Icelandic society generally, and Icelanders typically refusing to assign class labels to themselves (Oddsson, 2010). However, at one stage, an interviewee informed me that many of the people I had interviewed were related to each other, coming from an extended family that was historically more well-off and had better access to education. She directed me to other community members that did not belong to this extended family, who I later interviewed, to correct this imbalance. I grew up on a rural farm in Australia until I was 11 years old, and feel at ease in farming settings. I feel that this background helped facilitate interaction in the community, and meant that I was generally at ease around animals, including during sheep gathering.

Loftsdóttir (2012b) notes that whiteness is often the unmarked normative position in Iceland with people rarely reflecting on their position in relation to race. For example, in her research into Icelandic tourism, she argues that "even though some of the images emphasising 'wild' nature on the website show white bodies, they do not necessarily have to do so, because Iceland's racial position is already implied" (Loftsdóttir, 2015, p. 256). This also reflects the idealisation of the specific cultural construction of "wilderness", which has historic roots in the privileged experiences of the white middle-class (Ho & Chang, 2021). Tourism in Iceland generally, and especially adventurous activities in the "wilderness" are highly racialised spaces even though this is often unacknowledged. Similarly, the vast majority of foreign glacier guides that I interacted with in Öræfi during the study period were white, with most coming from Europe, the United States, Australia or New Zealand. My research did not examine the topic of the unstable Svínafellsheiði slope through a racial lens. I did not feel that my race specifically had an impact on my research, however, this likely reflected the presumed whiteness in the particular field I was researching. My being white undoubtedly helped me enter the field, conduct research as a glacier guide, and establish a rapport among participants (Gallagher, 2000; Lundström, 2010).

Atkinson (1997) discusses how ethnographers at times find it necessary to manage contrasting impressions of expertise and ignorance. Before starting my PhD, I worked more than seven years in international development and humanitarian response roles including for the United Nations. In several instances, this experience helped establish my credentials and build a rapport when interviewing and networking among government officials and local inhabitants. Several interviewees also identified my Australian background as source of common ground, remarking that I must also know what it is like to live with multiple natural hazards. This had the advantage of developing a shared understanding between the researcher and participants (Merriam et al., 2001). A potential drawback of this approach is that participants may have left out information and detail if they took this shared understanding for granted (DeLyser, 2001; Kanuha, 2000). However, I felt that in my research, the few moments where this shared understanding was emphasised, led to a deepening of conversation and further sharing of perspectives.

In other aspects of my research, especially in the early stages, I adopted the role of what Loftland (1971) termed the “acceptable incompetent”. I was open about my ignorance regarding local customs, traditions and practices, and as a result, interviewees tended to go into further detail and explain more fully the concepts and ideas that they were conveying. At the beginning of my research, I was very much an outsider. However, by watching, listening, asking questions, making blunders, and participating, I began to understand more about social structures, customs, skills, language, and the subject matter. The contextual knowledge I acquired was highlighted when I re-read initial interview transcripts towards the end of the research process, and could update the detailed place names with the correct spelling. What had felt foreign and strange at the beginning had become familiar.

3.5 Entering and staying in the field

An extensive literature examines how ethnographers enter and stay in the field (Esterberg, 2002; Hammersley & Atkinson, 2007; Hennink et al., 2011; Molinari & Corsaro, 2012). Negotiating access to the field is not a one-off event, rather it is often a process through which access is negotiated and renegotiated with the people studied (Hammersley & Atkinson, 2007). There were several discernible overlapping stages during which I conducted research with different demographics starting with government officials and scientists, then expanding to glacier guides, local inhabitants, and tourists as described earlier in this section. This was in response to ethical concerns (see below), and to grounded theorising that led me to dig deeper into certain themes that emerged through the analysis.

The process of entering the field typically involves finding gatekeepers, earning their trust, and gaining access. Gatekeepers are generally people who hold important roles in the community and have a deep understanding of the context (Esterberg, 2002; Hammersley & Atkinson, 2007). These gatekeepers have the power to open up or block off research access, and are considered by others to have the ability to control access by encouraging or discouraging others to participate (Esterberg, 2002; Hennink et al., 2011; Hammersley & Atkinson, 2007).

A government official that I interviewed in October 2018, two months into the research process, represented a key gatekeeper. The government official was particularly open about the risk management approach and challenges presented by the Svínafellsheiði slope. He invited me to attend a series of risk management briefings in the local area, and introduced me to numerous key people in the field. Without this connection, it would have taken longer and been more difficult to gain access to such a forum. Several interviewees mentioned that the particular risk manager had developed good working relationships with people in the area and had built a solid foundation of trust. The importance of this gatekeeper in granting access to the field was underscored when he changed jobs soon after the initial series of risk briefings. Thereafter, despite reaching out to different government officials and other interviewees, I was not informed about another risk briefing ahead of time for the rest of the study period despite an additional seven meetings being held (Table 1). That said, all interactions with participants throughout the research process were amicable and open.

A glacier guide that I interviewed October 2018, represented another important gatekeeper; he supported me taking on the role of a glacier guide, which represents a key route by which non-Icelanders come to live in the area. Becoming a guide was instrumental for me staying in the field, and opened many opportunities for participation, observation and further interviews. For example, one local person only agreed to be interviewed after learning that I was guiding for the company he used to work for. There were also other important gatekeepers within the local community that were involved in the study, for example, several interviewees asked at the beginning of the interview if I had already talked with a certain local inhabitant. My affirmative response appeared to bestow credibility on the research process, and they seemed more at ease sharing their own insights. This experience highlights the importance of comprehending the different power relations at play in the field. Living and working in the community enabled me to develop a nuanced understanding of these local dynamics, which informed the way I approached the interview process, and facilitated access to both people and information.

From early 2020 to mid-2021, many countries including Iceland implemented measures to mitigate the spread of COVID-19. The subsequent decline in tourism made it more difficult to study foreign tourism employees in the area. Fortunately, however, most of the interviews with that demographic had been conducted before the onset of the pandemic. As restrictions lifted, the tourism sector in the area quickly returned. Together with local inhabitants, I had planned to conduct a local and scientific knowledge exchange event in the community. This was also to include a presentation of my research. The event was organised twice—in October 2020 and March 2021—however, both times it was cancelled due to the tightening of COVID-related restrictions. At present, this event is planned to be conducted in late 2022. In addition, access to the field was made more difficult by recommended restraint towards social interaction during certain stages of the pandemic, and as a result, three interviews were conducted online.

3.6 Ethical concerns

Respect for the autonomy of research participants—including through informed consent—is a general principle that underpins anthropology (Resnik, 1998; Shamoo & Resnik, 2009). Informed consent requires that people are only involved in research if they freely agree to participate, and are aware to what they agree (Kristinsson, 2013; Plummer, 2000). When people were interviewed as part of this study, they were first informed about the project, my affiliation, and the method of audio-recording. Their informed consent to participate was audio-recorded in all cases. For interviews conducted with people living and working in the area, this information was outlined on a written form, together with interview guidelines (see Annex 2). The guidelines outlined that they could: withdraw at any time; refuse to answer any question without consequences; withdraw permission to use data within two weeks of the interview; and that they understood that the interview would be audio-recorded and the results treated confidentially. The participants were requested to review the sheet and sign if they consented to participate. They were offered a copy of the information sheet (see Annex 4). The information sheet was in English, with a verbal translation into Icelandic provided to the one interviewee who did not understand English. I also contacted the University of Iceland ethics committee by email regarding my research and was informed that I should pursue that research, and that further specific approvals were not required.

During most complete participant and participant observation activities, I conducted my research in an overt fashion, being upfront about my research. When I was invited to join different groups or activities, the people who gave me access were aware of my affiliation, research interests, and that the information gathered would inform my research. At the start of the scientific monitoring missions, sheep gathering and the smaller risk management briefings, my presence and role conducting research was announced to all attendees. In my work as a glacier guide, and at the town hall meeting, this was not officially announced to all people present; however, it came up during conversation for most people with whom I interacted. The numerous contacts made during my fieldwork made it practically impossible to secure written informed consent from everyone. In light of this, I placed emphasis on anonymity of participants and interviewees, and the research principle of do no harm.

The number of people living and working in areas exposed to a potential large landslide from the Svínafellsheiði slope was relatively small; the number of people working on assessing and managing the risk was even less. As a result, ensuring complete anonymity of sources was a challenge. In all transcripts and papers drafted as part of this research, interviewee sources were referred to by a system of codes that reflect the broad category people fit into for the purpose of this research. These codes included local inhabitants (LI), foreign inhabitants excluding glacier guides (FI), glacier guides (GG), municipal government authorities (MG), scientists (S), government risk management officials (RM/GO), tourism experts (TE) and tourists (T). Given the small number of people involved, additional information such as institutional affiliation, age, etc. would undermine the anonymity of sources. Gender was not reported in all cases but was sometimes indicated through the use of gendered pronouns in the written articles. This approach using broad categorisation provided sufficient information for the research purposes, as the main analysis was based on the interaction within and between these groups rather than emphasising other individual attributes.

From the initial planning phase, this research was guided by the obligation of anthropologists to avoid causing harm to others when undertaking research (American Anthropological Association, 2012) also termed non-maleficence (Kristinsson, 2013). I was concerned that my research might compound the uncertainty or anxiety of people living and working in areas exposed to the risk, by asking them to reflect on the risk and how it is managed. This was a particularly important concern as the risk was ongoing, with people continuing to live in exposed areas. As a result, the initial interviews and research focused more on people assessing and managing the risk in a professional capacity. Only after approximately one year of research, getting to know the area, and developing a good network of local contacts, did I feel comfortable to reach out to Icelandic local inhabitants for interviews. At this point, I felt that I had a sufficient understanding of the context and the situation to be able to do so in a sensitive manner. Towards the end of some interviews, participants asked me if I had any updated information about the science or risk management of the unstable slope. In these cases, I referred them to the latest official information sources available.

During one interview, the participant expressed frustration at the no-build policy in place and the effect it had on their lives. While this gave me important insights into the effect of the approach on the psychosocial wellbeing of people in the area, I felt that the interviewee perceived the interview process as an avenue through which her voice could be heard. Resnik (1998), and Resnik and Shamoo (2009) argued that another ethical principle that underpins ethnographic research is beneficence: that researchers should attempt to promote or advance social interests. Several months after conducting the above-mentioned interview, I presented my findings at an academic conference also attended by several decision-makers relevant to this specific case. I viewed this as a way to give voice to the concerns raised by my participants. By including a large excerpt from the interview about the difficulties faced by the interviewee, I felt I was able to deliver on this perceived responsibility to give voice to her concerns. In the weeks following the conference, government officials reached out to local inhabitants and notified them that the no-build policy had been eased to the extent that it was no longer a constant frustration for those in the area. It is unclear whether this change of policy was affected by my presentation, however, I hope that giving further voice to the concerns expressed by the community contributed towards the decision.

The data collection for the Greenlandic case focused on secondary data sources rather than direct interviews due to a combination of both ethical and resource constraints. There are numerous references to the psychosocial effects that the 2017 tsunami and subsequent risk management processes have had on affected people (for example: KNR 12 May 2021a; KNR 20 July 2019: KNR 22 June 2018; KNR 23 May 2021). I did not feel that I would be able to conduct the research in a manner that would sufficiently mitigate the risk of compounding anxiety, and assessment fatigue, which are commonly experienced among people affected by crises (Patel et al., 2020). This was a key consideration in the decision to gather information through news reports instead. The KNR reports included extensive quotations from the people affected, government officials, municipal officials, and other stakeholders. The reports represented a method to gather information about the topic, from a source that had not been used comprehensively in scholarly work, in a way that diminished the potential of causing further harm to affected people.

3.7 Reflections on terminology

The terminology used in this thesis was refined throughout the research and writing process. In Sections 5 and 7, the hazard was referred to as "the fracture". This was the direct translation of the Icelandic word "*sprunga*", which was often used among people working on, and exposed to, the hazard. In reviewing Article 2 (Section 6), one reviewer highlighted that the hazard comes from the unstable slope, of which the fracture is an indication. On the basis of this, he recommended that the article refer to the 'unstable Svínafellsheiði slope' rather than the 'fracture'. Unfortunately, Article 3 (Section 7) had gone through the final round of revisions by this time, and the change could not be incorporated.

Another revision of the terminology used relates to the use of “risk manager” to refer to people employed by the government in specific roles to manage risk. This term was used to distinguish this group from local inhabitants, tourists, and other demographics interviewed as part of this study. In the course of writing Section 8, I reconsidered the use of this terminology as I felt it validated the normative position that risk management should be controlled by government authorities. My research highlighted the need for a shift, especially in Greenland, to directly involving the people affected in decision-making processes. Furthermore, people manage a wide variety of risks on an individual level on a daily basis. While this position started to emerge from the research earlier, I had not reflected how the terminology I used further entrenched these positions. In Sections 1 to 4, and Section 8 “risk manager (RM)” was changed to “government official (GO)”.

The terms “local inhabitant” and “foreign inhabitant” were used throughout this PhD thesis. Virtually all foreign-born people living in the Öræfi district, have lived in the area for less than 10 years, due to the dramatic growth of the tourism sector in the past decade. Most foreign inhabitants who have lived in the area for several years do not speak Icelandic at a conversational level, and do not have Icelandic citizenship. For the purpose of this research, the term foreign inhabitants was used as a shorthand for people living in the area who do not speak Icelandic, do not have ancestorial connections to the area, and do not have Icelandic citizenship. Meanwhile, local inhabitants was used as a shorthand for people who speak Icelandic, have Icelandic citizenship, and have either personal and family history in the area. Icelanders who have moved to the area on a temporary basis were not included in the analysis undertaken as part of this PhD thesis as they represented a relatively small subset of the district’s population, except some brief references in Section 7.

The focus of Section 7 was on a subsection of foreign inhabitants, namely foreign tourism employees who were living and working in the area. The specification of “tourism employees” was added as the article focuses specifically on people working in the sector due to their role communicating risk to tourists. However, given that the vast majority of Icelanders and virtually all non-Icelandic people living in the area are employed in the tourism sector, the distinction has little effect on the demographic subset involved.

In Section 8, a distinction is made between local inhabitants in Iceland and indigenous inhabitants in Greenland. The United Nations has not adopted an official definition of indigenous people. Rather, an understanding of the term is based on: self-identification as indigenous people; historical continuity with pre-colonial and/or pre-settler societies; strong link to territory; distinct social, economic or political systems; distinct language, culture and beliefs; forming non-dominant groups within society; and resolve to maintain and reproduce ancestral environments and systems (UNPFII, n.d.). In total, 88 per cent of the Greenlandic population are indigenous Inuit people (International Working Group for Indigenous Affairs, n.d.). Iceland was uninhabited until settlement in the 9th century, and is the only Arctic State without an indigenous population (Heleniak et al., 2020). Some Icelandic personnel have “described local knowledges and traditions somehow parallel to that of Indigenous such in other Arctic states” (Medby, 2019, p. 1285), while the Icelandic history of Danish colonisation also engenders a sense of solidarity with other circumpolar peoples.

The final reflection on terminology is in relation to the phrase “natural hazards”. Starting in the 1970s, critical scholars from a range of disciplines including human ecology have insisted that there is no such thing as a natural disaster (Blaikie et al., 1994; Gaillard et al., 2014; Hewitt, 1983; Gould et al., 2016). The term ‘natural disaster’ overlooks socio-economic factors that lead to people being exposed to hazards, and that render marginalised populations vulnerable to hazards (Gould et al., 2016). Furthermore, “natural disasters” also overlooks the role of humans, including through anthropogenic climate change, in contributing to these hazards. In Section 7, the use of the wording “natural disasters” was highlighted by reviewers, with the recommendation that these references be changed to “disasters related to natural hazards”. In Sections 1 to 4, and Section 8, this recommended wording was used.

4 Conceptual background

This PhD thesis is nestled within the literatures on anthropology of climate change, and disaster risk management. This thesis explores risk management in a geographical area heavily affected by nature tourism and specifically glacier tourism. Grounded theory ethnography was used to identify specific concepts within risk management including local knowledge (Section 5), psychosocial coping in the pre-impact phase (Section 6), land use planning (Section 6), risk communication (Section 7), and planned relocation (Section 8). These different concepts are developed in further detail in the respective sections with a short summary of key elements provided below.

4.1 Disaster risk management

Disaster risk management aims to prevent new risks, reduce existing risk and manage residual risk, while helping to strengthen the resilience of communities and reduce disaster losses (UNDRR, 2022). It does not consist of a single adjustment or policy; rather, it involves dynamic social processes whereby individuals, communities, governments and other organisations mitigate risk (Eriksen et al., 2015). The present international framework for disaster risk is the Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework hereafter), which replaced the Hyogo Framework for Action (UNDRR, 2005; UNDRR, 2015). The Sendai Framework outlines four priorities for action: understanding disaster risk; strengthening disaster risk governance; investing in disaster risk reduction for resilience; and enhancing disaster preparedness (UNDRR, 2015).

Acceptable risk and residual risk represent two important sub-categories of disaster risk. Acceptable risk refers to the level of losses that a society considers acceptable, depending on economic, political, technical, social and environmental conditions (UNDRR, 2022). Residual risk is the disaster risk remaining once disaster risk reduction measures have been implemented (UNDRR, 2022).

The traditional 'top-down' or 'dominant' model to disaster risk management is based on the notion that disasters are the result of inaccurate risk perception or inappropriate behaviour of affected people in the face of a natural hazard; the recommended response is based on a combination of technological solutions, economic support and information provision (Scolobig et al., 2015; Gaillard et al., 2007). According to this model, government authorities are responsible for ensuring safety through disaster and emergency services, while the public are understood to be passive receivers of technical information (Mercer et al., 2008).

Since the 1970s, the theory and practice of disaster risk management has shifted towards a more 'people-centred' model that recognises the socio-economic and political origin of disasters (Gaillard et al., 2007). Research has drawn attention to non-technical factors that affect risk management including: cultural background (Lindell & Perry, 2004; Mileti & Sorensen, 1990), place attachment (Altman & Low, 1992), social capital (Cadag et al., 2017; Anderson-Berry et al., 2018), and trust in risk management (Wachinger et al., 2013; Haynes et al., 2008; Barberi et al., 2008). The people-centred model emphasises the central role of multi-stakeholder interaction, especially the inclusion of people affected by disasters in the design and implementation of risk plans (Eiser et al., 2012; Scolobig et al., 2015; UNDRR, 2015). Allowing the public to input knowledge, raise concerns, and enhance their capacities is understood to improve the quality and implementation of risk management and reduce underlying vulnerabilities (Demeritt & Nobert, 2014; Pelling, 2007; Maskrey, 2011; Cadag & Gaillard, 2012).

Under the people-centred model, the public is portrayed as being capable, resilient and empowered to protect themselves rather than vulnerable, passive receivers of information (Scolobig et al., 2015). Indigenous and local people are recognised to have a better understanding of the potential and limitations of the immediate environment, social vulnerabilities and local response capacities (Toyoda & Kanegae, 2014). The empowerment of affected people is particularly important, as community members are typically first responders when a disaster occurs (Toyoda & Kanegae, 2014). Implementing a people-centred model of disaster risk management requires governmental authorities to become attentive to social dynamics, willing to engage in a long-term dialogue with people at risk, and support these efforts with resources and institutional frameworks; the public must also be willing to engage in the process (Scolobig et al., 2015). As a result, it is not surprising that "many countries still struggle to adapt their institutional structures to promote increased participation" especially those with a long history of top-down risk management (Scolobig et al., 2015, p. 206).

4.1.1 Local knowledge

Local and indigenous knowledge systems refer to the "understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings" (UNESCO, 2020, p. 3). This knowledge is accrued from generation to generation, tested over long periods of time (Nakashima, 2018), and becomes embedded in practices, institutions, and rituals (UNDRR, 2009; Ngwese et al., 2018). Local knowledge plays an important role in disaster risk management, including helping communities develop resilience by: identifying signs that trigger early response; anticipating potential hazards intensified by climate change; becoming empowered in the implementation of disaster risk reduction and management (DRRM) activities; and improving recovery from the effects of disasters (Khailani & Perera, 2013; Hiwasaki et al., 2015; Cadag et al., 2017). The Sendai Framework calls on countries to complement scientific knowledge with local knowledge when developing and implementing DRRM strategies and policies (UNDRR, 2015). The connection between local knowledge and risk management has been explored in many different contexts including floods in China (Chen & Cheng, 2020) and Zimbabwe (Mavhura et al., 2013), rock-ice avalanches in Peru (Carey et al., 2012), earthquakes in India/Pakistan (Ahmad et al., 2017), and tropical cyclones in Fiji and Tonga (Johnston, 2015). This is part of a broader shift whereby social science researchers are increasingly focusing on local understandings and experiences of climate change (e.g. Orlove et al., 2010; Raymond et al., 2010; Head & Gibson, 2012; Rice, Burke, & Heynen, 2015; Dujardin, Hermesse, & Dendoncker, 2018).

4.1.2 Land use planning

Land use planning can reduce the vulnerability of individuals and communities to environmental hazards by encouraging the development of safer physical environments (Adger et al., 2014; King et al., 2016). This land planning can take the form of building standards, risk zoning, protective infrastructure, and retreat and relocation policies (Burby, 1998; Burby et al., 2000). Land planning has been identified as a priority action under the Sendai Framework (UNDRR, 2015). However, in practice, such measures are typically introduced after disasters occur (Garrido & Saunders, 2018), and face strong opposition from developers, property owners and local inhabitants (Burby et al., 2000). Restricted building zones for risk management purposes have also been linked to exacerbating difficulties faced by displaced families, heightening ethnic tensions, compounding fear and mistrust, and the creation of new vulnerabilities (Ingram et al., 2006; Hyndman, 2008; Iuchi, 2014; Yamada & Galat, 2014; Santos et al., 2015).

An emerging literature examines the use of zoning for mitigating landslide risk in different country contexts including Andorra (Cascini et al., 2005), Hong Kong (Cascini et al., 2005), Italy (Cascini et al., 2005; Mattea et al., 2016), Peru (Carey et al., 2012; Klimeš et al., 2019), Switzerland (Cascini et al., 2005; Lateltin et al., 2005), the UK (Gibson et al., 2013), and the US (Cascini et al., 2005). Both Norwegian and Swiss governments have identified land zoning as one of the most effective measures to prevent damage from landslides (Kalsnes et al., 2016; Lateltin et al., 2005).

Following the catastrophic 1995 avalanches in Súðavík and Flateyri, a plan was developed for assessing avalanche risk and implementing mitigation measures across Iceland (Margreth et al., 2014). Of the 34 people that died in the two avalanche events, most victims were in houses outside the hazard land use zones existing at that time (Grímsdóttir, 2008). The national plan developed after the avalanches included an overhaul of the risk zoning system for land usage. The determination of acceptable risk was based on the reasoning that avalanche risk should not constitute more than 10 per cent of the mortality risk experienced by children living in the area (Arnalds et al., 2004). Based on this, the risk to a person in a residential house higher than 0.3×10^{-4} per year was considered unacceptable (Arnalds et al., 2004). Using this formulation, avalanche hazard maps were developed for urban areas, delineating zones where: residential buildings are allowed; residential homes are allowed but should be reinforced, but schools and similar structures are not allowed; and no buildings are allowed where people are living or working (Grímsdóttir, 2008). The Icelandic Avalanche and Landslide Fund (Ofanflóðasjóður) was established to finance avalanche mitigation measures and relocation from exposed areas (Parliament of Iceland, 1997).

4.1.3 Psychosocial coping in the pre-impact phase

Disasters can cause significant psychological and social suffering among affected individuals, families and communities (IASC, 2007; Okada et al., 2014). While disaster management has shifted towards a greater emphasis on risk reduction, psychosocial research and interventions remain squarely focused on response and recovery phases (Gray et al., 2021). Pre-impact psychosocial reactions are varied and often difficult to assess (Hu et al., 2017). Afifi et al. (2016) find that being exposed to risk typically generates anxiety, while Sword-Daniels et al. (2018) find that it can lead to uncertainty about the future. Stancu et al. (2020) find that previous experience of a similar hazard increases perceived risk among affected people, but that this decreases over time. Prolonged exposure to uncertainty has also been linked to a rise in anxiety, increased apathy, and a reduction in perception of risk (Paton, 2003; Weber, 2006).

Coping encompasses a wide range of cognitive and behavioural efforts that people employ to manage or tolerate stressful situations (Lazarus & Folkman, 1984). Stancu et al. (2020) argue that the employment of coping mechanisms is affected by a range of factors including risk perception, trust, past experience, affiliative behaviour, and place attachment.

4.1.4 Risk communication

Risk communication is widely accepted as a key strategy to inform people of a risk and to promote protective actions that people can take well in advance and when faced with an impending disaster to reduce their vulnerability (Rahman & Munadi, 2019; Paton, 2006). The term risk communication refers to the interactive flow of information to notify the general public of the probability of a hazard occurring, likely consequences, and actions that people can take to reduce their risk (Plough & Krimsky, 1987). Since the 1980s, the theory and practice of risk communication has shifted from a top-down flow of information from experts to the public, to a broader approach that takes into account community participation, cultural factors, social relationships and trust (Eiser et al., 2012; Khan et al., 2017; Lin et al., 2020). Risk communication strategies are more effective when they are tailored to the intended audiences (Paton, 2006; Seeger, 2006). Factors which affect how people engage with, and act upon, risk communication include, but are not limited to, cultural background (Lindell & Perry, 2004; Mileti & Sorensen, 1990), trust in risk management authorities (Wachinger et al., 2013; Haynes et al., 2008), confidence in emergency procedures (Barberi et al., 2008), duration of exposure to risk (Stancu et al., 2020), and level of social capital (Cadag et al., 2017; Anderson-Berry et al., 2018). When the public are not familiar or do not recognise response and evacuation plans in advance, these protocols are less likely to be followed during an emergency (Voight, 1990; Carey et al., 2012).

4.1.5 Planned relocation

Planned relocation is defined as "the planned, permanent movement of a group of people from identifiable origin(s) to identifiable destination(s), predominantly in association with one or more hydrometeorological, geophysical/geological, or environmental hazard(s)" (Bower & Weerasinghe 2021, p. 7). Numerous cases of planned relocation have been described in the literature including: the Matatā community in New Zealand, which relocated due to the risk of debris flows (Hanna et al., 2018); the community of Isle de Jean Charles in Louisiana, which relocated after coastal land loss reduced the island by more than 98 per cent (Simms et al., 2021); and coastal communities in Alaska that voted to relocate after diminishing sea ice and storm surges accelerated erosion (Bronen, 2015).

The relocation of people represents one of the most complex governance challenges generated by climate change (Bronen, 2021). Relocated communities are more likely to consider their relocation "successful" if they are well informed and participate in all phases of the decision-making process, are adequately compensated, and feel that they have some control over the choice of destination and process of movement (McAdam & Ferris, 2015; Okada et al., 2018). Cullen argues that relocation requires a "governance framework that underpins and supports, not dictates, community agency" and leads to "improved local resilience and empowerment, and also better potential to preserve culture, identity, mental and physical health as well as the natural environment itself" (2022, p. 13).

4.2 Nature tourism and risk management

Nature tourism involves travel to natural areas with a primary motivation of appreciating nature and enjoying the scenery (Sæþórsdóttir, 2010). It is becoming an increasingly large component of the developed world's leisure and travel preferences (Newsome et al., 2013). In Iceland, the tourist industry is centred on visitors engaging with various natural attractions including mountains, volcanoes, glaciers, geysers, waterfalls and the rugged coastline (Sæþórsdóttir, 2010). Several of these types of attractions are inherently hazardous to visit.

Cohen writes that "in the popular imagination, death and tourism belong to utterly different spheres of life" (2009, p. 184). As demand for nature tourism experience grows, so too does the risk of accident, injury and death (Espiner, 2001). A large number of fatal tourism accidents have occurred around the world including in volcanic, geothermal, glacial, mountainous, coastal and marine environments (e.g. Gstaettner, et al., 2019; Whittlesey, 2014; Nally, 2013). The main causes of tourist fatalities are road accidents, accidents undertaking touristic activities, substance abuse, terrorist acts, and disasters related to natural hazards (Cohen, 2009). Examples of disasters with high tourist fatality rates include: the eruption of Whakaari/White Island in December 2019, where 21 tourists and guides died (March et al., 2020); a flash flood near Interlaken, Switzerland on 27 July 1999, where 21 canyoning tourists and guides died (Morgan & Fluker, 2006); and the approximately 225,000 people who died in the Indian Ocean tsunami on 26 December 2004, included an estimated 3,300 tourists visiting the Andaman coast of Thailand (Cohen, 2009).
There is an important distinction between tourists being exposed to hazards by just visiting an area, and tourists participating in adventurous activities that test mental and physical skills against environmental hazards, such as rock climbing and white-water rafting (McCool & Braithwaite, 1992; Carter, 2006; Purdie et al., 2015). For some people who take part in adventure tourism activities, exposure to risk is an integral part of the experience; by contrast, hazards typically represent an impediment to the optimal tourism experience for non-risk-seeking visitors (McCool & Braithwaite, 1992;

Purdie et al., 2015). Risk is often exacerbated by the tourists' lack of familiarity with the local environment, their inexperience in recognising and responding to specific hazards, distance from regular support networks of kin and social circle, and the pursuit of thrill-seeking behaviour by some (Bentley & Page, 2008; Bird & Gísladóttir, 2020; Purdie et al., 2015; Espiner, 2001; Cohen, 2009).

Within the broad category of nature tourism, glacier tourism has emerged as a concept in the tourism literature (Salim et al., 2021). Experiencing glaciers is unique, educating, and confronts first-time visitors with indisputable "otherness". Furunes and Mykletun explain that being on a glacier hike "gives a strange feeling of being slightly different, daring and powered by the group, the guide and the outfit, and especially the rope, the axe, and the crampons" (2012, p. 343). While earlier glacier tourism focused on lower latitudes in New Zealand, European Alps and Pyrenees, increased leisure time and improved infrastructure have seen the expansion of glacier tourism to polar regions including Alaska, Antarctica and Iceland (Wang & Zhou, 2019). Hazards associated with glacier tourism include steep and slippery terrain, crevasses, rockfall, extreme weather and river crossings (Purdie et al., 2015). Changes to the conditions, including as a result of climate change-related glacial retreat, have a large impact on glacier tourism. Climate change has resulted in: increased difficulty accessing glaciers (Stewart et al., 2016; Mourey et al., 2019), more dangerous activities (Purdie et al., 2015), and the loss of visual appeal of glacial sites (Diolaiuti & Smiraglia, 2010; Salim et al., 2021). For example, since 2009, the Fox glacier on the West Coast of New Zealand has:

> lost around 700 metres in length and 150 metres of ice thickness in the lower regions. This thinning has resulted in the flattening of the previously convex glacier cross-profile, and consequential removal of the lateral trough between the slopes and the glacier, which used to trap rockfall originating from the over-steepened slopes […] the morphological variation of the glacier has the potential to increase the travel distance of rocks over the glacier by up to 50 m, which is important to day-to-day tourism operations and management (Purdie et al., 2015, p. 198).

There have been calls to improve risk management within the tourism sector (e.g. Aliperti & Cruz, 2019; Becken & Hughey, 2013; Bird et al., 2010; Hystad & Keller, 2008; Mair et al., 2016). Several factors make it particularly challenging to manage risk in nature tourism hot spots. These include: language barriers for communicating information directly with tourists, limited interaction between tourists and locals, high mobility of tourists, the poor adoption of risk management protocols by tourism operators, and the often passive approach towards risk management by tourism businesses (e.g. Becken & Hughey, 2013; Cioccio & Michel, 2007; Glaesser, 2003; Hystad & Keller, 2008; Bird et al., 2010).

5 Local knowledge of emerging hazards

This section contains the peer-reviewed journal article:

Matti, S., & Ögmundardóttir, H. (2021). Local knowledge of emerging hazards: Instability above an Icelandic glacier. *International Journal of Disaster Risk Reduction.* 58. https://doi.org/10.1016/j.ijdrr.2021.102187

Abstract

Climate change is contributing to shifts in the magnitude and scale of hazards, and the emergence of risks in areas where they were previously unknown. In south-east Iceland, a fracture in the mountainside of Svínafellsheiði threatens to cause between 60 and 100 million cubic metres of rock to fall onto the glacier below. A large landslide could break up the surface of the glacier, crash into the proglacial lake, and affect people and infrastructure downhill. In addition to the unprecedented scale, the Svínafellsheiði fracture represents the first time people and infrastructure have been exposed to this type of hazard in Iceland. In this article we examine the role of local knowledge in disaster risk reduction and management for communities that are facing a particular type of hazard for the first time. We argue that even when a community lacks experience with a specific type of hazard, local knowledge can still play a valuable role in hazard identification and risk management.

Keywords

Disaster Risk Reduction and Management; Local knowledge; Landslide; Iceland; Emerging hazard; Svínafellsjökull

5.1 Introduction

In 2014, local farmers gathering sheep on the slopes above Svínafellsjökull outlet glacier in south-east Iceland discovered a fracture in the mountainside. It appeared to be 100 metres long, and close to a cliff-edge that rises 400 metres vertically above the glacier. The farmers monitored the fracture and made some basic measurements before bringing it to the attention of scientists and disaster management authorities. The fracture is now understood to be 1.7 kilometres long with approximately 60 million cubic metres of rock in motion (Sæmundsson et al., 2019; Figure 5). If the entire section of the cliff collapses at once onto the glacier it may cause no further damage, however, a large landslide could break up the surface of the glacier, crash into the proglacial lake,[4] and cause a “fast-flowing slurry of rock, ice, water and even air” that could affect people and infrastructure downhill (IMO, 2018a). At the time of writing, the fracture was widening, and there was a high degree of uncertainty about the timing and ultimate form the large landslide would take.

Icelandic people have a long history of managing environmental risks including volcanic eruptions, glacial floods, surging glaciers and extreme weather. This has fostered traditions of local risk knowledge, and driven the development of advanced monitoring and warning systems, and disaster management protocols that have reduced casualty rates to almost zero (Sigurðsson et al., 2011). However, large landslides onto glaciers—defined as landslides with a volume of more than one million cubic metres (Bonnard et al., 2004)—represent a relatively unknown hazard in Iceland. There is no record of a large landslide onto a glacier that affected people or infrastructure since the country was first settled in the 9th century. The massive scale of the Svínafellsheiði fracture also singles it out as unique in Icelandic history, with scientists predicting that it may result in “one of the largest mass movements in Iceland during the Holocene” (Sæmundsson et al., 2019, p. 1).

There is broad consensus in the disaster risk reduction and management (DRRM) literature that local knowledge is a critical element of the coping capacity of local communities (Khailani et al., 2013; Hiwasaki et al., 2015; Cadag et al., 2017). This local knowledge is often portrayed as being deeply rooted in a people’s historic experience of similar hazards. Dominey-Howes and Minos-Minopoulos, for example, suggest that the “inherited memory” of a hazardous event is “a vital element of community resilience” (2004, p. 306). However, the IPCC has established that extreme events, which trigger

[4] The Svínafellsjökull proglacial lake refers to a body of water dammed by the glacier and rock moraines during glacial retreat.

disasters are increasingly likely to occur in places they were previously unknown due to climate change (Adger et al., 2014). The role of local knowledge in DRRM for communities that are facing a particular type of hazard for the first time represents a gap in the literature that this study addresses, drawing on the case of the Svínafellsheiði fracture. In this article we argue that even when a community lacks experience with a specific type of hazard, local knowledge can still play an important role in DRRM, especially in the identification of hazards. However, when it comes to predicting the impact and suggesting survival strategies for new hazards, local knowledge plays a more varied role.

This article is structured as follows. The next section discusses the research design including literature review, study area, and methodology. Section 5.3 outlines the main natural hazards in the area. Section 5.4 examines local knowledge in the area as it relates to large landslides onto glaciers, and how this has been incorporated into DRRM processes. We conclude the findings in Section 5.5.

Figure 5: Scientific monitoring visit to the fracture in August 2019. The fracture is visible on the surface as a trench, starting from the bottom right corner of the photograph and extending downhill (Photo: Stephanie Matti, 2019).

5.2 Research design

5.2.1 Literature review

In recent decades, DRRM scholarship and practice has embraced an increasingly holistic view of hazard risks, taking into account the resilience and underlying vulnerabilities of people living in exposed areas. Local and indigenous knowledge systems, defined by UNESCO as the "understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings," are understood to play a critical role in improving the resilience of communities (2020, p. 3). Many terms have been used in the literature to refer to local knowledge, including indigenous knowledge, traditional knowledge, traditional ecological knowledge and folk knowledge (Nakashima et al., 2018). These terms differ somewhat in terms of reference group and connotations but maintain significant cross-over in meaning. In this article, the term 'local knowledge' is preferred over 'indigenous' or 'traditional knowledge' as it avoids the static connotations associated with 'traditional knowledge', and has a broader scope that encompasses both indigenous and non-indigenous local knowledge (Nakashima et al., 2018; Berkes, 2017).

Local knowledge is acquired by people through long-term local-scale observations, including about the environment, natural hazards and the weather (Rosenzweig and Neofotis, 2013; Hiwasaki et al., 2014). Local knowledge is typically accrued from generation to generation, and tested over long periods of time (Nakashima, 2018). This knowledge becomes embedded in practices, institutions, and rituals within the community (UNDRR, 2009; Ngwese et al., 2018). While often depicted as static and hermetically sealed, recent scholarship has emphasised that local knowledge systems are complex, porous, dynamic, and constantly updated (Cruikshank, 2005).

Since the 1990s, the endeavour to integrate local knowledge into the study and practice of DRRM has gained momentum (Adger et al., 2014; UNPFII, 2015; Hiwasaki et al., 2014; Rosenzweig and Neofotis, 2013; UNDRR, 2015). Local knowledge is now understood to play an important role in DRRM, including helping communities develop resilience by: identifying signs that trigger early response; anticipating potential hazards intensified by climate change; becoming empowered in the implementation of DRRM activities; and improving recovery from the effects of disasters (Khailani and Perera, 2013; Hiwasaki et al., 2015; Cadag et al., 2017). The importance of local knowledge in DRRM is recognised under the Sendai Framework for Disaster Risk Reduction (2015–2030), which calls on countries to complement scientific knowledge with local knowledge when developing and implementing DRRM strategies and policies (UNDRR, 2015).

A rich case study literature examines how communities have employed local knowledge to improve DRRM for a wide variety of hazards, including floods in China (Chen and Cheng, 2020) and Zimbabwe (Mavhura et al., 2013), rock-ice avalanches in Peru (Carey et al., 2012), earthquakes in India/Pakistan (Ahmad et al., 2017), and tropical cyclones in Fiji and Tonga (Johnston, 2015) to name but a few. While studies dealing with local knowledge and DRRM typically focus on developing countries, some studies point to the important but less well-understood role of local knowledge in developed countries such as Scotland, Finland (Henriksen et al., 2018), and other European countries (Gould, 2011). A complementary body of scholarship examines the long-term transfer of hazard knowledge in Europe including in relation to flood practices in Germany (Poliwoda, 2007), landslides and flood prevention in Italy (Tropeano and Turconi, 2004), floods across Europe (Brázdil et al., 2010), and traditional disaster memory in Switzerland (Pfister, 2009).

In the Icelandic context, several studies have examined local knowledge and DRRM practices in relation to Katla and Eyjafjallajökull, two volcanoes in southern Iceland (Jóhannesdóttir and Gísladóttir, 2010; Bird et al., 2009; Bird et al., 2011; Bird and Gísladóttir, 2012). Research into the rich local knowledge and folklore of the area has captured stories of the origin of Katla and predictions of future flood paths, as well as recollections of heroic escapes and ineffective responses (Tryggvasson, 2000; Bird et al., 2010; Jóhannesdóttir and Gísladóttir, 2010). Bird et al. (2009) assessed resident knowledge, behaviour and perceptions of risk relating to Katla, while subsequent research highlighted how inherited local knowledge has increased the resilience of inhabitants in the area (Bird et al., 2011). This article adds to this body of research on the intersection of local knowledge and DRRM processes in developed countries, as well as shedding further light on DRRM practices in relation to landslide hazards in Iceland.

In the literature, local knowledge is often portrayed as being rooted in people's historic experience of similar hazards (Mercer, 2010). For example, Iloka explains that local knowledge "has been gathered by ancestors who have experienced and recovered from the impacts of hazards and disasters, who then pass the knowledge down to their children" (2017, p. 30). Dominey-Howes and Minos-Minopoulos suggest that "inherited memory" of a hazardous event is "a vital element of community resilience" (2004, p. 306). The role of local knowledge in communities that are facing a particular type of hazard for the first time represents a gap in the literature that this study aims to address. Gaillard and Mercer argue that "local people and communities are not helpless in the face of natural hazards" and that "local knowledge is a valuable resource" (2012, p. 94). We argue that even in cases where a community has an almost total lack of experience with a particular type of hazard, local knowledge can still be a valuable resource in identifying hazards and building resilience.

5.2.2 Study area

Located at the confluence of the North Atlantic and Arctic Oceans, Iceland is prone to a multitude of hazards including extreme storms, floods, earthquakes, volcanic eruptions, landslides, and avalanches. This study was conducted in the Öræfi district of south-eastern Iceland with a specific focus on the two hamlets exposed to the Svínafellsheiði fracture: Freysnes and Svínafell. The seven small settlements of the district are spread around the base of Öræfajökull—a large ice-capped stratovolcano—separated by a series of steep outlet glaciers and their meltwater rivers. Sigurmundsson et al. have established that the district is one of the most vulnerable areas to glacial floods, volcanic eruptions and climate change in Iceland (2013). Öræfi had a permanent population of 151 people in 2018 (Statistics Iceland, 2020) however, the number of people living and working in the area on a temporary or seasonal basis is much higher.

Freysnes is located 800 metres beyond the terminus of the Svínafellsjökull outlet glacier while Svínafell lies approximately two kilometres further south-east (Figure 1). In 2018, Freysnes consisted of 17 buildings including a hotel, farm, petrol station and several houses; it is also traversed by the country's main highway, locally known as the Ring Road (Figure 2). Svínafell consisted of 21 buildings including two farms, three guesthouses, a campground and several residential buildings. In recent decades, the district has shifted from a dependence on sheep farming to large-scale tourism including glacier walks on Svínafellsjökull. This has been part of a larger trend that has seen tourism in Iceland rise from 448,000 foreign visitors in 2010 to over 2.2 million in 2017 (Icelandic Tourist Board, 2018).

Many of the local inhabitants in Freysnes and Svínafell come from families that have lived in the district for generations, with some tracing their history back to 1300 AD. Both Freysnes and Svínafell are mentioned in early Icelandic literature, suggesting that they date from at least as early as 1000 AD (Ives, 2007). Svínafell, for example, is mentioned in Njáls Saga: "Flosi dwelt at Swinefell, and was a mighty chief" (Anonymous 1290. Ch. 94). Iceland generally has a rich literary tradition of documenting events that started soon after the country was first settled. This has resulted in a wealth of detailed observations about the landscape, weather phenomena, volcanic eruptions, earthquakes, avalanches and other natural events (Ogilvie, 2007).

5.2.3 Methods

The purpose of this study was to examine the role of local knowledge in the identification and management of the Svínafellsheiði fracture. This article presents the findings of an ethnographic study that used mixed methods, including participant observation, semi-structured interviews and open discussions, to review existing local knowledge as it applied to the Svínafellsheiði fracture and DRRM processes. This differs from a citizen science approach, in which inhabitants are directly engaged through the research process to gather data and develop knowledge to advance scientific inquiry (Liu, 2014). The research was undertaken between August 2018 and November 2020 in Iceland.

A series of 53 semi-structured face-to-face interviews were conducted with 15 local inhabitants, nine glacier guides, eight foreign inhabitants, eight tourists, three DRRM experts, two scientists, two tourism experts, two search and rescue coordinators, and one national park ranger (see Annex 1).[5] Several local inhabitants were interviewed multiple times. Most people were interviewed individually, however five interviews were conducted with couples and one interview was conducted with a group of four local women together. Of the participants, 23 were female and 27 were male; all were aged between 20 and 75 years old. All interviews were conducted in English except one, which was conducted in Icelandic with the assistance of an interpreter. The proficiency of local inhabitants with English reflects the important role of tourism in the local economy. Participants were identified through snowball sampling. This was effective given the relatively small number of people exposed to the hazard (Bernard et al., 2016).

Each interview typically lasted between one and one-and-a-half hours, and covered the interviewees' understanding of hazards in the area, local knowledge and practices, and their awareness of and involvement in DRRM processes. The questions were open-ended to allow important issues, perceptions and ideas to be raised and discussed. All interviews were audio-recorded, transcribed by the authors, and analysed together with field notes using *QSR Nvivo 12®* (qualitative data analysis software). A bottom-up inductive analytical approach was taken to allow sub-themes and commonly held views to emerge from the data (Priest et al., 2002). An advantage of this approach was that it gave voice to the experiences of local people (Braun & Clarke, 2012). In this paper, the interviews are referenced using the coding system presented in Annex 1, which draws attention the role of the person interviewed.

In addition to semi-structured interviews, the first author actively conducted research while living in the community and working as a glacier guide from April till October 2019. This intensive and long-term involvement helped

[5] See Annex 1 note for an explanation of the discrepancy between the figures for interviews cited here and in the rest of the PhD.

rule out spurious associations and enabled the authors to develop a deeper understanding of the topic (Maxwell, 2009). Twelve additional trips to the study site were undertaken to participate in specific events relevant to the research including scientific monitoring missions (October 2018 and August 2019; Figure 5), formal public risk briefings (October 2018 and November 2020), and to assist gathering sheep on Svínafellsheiði (August 2020; Figure 3). Triangulation of the results reduced the chance of systematic bias and limitations associated with using a single data source (Maxwell, 2009). In addition, the research findings were reviewed by several respondents including local inhabitants, scientists and risk managers, who provided feedback, and validated the results (Maxwell, 2009).

5.3 Hazards in the Öræfi district

5.3.1 Large landslides onto glaciers

The fracture in Svínafellsheiði is estimated to be 1.7 kilometres in length with 60 million cubic metres of rock in motion (Sæmundsson et al., 2019; Figure 5). If it collapses, 60 to 100 million cubic metres of rock and debris are predicted to fall onto the surface of the glacier approximately 400 metres below (Sæmundsson et al., 2019; IMO, 2018a). A large landslide could break up the surface of the glacier, cause a tsunami in the proglacial lake, and affect the downhill settlements of Freysnes and Svínafell (IMO, 2018a). Scientific research presented at public scientific briefings suggest that the entire mass will release as a single landslide rather than several smaller slides, increasing the risk for downhill settlements (attended by first author, 24 October 2018).

DRRM of the fracture is coordinated by local police with the support of Civil Protection. Public briefings about the fracture are conducted on a roughly annual basis or when new findings become available. A green alert has been in place for the hazard since October 2018.[6] Risk management activities have focused on scientific monitoring, assessing the fracture, public information and reducing exposure. On 22 June 2018, local police together with Civil Protection issued an advisory:

> WARNING: Civil Protection advises against travel on Svínafellsjökull due to landslide danger. In particular, guided tours on the glacier are discouraged. Travelers are advised to stop only for a short while at viewpoints by the glacier tongue (DCPEM, 2018b).

[6] Civil Protection classifies hazards as uncertainty phase (green alert), alert phase (yellow alert), and emergency/distress phase (red alert).

In early 2019, large warning signs were erected on the main roads leading to Svínafellsjökull, warning people about the hazard (Figure 6).

While outlet glaciers in the Öræfi district have been retreating since the end of the Little Ice Age in 1890, the rate of retreat has accelerated significantly since 2000 (Hannesdóttir and Baldursson, 2017). Hannesdóttir and Baldursson (2017) established that in the period since 2000, the mass loss per unit area of glaciers in south-east Iceland has been among the highest in the world. From 1890 to 2010, Svínafellsjökull retreated approximately 800 metres and decreased in volume by 30 per cent (Hannesdóttir et al., 2015). The IPCC confirmed that climate change has played, and continues to play, a major role in the retreat of Icelandic glaciers (Adger et al., 2014). As glaciers thin and recede, slopes that were previously buttressed by larger volumes of ice become unstable (Ballantyne, 2002; Purdie et al., 2015). In Iceland and worldwide, landslides in recently deglaciated areas are predicted to become more frequent due to glacial retreat, heat waves, permafrost degradation, changes in precipitation and the expansion of glacial lakes (Sæmundsson and Margeirsson, 2016; Seneviratne et al., 2012; O'Connor and Costa, 1993; Huggel, 2009).

Large landslides onto glaciers are rare in Iceland with only four recorded between 1950 and 2018; there is no record of this type of hazard affecting people or infrastructure (Sæmundsson and Margeirsson, 2016; Icelandic Meteorological Office, 2018). The largest of these landslides occurred in 1967 when 15 million cubic metres of rock fell onto Steinsholtsjökull outlet glacier, north of the Eyjafjallajökull ice cap. While less than half the debris was deposited on the glacier, it was enough to send a huge mass of air, ice, and water into the proglacial lake causing a wave 75 metres high (Kjartansson, 1967; Sæmundsson and Margeirsson, 2016). Two other large landslides took place in the Öræfi district: 4.5 million cubic metres fell on Morsárjökull in March 2007; and 5.4 million cubic metres fell on Svínafellsjökull, close to the current fracture, in February 2013 (Icelandic Meteorological Office, 2018). Based on current research, if the Svínafellsheiði fracture collapses in a single event, the mass movement would be between four and seven times as large as that on Steinsholtsjökull. In addition to the unprecedented scale, the Svínafellsheiði fracture represents the first time people and infrastructure have been exposed to this type of hazard in Iceland, and the first time a large landslide onto a glacier has been identified and the risk managed in advance (Gylfason, 2018). These factors single it out as a new type of hazard in Öræfi and in Iceland more generally.

Areas exposed to the Svínafellsheiði fracture include the proglacial lake, glacier viewing area, terminal moraine, and areas behind the terminal moraine including Freysnes and two farms in Svínafell (formal public briefing attended by first author, 24 October 2018). In June 2018, an estimated 1,500 people spent some period of time in the exposed area on an average day, this included local and non-local inhabitants, tourists, glacier guides and people driving on the road.[7]

Figure 6: Warning signs on access roads to Svínafellsjökull (Photo: Stephanie Matti, 2019).

5.3.2 Other hazards

Other hazards in the area have had a significant impact on the local environmental and the risk knowledge of inhabitants. In 1362, Öræfajökull erupted in what is considered the most powerful volcanic eruption in Iceland during historic times (Guðmundsson et al., 2016). The eruption sent torrents of hot mud and water down outlet glaciers, destroying several settlements and

[7] In peak tourist season of early June 2018, rough estimates of daily exposure rates were as follows: 25 local and 55 non-local inhabitants in Freysnes (24 hours), four local inhabitants in two Svínafell farms (24 hours), up to 200 tourists at the hotel (14 hours), 50 glacier guides (5 hours), 1,000 tourists on glacier walks (3 hours), 1,200 people predominantly tourists passing on the road (0.25 hours) (S.4, LI.1, GG.3; Icelandic Road Authority, 2019). The people who participated in glacier hikes were also including under the figures for number of people passing on the road. These figures represent a rough estimation of the number of people exposed. When glacier operations were moved to another glacier after 22 June 2018, the rate of exposure for guides and glacier tourists decreased from several hours in high-risk areas on the glacier surface to approximately 15 minutes in lower-risk areas along the road. However, roughly 1,500 people still spent some period of time in the exposed area on an average day during peak season. (RM.2).

depositing an estimated one billion cubic metres of volcanic ash across the surrounding area (Ives, 2007). The annals of Oddi recorded in 1580 explain that “no living creature survived except one old woman and a mare” (Islandske Annaler, 1888, p. 489).

Although the next—and most recent—eruption of Öræfajökull in 1727 was smaller, eyewitness accounts still describe how the “glacier grew higher and swelled out one moment and then collapsed and sank inwards the next”, the following day there were earthquakes and a “horrifying cracking sound as loud as thunder” (Olavius 1780, pp. 224-5). These were followed by the eruption and glacial floods that “slewed down onto the lowland, like molten metal poured out of a melting-pot.” (Olavius 1780, pp. 224-5) More detailed accounts are provided of survival strategies from the 1727 floods including that “people saved themselves by getting on the tops of the houses” (Horrebow 1758 p. 14). In July 2018, the Icelandic Meteorological Office announced that Öræfajökull was showing “clear signs of unrest” (2018b, p. 1); a year later the warning had been downgraded to normal levels.

Approximately 50 kilometres north-east of Freysnes, the Grímsvötn volcano lies beneath 700 metres of ice cap. The most active volcano in Iceland, Grímsvötn typically erupts every 10 years, sending glacial floods down the Skeiðarárjökull outlet glacier, 10 kilometres east of Freysnes (Icelandic Meteorological Office, 2020).

Historically, crossing glacial rivers in Öræfi was often treacherous. However, this hazard has faded since the construction of a bridge over Skeiðará river in 1974. Another hazard emerged during the Little Ice Age (1500 to 1890) as advancing glaciers engulfed several farms in the area; with glaciers in retreat, this no longer represents a threat. Snow avalanches are common in other regions of Iceland but have only caused damage or deaths in two sites in Öræfi since settlement (Jóhannesson and Arnalds, 2001). Finally, the Öræfi district is prone to violent storms and hurricane-force winds especially in the winter months.

5.4 Results and discussion

This section presents the results of our research and discusses the findings. The first sub-section explores how knowledge of the land has been fostered through traditional sheep gathering practices, and how this led to the discovery of the fracture. The following sub-sections unpack the role of local knowledge in different aspects of DRRM including: understanding warning signs, predicting potential impact, planning response strategies, and participating in formal DRRM processes. Comparisons are made to local knowledge of other hazards in the area especially glacial flooding triggered by Grímsvötn. The findings are based on informal discussions, semi-structured interviews, study trips to the field site, and first first-hand experience of the public risk briefings. In contrast to the area around Katla, the few mythical folklore stories told in Öræfi did not cover natural hazards.

5.4.1 Sheep gathering and knowledge of the land

Every year, sheep across Iceland are released to lowland pastures, common highland pastures and the mountains to graze for the summer months. Then in the autumn, farmers scale the mountains, cross valleys and sweep through the lowlands gathering sheep and rounding them into communal pens. Sheep gathering has a long history in Iceland with written descriptions dating back to 1220 (referenced in Sigurðsson 1857-1876). While sheep farmers are now a minority of the population, norms derived from this practice remain embedded in Icelandic culture and continue to influence government decisions.

Farmers in Freysnes and Svínafell own approximately 1,100 sheep out of an estimated 4,000 sheep in the district (RM.2; LI.12). In the mountainous areas of Öræfi, the sheep are gathered on foot. On Svínafellsheiði, a team covers the landscape in a coordinated manner to ensure that no sheep is overlooked. Interviewees recalled hauling sheep up cliffs with ropes (LI.10), going deep into glacial crevasses to search for sheep (LI.15), and herding sheep across glaciers (LI.1; LI.3; LI.11). On Svínafellsheiði, four to ten people gather the sheep in a single day. For the whole district, the gathering takes about eight full days with several additional days to locate any missing sheep (LI.10; Figure 3).

The same people typically gather the sheep each year, with value placed on the skills and knowledge of veterans. Young or inexperienced people learn by listening to stories told by adults, and following their lead (LI.10; LI.12; LI.15). This acquisition of local knowledge resonates with Pálsson’s (1994) analysis of how Icelandic fisherman learn their trade, by actively engaging with their environment.

From the perspective of hazard identification, an important element is that people move through the landscape in a different way to when they hike or conduct other activities in the mountains. Sheep gathering requires that people cover the area extensively and move through terrain where they would not normally venture:

> It’s also a very different way of hiking the mountains when you’re sheep herding because you’re going to places where you would never have to go or you never think that you could go there. So you learn the to know the mountain in a very different way (LI.10).

> For sheep herding, people go into places where nobody would dare to go because the sheep go crazy places. And people walk on a section with a drop of 200 meters below and it’s like ‘yeah you just have to go there’. I think they’re also pretty proud of it. They’re like ‘yeah we went there, nobody goes there’ (LI.10).

During and after the sheep gathering, people discuss how the gathering was conducted, how the sheep reacted, and anything else noteworthy (LI.13). This analysis is important for reviewing and updating the collective knowledge of local inhabitants.

Another important factor is the frequency. One inhabitant emphasised that “if you are just going once or twice in a lifetime you don’t have the same feeling for the land as a farmer that goes twice each year” (LI.11). In this way, local people develop a practical and intimate knowledge of the landscape that they continue to update and renegotiate each year. A French glacier guide compared the in-depth knowledge Icelandic farmers have about the mountains to the situation in France:

> In Iceland the farmers do extensive farming with their sheep, so they have a better look at the mountains. Even though they don’t live in the mountains—they’re not there 24 hours a day—but they still go there. And they go everywhere, and they check and monitor their land. In Europe, there is nobody in the mountains, people just pass through the land. But if you don’t go every year to the same areas, then you will not notice the change. They are closer to their land here. (GG.8)

In many ways the sheep gathering acts as an unofficial annual land survey conducted by people who have an intimate knowledge of the landscape. Typically this knowledge is not recorded but rather transferred from generation to generation orally and through the practice of sheep gathering. This unofficial survey yields important observations, including the discovery of the Svínafellsheiði fracture.

5.4.2 Discovery of the fracture

In 2014, farmers discovered the fracture in an area rarely visited except when gathering sheep. Based on local knowledge built up through sheep gathering, the farmers were aware that the fracture had not been there previously. None of the interviewees were surprised that farmers discovered the fracture when gathering sheep (LI.10; LI.12). Instead locals mentioned that "a farmer knows his land very well… they go year after year after year to the same places" (LI.13).

Before the fracture was discovered, there was a dearth of human and financial investment in the study of large landslides in Iceland. This is likely to be common in cases where a country has had little or no past experience with a certain type of hazard. A risk manager reflected that in Iceland:

> we have been researching *jökulhlaup* [glacial floods] for decades, but landslides are something that we haven't looked at much. If you go to the university here I guess you would easily find fifty or sixty people that have a good knowledge and have done some research in *jökulhlaup*, you probably find two or three that have done some real research on landslides (RM.2).

Prior to the discovery of the fracture, there had been no country-wide assessment of landslide risks. Given the general lack of scientific research into large landslides around glaciers, the local knowledge gained through sheep gathering proved critical in the discovery of the hazard. Local people were well-positioned to identify this new type of hazard based on their in-depth understanding of the terrain and conditions faced in the area.

5.4.3 Warnings signs

There is an expansive body of local knowledge in Öræfi about flooding triggered by Grímsvötn, which typically occurs every 10 years. The short return period means that even young farmers have had first-hand experience of the floods (LI.12). Several interviewees recalled a farmer who could accurately predict glacial flooding in the 1960s, even when "scientists had no idea" (LI.15). He would observe the Skeiðarárjökull outlet glacier every morning from his window, and take note of its position (LI.13). Over time he observed that the glacier would rise in relation to the mountain several days before a flood emerged (LI.10; LI.11). A local woman recalled that "he told me himself that you see over the glacier to the mountain, when he saw it rising he said now the river is preparing to come" (LI.11). In this way, through regular monitoring and in-depth understanding of the surroundings developed over decades, he was able to predict flooding with a high degree of accuracy. Other flood indicators included a change of colour of the river water (LI.16) and a sulphuric smell (LI.13). People could build up this detailed knowledge because the flooding "was so regular and you had multiple floods in one lifetime, so people got a chance to actually study it, understand it and build up some knowledge" (LI.10). One interviewee explained that "people studied that [the flooding of rivers] really closely because it really mattered for their wellbeing and lives" (LI.10), others mentioned cases in which people had to flee the floodplains for their lives (LI.15).

In terms of Öræfajökull, interviewees indicated that an eruption would typically be preceded by a series of earthquakes and loud crack (LI.13). This has been supported by scientific investigation. Another warning sign was that silverware would become tarnished due to higher levels of sulphur in the air and water (LI.3; LI.11). In general, however, people noted that there were relatively few local stories and oral histories from the 1362 eruption with one woman reasoning that if "everyone died in the eruption, then if there were stories they wouldn't have survived…they would have died with the people" (LI.10).

The extensive body of local knowledge about warning signs of Grímsvötn flooding contrasts to the lack of information on warning signs for a large landslide from Svínafellsheiði. After the 2013 landslide onto Svínafellsjökull, many locals were not aware of the collapse until several days later when they noticed it by coincidence (LI.10; LI.13; LI.16). One woman explained that "people were driving by the glacier and were like 'oh, there was a slide on it'" (LI.10). Only one local inhabitant was aware that something had happened at the time because his horses were distressed; he made the connection when he found out about the landslide days later (LI.11). A local glacier tour operator recalled that in the days before the landslide:

> there was very much rain and we cancelled tours. Then when I came back, I didn't notice that the slide had fallen. It was very cloudy and rainy. Luckily, because of the terrible rain, nobody was on the glacier when it fell. (LI.15)

Based on this experience he reasoned that a large landslide resulting from the Svínafellsheiði fracture may be triggered by heavy rainfall (LI.15). Another local inhabitant believed that it would occur in early spring as the ground starts to thaw (LI.10), while a third mentioned that if he saw the sheep coming down from the mountain in the middle of summer, he would take this as an indication that "something is happening up in the mountains [such as an eruption or a landslide], then it would be better for us to go away" (LI.11). In discussing warnings, one local inhabitant commented that someone in her family would receive a premonition of the landslide and pass on the warning to other people in the community (LI.10). Finally, some inhabitants believed that the landslide would occur without any warnings based on their experience with volcanic eruptions: "even though the volcanoes are watched and measured a lot, there are many eruptions that come like [finger click] always as a surprise" (LI.5).

There was a high degree of uncertainty and a wide range of opinions expressed about when the fracture would collapse. One local inhabitant typified this doubt when she mentioned "we never know what's going to happen and we don't know if it's going to fall down in 10 years, 20 years or tomorrow" (LI.6). This understanding has been informed by scientific investigations which suggest that it could collapse with less than 60 seconds warning (LI.7). Interviewees often referred to scientific knowledge when discussing warning signs and the timing, indicating a greater dependence on science for this type of hazard compared with other hazards in the area.

Part of this lack of understanding of warning signs may stem from the novelty of this hazard, however it may also reflect the nature of large landslides. Carey et al. (2012) point out that the exact location and timing of slope failures are notoriously difficult to predict in any context. Through the interviews it was clear that there was a much lower level of confidence among people about meteorological or other conditions that may act as a warning sign or increase the risk of a large landslide compared with warning signs for eruptions and glacial flooding. Some interviewees, however, drew on their experience of smaller landslides and other hazards in the area, to speculate on factors that may increase the likelihood of collapse (LI.3; LI.15).

In explaining the large body of local knowledge about Grímsvötn flooding, local inhabitants pointed to a number of factors including the short return period, the high potential danger, and the typically low mortality rate. The long return period of Öræfajökull eruptions and the high mortality rate of the 1362 eruption were associated with a lower level of local knowledge. The relative rarity of large landslides onto glaciers in Iceland and dearth of experience people have with this kind of hazard were understood to be key factors in the lack of local knowledge on warning signs.

5.4.4 Potential impact

As with warning signs, the detailed local knowledge related to the likely effects of Grímsvötn flooding contrasted with the relative lack of knowledge about the potential effects of a large landslide triggered by the Svínafellsheiði fracture. All local inhabitants interviewed had a detailed understanding of the different paths of historic floods triggered by Grímsvötn. The floods of 1913 and 1921, for example, were remembered to be particularly destructive for farming land (LI.11). The location of houses in Svínafell, traditionally built part-way up the slope, reflected these flood paths. Over the past hundred years, man-made flood barriers and dykes have been erected to alter the direction and intensity of these floods. In response, people have shifted several houses in Svínafell further downhill to flatter and more fertile areas (LI.16). However, some of these buildings are now potentially exposed to runout from a large landslide triggered by the Svínafellsheiði fracture.

An understanding of the areas that will be affected by a collapse of Svínafellsheiði fracture, and specifically whether the runout will affect Freysnes or if the settlement will be protected by the terminal moraine, has been contested between scientific and local knowledge. Scientists and risk managers interviewed between October 2018 and January 2019, predicted that Freysnes would be affected directly, cautioning that the land/ice/water/air slurry may become airborne after reaching the terminal moraine, with catastrophic results for Freysnes (RM.2, S.1, S.2). When presented to the local community in a formal public briefing, this interpretation was questioned by several locals during question time and in open discussions afterwards (attended by first author, 24 October 2018). Drawing on their experience with glacial floods, several locals maintained that the runout would follow the path of the rivers on either side on Freysnes rather than affecting the settlement itself (LI.2., LI.5.). “With floods caused by the glacier, the runoff has always come down these two rivers”, one local reasoned, “why would this be any different?” (Informal discussion, 24 October 2018).

Updated scientific modelling conducted in mid-2019 suggested that the runout would likely follow the existing flood patterns and avoid Freysnes. Scientists predict, however, that the runout will be more likely to affect Freysnes as the volume in the proglacial lake increases (S.4). Even after the presentation of this updated modelling, some local inhabitants remained uncertain about the runout zone: “they believe that the moraine will be a shelter that divides the flood but we do not know how much flood will come, how much water. Maybe it won't just flood, maybe it will jump [due to the terminal moraine as first predicted by scientists]" (LI.12). Another interviewee added, "I hope so but you never know. It's really hard to calculate these things" (LI.12).

Even though people in the area have not faced a large landslide onto a glacier anywhere close to this size, they drew on typical impact patterns from other flooding hazards in an attempt to deduce potential effects. While local knowledge based on lessons learnt from glacial floods was ultimately supported by scientific investigation, these two forms of knowledge could have continued to run counter to each other.

5.4.5 Response

No large landslides have affected people or infrastructure in Öræfi. As a result, there are no stories of effective or ineffective responses for this specific type of hazard. This contrasts to the flooding from Grímsvötn. While flooding has not typically led to fatalities, people told many stories of survival and near-miss responses. These oral histories included stories of people collecting bird-eggs on nearby cliffs who were saved by people riding to warn them of an imminent flood. Other heroic stories involved people rowing into the floodwaters to rescue sheep (LI.15). Many interviewees also recalled stories of daring river crossings, with knowledge about how to cross rivers safely passed down through families (LI.11).

In general, there was a high degree of uncertainty about how people should respond to a large landslide caused by the fracture, including what is the safest places to take shelter. After attending public hazard briefings one local woman mentioned that she started to reconsider her previous plan of taking shelter in the basement of a nearby house, as scientists predicted that the house would be overrun by the landslide (LI.1.). She was left not knowing the safest way to react. Compared with other types of hazards experienced in the area, people did not have a clear idea of how to respond in the case of a large landslide, or the most effective survival strategies to follow.

5.4.6 DRRM processes

This study found that Icelandic authorities typically engaged and involved local communities in DRRM planning and preparedness activities for the Svínafellsheiði fracture. Based on their study of public perceptions of evacuation procedures for a potential eruption from Katla in 2006, Bird et al. (2009) determined that this participatory focus developed as a result of local inhabitants—especially those with local knowledge—rejecting top-down disaster management approaches.


Figure 7: Town hall meeting about the fracture, Hof (Photo: RUV, 2018).

Public hazard briefings represent a key forum whereby DRRM authorities drew on knowledge and experience of local inhabitants about the Svínafellsheiði fracture and surrounding area, to inform the development of DRRM plans (RM.2, RM.3; Figure 7). Bird et al. (2017) similarly identified public meetings as a forum where trust was developed between the locals and DRRM authorities in volcano risk management processes. Planning workshops conducted in October 2018 by the DRRM authorities with locals directly exposed to the Svínafellsheiði fracture, were interactive and involved frank discussion among participants. Local residents expressed their appreciation of the generally inclusive approach by authorities, with one local inhabitant reflecting that the authorities were "ready to listen to the people who live here" (LI.15).

There were several examples in which DRRM authorities and scientists were able to draw on local knowledge to improve their understanding of the hazard or the planned response. For example, one attendee remembered:

> In the last meeting, when they were presenting their findings, they showed some pictures that they took that morning from a plane. I think they said 'we think there is a new fracture here in Hafrafell' [next mountain west of Svínafellsheiði]. And then a farmer, said 'no, no, that is not a fracture, it is a sheep path. I always walk this path when I'm sheep herding.' And they said 'thank you for telling us so we don't have to hike up to find out that this is a path from the sheep not a new crack.' So that is an example of knowledge that farmers could add to the scientists. (LI.10)

The disaster management briefings mobilised the participation of the local population and played an important role in the exchange of information between the local community and authorities engaged in DRRM. While local inhabitants where typically involved in DRRM planning and preparedness, there were still areas of contention where local people did not feel that their voices were heard, including one DRRM decision that interviewees described as “a mistake” (LI.15). The main topics of contention involved specific policies, including the decision to limit access to the glacier for some activities but not restrict access entirely, and the decision to implement a no-build zone in the areas exposed to the fracture (LI.15). The effects of these decisions on the local community and their coping mechanisms warrant further investigation but lie beyond the scope of this article. Several interviewees were also frustrated that DRRM authorities did not always respect pre-arranged timeframes. For example one woman noted that “last autumn they said we would get answers in springtime, and now it is July and I think springtime is over. Maybe they are going to wait until the monitoring has been conducted for one year and I think that is in September or October, but why are they promising us springtime if it’s not true” (LI.1). Such statements suggest that lapsed deadlines eroded local trust in the process. However, overall what emerges is a broadly participatory approach to DRRM in which authorities and scientists value, and draw on the knowledge of local inhabitants. That said, while local knowledge is taken into account, scientific knowledge still tended to be given greater weight for example in determining runout zones.

5.5 Conclusion

There is consensus in the DRRM literature about the importance of incorporating local knowledge (Adger et al., 2014; UNPFII, 2015). With climate change, new hazards are increasingly emerging in areas where they were previously unknown. Building a better understanding of the role of local knowledge in DRRM in the context of emerging hazards is paramount. This ethnographic investigation of the Svínafellsheiði fracture helps illustrate how local knowledge has informed DRRM processes for a large landslide onto a glacier, a type of hazard that has not previously affected people or infrastructure in Iceland.

The case of the Svínafellsheiði fracture demonstrates how local knowledge can be instrumental in the discovery of emerging hazards. In the Öræfi district, local inhabitants develop skills and in-depth knowledge of the terrain through sheep gathering practices which, in many ways, acts as an unofficial annual land survey conducted by people who have an intimate knowledge of the landscape. Local people, especially those with customary practices of natural resource management, are often well positioned to identify changes in the terrain and conditions based on their in-depth understanding of their local area. This can be particularly important in the case of new hazards where large-scale funding for scientific research into a particular hazard is not yet available. The important role of local knowledge in discovering new types of hazards may be relevant to a range of slowly-emerging climate change-related hazards including floods, landslides, rising sea levels. The potential of local knowledge could be further capitalised upon in Öræfi and elsewhere, if inhabitants were engaged systematically through citizen science initiatives incorporated into formal DRRM processes. This represents an avenue for further investigation.

In terms of warning signs, potential impact and response, we found there was an extensive body of local knowledge pertaining to flooding from Grímsvötn, and, to a lesser extent, eruptions of Öræfajökull. Comments from local people suggest that there was a greater volume of hazard-specific local knowledge when a hazard had a relatively short return period, such as flooding from Grímsvötn, enabling people to make observations and test theories several times within a lifetime. A small number of local inhabitants attempted to draw lessons learnt from other types of hazards to better understand the warning signs and potential impact of Svínafellsheiði fracture, with varying success. Meanwhile, local knowledge of other hazards provided little guidance on how to respond in the case of a large landslide. These findings suggest that while it is important to draw on local knowledge, it may be less directly applicable for understanding the predicted impact and effective response strategies for new hazards.

Finally, this study found that local knowledge is not just relevant to DRRM processes in less developed and developing countries. McWilliam et al. argue that "local knowledge for DRR is particularly important in countries where government capabilities are limited" (2020, p. 1). This has been confirmed through a large body of scholarship. However, this case adds support to the contention that local knowledge is also important in countries with well-established and well-funded DRRM processes. Even in highly developed countries, implementing effective DRRM strategies requires an integrated approach that involves local inhabitants, scientists and DRRM authorities, bringing together the knowledge of all three groups.

6 Psychosocial response to a no-build zone

This section contains the peer-reviewed journal article:

Matti, S., Ögmundardóttir, H., Aðalgeirsdóttir, G., & Reichardt, U. (2022). Psychosocial response to a no-build zone: Managing landslide risk in Iceland. *Land Use Policy*, *117*. https://doi.org/10.1016/j.landusepol.2022.106078

Abstract
Land use planning has been promoted as a key measure to decrease the risk of natural disasters including landslides, however, there is a dearth of research on the impact it has on the psychosocial wellbeing of affected people. This ethnographic study examines the risk management of the Svínafellsheiði mountain in south-east Iceland. Scientific monitoring suggests that an estimated 60–100 million cubic metres of bedrock could fall onto the glacier below, and cause flooding or a tsunami in the proglacial lake. A no-build zone was in place between 2018 and 2020 to prevent a further increase in the number of people exposed to the hazard. Our results indicate that the no-build zone had adverse effects on the psychosocial wellbeing of those affected including frustration about a perceived inability to make changes to their home and business operations, leaving them feeling that their future was uncertain or on hold. These frustrations also acted as a persistent reminder of the risk posed by the unstable slope, reinforcing anxiety and undermining people's ability to gain respite through day-to-day routine. Based on the findings, we recommend that land use planners take the psychosocial wellbeing of affected communities into account when contemplating no-build zones, and that psychosocial support be offered especially when a small group of people face an existential threat for an extended period.

Keywords
Risk management, Land use planning, Landslide, Iceland, No-build zone, Svínafellsjökull, Psychosocial, Mental health

6.1 Introduction

Natural disasters are increasing both in frequency and magnitude globally (UNDRR 2015). In all countries, the exposure of people and assets to disasters has risen faster than vulnerability has decreased, generating new risks and leading to burgeoning disaster-related losses (UNDRR, 2015). Climate change, growing population density, globalisation and unsustainable development practices all represent key drivers of this increased risk exposure (Cutter et al., 2015; IPCC, 2012; Lateltin et al., 2005). The incidence of landslides has also risen (Cascini et al., 2005), and is predicted to rise further in high mountain areas due to effects associated with climate change such as heat waves, glacial retreat, permafrost degradation and changes in precipitation (IPCC, 2012).

Glaciers in Iceland have been retreating at an increased rate in recent decades (Aðalgeirsdóttir et al., 2020, Hannesdóttir et al., 2015, Hannesdóttir and Baldursson, 2017; Adger et al. 2014; Schmidt et al., 2019). As glaciers retreat, they provide less buttressing support for over-steepened valley flanks, leaving them susceptible to failure (Ballantyne, 2002; IPCC, 2012; Hock et al., 2019). In 2014, a fracture was identified in the Svínafellsheiði mountain, in Spring 2018 another fracture was observed on the lower part of the mountainside (Sæmundsson et al., 2019). Subsequent investigation has shown that the "two fractures are connected and form an up to 1.7 kilometre long fracture system, which can be traced from 850 metres height down to the surface of the Svínafellsjökull outlet glacier at around 300 metres above sea level" (Sæmundsson et al., 2019, p. 1). As of 2019, the fracture in the bedrock was approximately 30 centimetres, and widening at 1.3 centimetres per year between 2016 and 2018 (Sæmundsson et al., 2019; Figure 2). There is an estimated 60 million cubic metres of rock in motion; if the unstable slope collapses, scientists predict that between 60 and 100 million cubic metres of debris will fall on the surface of the glacier (Sæmundsson et al., 2019). There is a risk that it could break up the surface of the glacier, and produce a tsunami in the proglacial lake that could affect people and infrastructure downhill (IMO, 2018a). This is the first time that the risk of large landslide[8] onto a glacier has been identified and the risk managed since Iceland was first settled (Gylfason, 2018). At the time of writing, the fracture was continuing to widen (Figure 1; Figure 2; Figure 8).

[8] A large landslide is defined as a mass movement involving more than one million cubic metres of debris (Bonnard et al., 2004)

Figure 8: The Svínafellsheiði fracture is visible as a large trench in the photographs is approximately 30 centimetres wide in the bedrock (Photo: Þorsteinn Sæmundsson, 2019).

In October 2018, people living downhill from the unstable slope in the settlements of Freysnes and the western end of Svínafell (Figure 1), were informed that all building in the area would be halted until a risk assessment of the slope was completed. The aim was to prevent further increasing the risk as a result of people spending longer periods in the exposed area, which could produce higher casualties and economic losses in the case of a large landslide. The no-build zone remained in place for more than two years before it was reversed following the release of the risk assessment.

Recent international efforts, including the Hyogo Framework for Action and the Sendai Framework for Disaster Risk Reduction 2015–2030, have identified land use planning as a key method to manage the risk of disasters (UNDRR, 2005; UNDRR, 2015). This is supported by a substantial body of research (e.g. Burby, 1998; Burby et al., 2000; Adger et al., 2014; King et al., 2016). While this body of work incorporates many technical elements, the psychosocial effects of pre-impact land use risk management remains a gap in the literature. This paper addresses this gap by examining the psychosocial responses of people affected by the no-build zone established in response to the unstable slope of Svínafellsheiði. This study is based on ethnographic research, consisting of 50 interviews with people either working on or exposed to the hazard, as well as a series of field trips and participant observation conducted in the area, between August 2018 and April 2021.

This study will be useful for planners and policy makers contemplating restrictive land use policies to manage disaster risk. One of the main findings is that the no-build zone undermined the psychosocial wellbeing of people in the community both by exacerbating uncertainty about the future, and undermining people's ability to gain respite through everyday routine. This paper reports on a specific case in south-eastern Iceland, however, the issues explored and the implications for the application of land use policies in disaster risk reduction are relevant to a broader international audience.

The remainder of the paper is structured as follows. Section 6.2 provides an overview of the relevant background to landslide risk management in Iceland, land use management, and psychosocial effects associated with disasters. Section 6.3 describes the research design including study area, and methodology. In Section 6.4 we discuss the results of our research. Finally, our conclusions are reported in Section 6.5 along with policy implications for land use planning for disaster risk management.

6.2 Background

Iceland is prone to a multitude of hazards including extreme storms, floods, earthquakes and volcanic eruptions, however most fatalities in the country have been attributed to rapid mass movements in the form of landslides and avalanches (Van Well et al., 2018). In winter 1995, two avalanches occurred in Súðavík and Flateyri causing 34 fatalities, representing the deadliest natural disasters to affect Iceland in recent decades (Nadim et al., 2008). Both occurred in areas previously considered safe (Arnalds et al., 2004). During the research period, there were several avalanches—including in Flateyri on 14 January 2020—on a similar scale to the 1995 avalanche (Vísir, 2020). Then on 18 December 2020, a landslide fell on the town of Seyðisfjörður in eastern Iceland; damaging 12 buildings, it was the "most damaging landslide to have affected an urban area in Iceland" (IMO, 2021, p. 1).

6.2.1 Landslide risk management

In Iceland, municipal governments are the leading authority in disaster mitigation and prevention in the fields of civil protection, health, spatial (including land-use) planning and education (Lidmo et al., 2020; Van Well et al., 2018). At the national level, the Department of Civil Protection and Emergency Management (DCPEM; Almannavarnadeild ríkislögreglustjóra) plans and implements measures aimed at preventing and mitigating risk from natural hazards (Parliament of Iceland, 2008). Iceland is also signatory to both the Sendai Framework for Disaster Risk Reduction 2015–2030 and the preceding Hyogo Framework for Action 2005–2015 (United Nations Office for Disaster Risk Reduction (UNDRR; formerly UNISDR), 2005, United Nations Office for Disaster Risk Reduction (UNDRR; formerly UNISDR), 2015). The Icelandic National Planning Policy (2015–2026), establishes that natural hazards and climate change be taken into account by municipalities when planning land use (Icelandic Planning Agency, 2016).

The 1995 avalanches spurred the large-scale revision of risk assessment and mitigation processes for rapid mass movements in Iceland. This included passing the Act on Protective Measures Against Avalanches and Landslides (Parliament of Iceland, 1997) and establishing the Icelandic Avalanche and Landslide Fund (Ofanflóðasjóður) to finance protection measures and relocation from exposed areas (Parliament of Iceland, 1997). Further regulation passed in 2000 restricted land use in areas deemed to have an unacceptable level of risk due to avalanches or landslides (Parliament of Iceland, 2000).

The Avalanche and Landslide Fund covers both types of hazards, however, the vast majority of zoning, assessment and mitigation work has been devoted to avalanches while "landslide risk zoning has rarely been explicitly carried out" (Illmer et al., 2016, p. 25); there has also been a dearth of research on landslide risk in the country (Sæmundsson et al., 2003).

Land planning is an important tool to reduce the risk and future losses from natural hazards (Adger et al., 2014; King et al., 2016; UNDRR, 2015). This land planning can take the form of building standards, risk zoning, protective infrastructure, and retreat and relocation policies (Burby, 1998, Burby et al., 2000). Risk zoning regulates or prohibits (i.e. a no-build zone) construction in areas assessed as being at risk from a given hazard (Henstra and McBean, 2005; Japan International Cooperation Agency, 2017). An emerging literature examines the use of zoning for mitigating landslide risk in different country contexts including Andorra (Cascini et al., 2005), Hong Kong (Cascini et al., 2005), Italy (Cascini et al., 2005; Mattea et al., 2016), Peru (Carey et al., 2012, Klimeš et al., 2019), Switzerland (Cascini et al., 2005; Lateltin et al., 2005), the UK (Gibson et al., 2013), and the US (Cascini et al., 2005). Both Norwegian and Swiss governments have identified risk zoning as one of the most effective measures to prevent damage from landslides (Kalsnes et al., 2016; Lateltin et al., 2005). While land use planning can reduce vulnerability and mitigate risk before a disaster occurs, these measures are typically introduced immediately after (rather than before) destructive natural disasters including landslides (Bonnard et al., 2004, Burby et al., 2000; Garrido and Saunders, 2018).

While scientists argue that risk zoning is one of the most safe and cost-effective methods to mitigate landslide risk (Klimeš et al., 2019, Schuster and Highland, 2007), there is often strong opposition from developers, property owners, and local inhabitants (Carey et al., 2012, Vilímek et al., 2006). The IPCC confirms that risk zoning is controversial and that a lack of enforcement can open the way for temporary settlements, land speculation and the creation of new vulnerabilities (Ingram et al., 2006; IPCC, 2012). Furthermore, risk zoning has been criticised for enhancing public feelings of discrimination, tension, fear and mistrust (Hyndman, 2008, Ingram et al., 2006, Santos et al., 2015). Research indicates that risk zoning is more effective if conducted at the local level, and based on a participatory approach drawing on local knowledge (Asian Development Bank, 2016; 68; Khailani & Perera, 2013; Norizan et al., 2021; UNDRR, 2015; Wamsler, 2004).

6.2.2 Psychosocial response

Natural disasters can cause significant psychological and social suffering among affected individuals, families and communities (IASC, 2007). While disaster management has shifted towards a greater emphasis on risk reduction, psychosocial research and interventions remain squarely focused on response and recovery phases (Gray et al., 2021). That said, a body of literature sheds light on how people react to pre-impact uncertainty, warnings, and evacuations as well as psychological resilience (Adger et al., 2012; Cutter et al., 2008; Heath et al., 2001; Thompson et al., 2017).

Pre-impact psychosocial reactions are varied and often difficult to assess (Hu et al., 2017). Afifi et al. (2016) find that being exposed to risk typically generates anxiety, while Sword-Daniels et al. (2018) show that it can lead to uncertainty about the future. Stancu et al. (2020) find that previous experience of a similar hazard increases perceived risk among affected people, but that this decreases over time. Prolonged exposure to uncertainty has also been linked to a rise in anxiety, increased apathy, and a reduction in perception of risk (Paton, 2003; Weber, 2006). Meanwhile, threat denial, near miss experiences, belief in the safety of one’s home, protecting dependents and place attachment have all been found to have an effect of how people behave during evacuations (Adger et al., 2012; Heath et al., 2001; Thompson et al., 2017).

Coping encompasses a wide range of cognitive and behavioural efforts that people employ to manage or tolerate stressful situations (Lazarus and Folkman, 1984). Stancu et al. (2020) argue that the employment of coping mechanisms is affected by a range of factors including risk perception, trust, past experience, affiliative behaviour, and place attachment. There are several references in the risk management literature to people affected by disasters gaining respite from everyday routines. For example, Scaffa et al. (2006) argue that occupation can help people re-establish their lost sense of control after a disaster, while Mutch (2015) refers to the importance of teachers returning to work after earthquakes in New Zealand.

Since 1995, psychosocial support for survivors has been incorporated into Icelandic disaster response, with the government and local authorities responsible for providing psychosocial support (Þórðardóttir, 2018). For large-scale disasters, the psychological first aid provided includes physical and emotional comfort, supporting adaptive coping, connecting survivors to support networks and the provision of information (Þórðardóttir, 2018). While increased insecurity and anxiety has been identified among people living in areas exposed to avalanches in Iceland (Jóhannesson and Arnalds, 2001), psychosocial support remains firmly focused on the post-impact phases of a disaster (DCPEM, 2018a).

By and large, studies and policies about risk zoning rarely mention the psychosocial wellbeing of inhabitants. An exception is the criteria used for the buy-out of properties following the 2010/11 earthquakes in New Zealand that takes into account the "health and wellbeing of the affected property owners" (Harris, 2016, p. 10).

6.3 Materials and methods

6.3.1 Study area

The study area for this research is the Öræfi district in south-eastern Iceland (Figure 1). The district is spread around the base of a large ice-capped stratovolcano, Öræfajökull, which extends south from the Vatnajökull ice cap. Öræfajökull erupted most recently in 1727, and before that in 1362 in the most powerful volcanic eruption to occur in Iceland during historic times (Guðmundsson et al., 2016).

In the past two decades, this sparsely populated rural district has changed from being largely dependent on agriculture to becoming an important area for tourism (Welling and Abegg, 2019). These changes have led to a massive increase in the number of both Icelanders and foreigners working in the tourism sector in the area, along with the high numbers of tourists visiting the area year-round. In 2018, the Öræfi district had a permanent population of 151 people, however, the number of people living and working in the area was much higher (Statistics Iceland, 2020).

On 22 June 2018, local police together with the Department of Civil Protection and Emergency Management issued an advisory based on the risk of the unstable Svínafellsheiði slope. The advisory recommended that travellers “stop only for a short while at viewpoints by the glacier tongue” and that glacier walks on Svínafellsjökull be discontinued (2018a, p.1). In the days that followed, tourism-orientated activities were shifted to other glaciers in the area. Later that year, hazard warning signs were erected on the main routes to the glacier, and in October a series of public risk briefings were held with the local community (Figure 7). The key risk management activities conducted since 2018 have included the monitoring and risk assessment of the slope, risk communication, and the imposition of a no-build zone in potentially exposed areas of Freysnes and Svínafell. Studies published about the slope have focused on the potential landslide dynamics (Helgason et al., 2018; Sæmundsson and Margeirsson, 2016; Sæmundsson et al., 2019) and the role of local knowledge in risk management (Matti and Ögmundardóttir, 2021).

Freysnes lies approximately 800 metres in front of the Svínafellsjökull proglacial lake while Svínafell is located two kilometres further south-east (Figure 1; Figure 2). In 2018, there were approximately 80 people who lived in Freysnes: a settlement consisting of 17 buildings including a hotel, petrol station, diner, search and rescue coordination centre, a farm and several houses, and traversed by the country’s main highway. Only the western-most farms of Svínafell are considered to be potentially exposed to risk stemming from the unstable Svínafellsheiði slope. In summer 2018, approximately 1,500 people spent time in the area potentially exposed to the hazard each day, including an estimated 800 tourists on glacier tours (Matti and Ögmundardóttir, 2021).

6.3.2 Methodology

This study was based on a mixed-methods ethnographic research design conducted between August 2018 and April 2021. A purposive sampling method was used to identify 52 people (25 females; 27 males) who participated in a series of 50 semi-structured interviews. The interviewees were 14 Icelandic local inhabitants, seven foreign inhabitants, nine glacier guides, nine tourists, three risk management experts, three scientists, two municipal government officials, two tourism experts, two search and rescue coordinators, and one national park ranger. Some participants were interviewed several times throughout the course of the research. Most interviews were conducted individually, however, five were conducted with couples and one was conducted with a group of four local women. All interviews were conducted in English with the exception of one which was conducted in Icelandic through a local interpreter. The length of the interviews was typically between 60 and 90 min, and in most cases either took place in the workplace or home of the interviewee. The final three interviews were conducted online to comply with COVID-19 restrictions. The interviews were semi-structured (Paton, 2002), using a basic interview frame with similar core questions.

Information from the semi-structured interviews was triangulated with data gathered through active participant observation conducted by the first author while living in the community and working as a glacier guide between April and October 2019. This helped the authors gain a deeper understanding of the topic (Maxwell, 2009). Twelve additional trips were undertaken to field site including to participate in two scientific monitoring missions (October 2018 and August 2019; Figure 4; Figure 5; Figure 9; Figure 10), and three formal public risk briefings (October 2018). All interviews and field notes were recorded, transcribed verbatim, and analysed using qualitative data analysis software (QSR Nvivo 12®). The analysis process was inductive, allowing sub-themes to emerge from the data, including psychosocial stress stemming from the no-build zone (Priest et al., 2002). The lack of a documented risk management and zoning plan for the unstable Svínafellsheiði slope represented a challenge while conducting the research. To ensure anonymity, sources were broadly categorised and coded as local inhabitants (LI), foreign inhabitants excluding glacier guides (FI), glacier guides (GG), municipal government authorities (MG), scientists (S), risk managers (RM), tourism experts (TE), tourists (T), and observations from the public risk briefings (PB). Reference to specific interviewee codes are only included for direct quotes (e.g. LI.3). Where information is paraphrased, the source includes information on the number of interviewees by demographic. For example, “5 GG” indicates that it was mention by five glacier guides.

Figure 9: Solar-powered scientific instruments have been set up on the slopes of Svínafellsheiði to monitor changes in the slope stability (Photo: Stephanie Matti, 2018).

From initial planning, the research was guided by the primary obligation of anthropologists to do no harm (American Anthropological Association, 2012). The authors were conscious of ensuring that the research did not contribute to the stress or anxiety of participants who lived or worked in areas exposed to the hazard. A number of specific preventative steps were taken. Relevant risk managers were consulted in advance about how and when the authors should conduct interviews with people in the area to reduce the potential for harm. The detailed understanding of the environment, unstable slope, and community dynamics we acquired through interviews with scientists and risk managers, as well as ethnographic research, helped us conduct interviews with people living in the area in a considerate manner. Immediately after the conclusion of interviews, participants were asked informally how they felt about the interview process and the research, and specifically whether it contributed to any feelings of stress or anxiety. There were no indications either through the responses provided or body language that the research had a negative effect on psychosocial wellbeing. On the contrary, several participants mentioned that they were happy the research was being conducted into the risk management of the unstable slope, and how it affects people in the area. In cases where participants requested further information about the slope instability during interviews, they were referred to relevant government websites at the end of the interview. In this way, the study process also helped increase awareness. The research findings were shared with several members of the community for their review and feedback before publication. This continued exchange and ongoing presence in the community represented an opportunity for people to engage further or request additional information.

Figure 10: View from Svínafellsheiði across Svínafellsjökull and the Öræfi District (Photo: Valdimar Leifsson, 2018).

6.4 Results and discussion

In this section we present the results of our research into the psychosocial responses to both the risk of the unstable Svínafellsheiði slope as well as the no-build zone imposed to mitigate the risk. The first sub-section provides an overview of psychosocial reactions to the risk of the unstable slope observed during the research. The second examines the establishment of the no-build zone, and the next looks into how the no-build zone affected the psychosocial wellbeing and coping mechanisms of people living and working in the area.

6.4.1 Psychosocial reactions and risk coping mechanisms

The majority of participants living or working in areas exposed to the Svínafellsheiði slope instability reported that they did not feel stress or anxiety due to the fracture on a daily basis. This points to a high overall level of resilience within the community. There were, however, several cases in which young adults reportedly experienced psychosocial responses. This included participants who recalled experiencing nightmares about the slope collapsing (1 GG), and feeling hyper-sensitive to sounds emitted by the glacier (1 FI), as well as an interviewee who recalled that a foreign inhabitant moved away from the area because of her concerns about the slope (1 FI).

A common sentiment expressed by participants was the feeling of responsibility towards others, including family members, clients and staff members in the case of a landslide. This was particularly apparent in people whose jobs entailed responsibility for the safety of others, either as employers or as glacier guides (3 GG; 3 LI). A local inhabitant reflected that "if you have a company then you're always responsible for the people who are working for you and you're also a bit responsible for your guests" (LI.6). Among participants who mentioned feeling responsible for others, this was considered a source of heightened concern (2 LI; 3 GG).

Another source of added stress came from the reactions of family and friends living outside the Öræfi district. A local inhabitant reflected that people from outside the area tend to question "why you are living underneath the biggest volcano in the country and having a possible landslide on the glacier causing a tsunami? You're far away from everything and there's nothing there, why wouldn't you move somewhere else?" (LI.3). The suggestion that people move causes affected people to reflect on and justify their choices, while ignoring the important reasons why people decide to live in the area, including sense of place, community, belonging, and historical rootedness.

In general, the participants noted that their perceived risk and anxiety lessened over time when there was either no change or a decrease in the threat level; the release of information indicating an increased danger was associated with a brief increase in anxiety. A foreign inhabitant reflected that after public risk briefings "it would be 'panic panic panic' and then 'oh like it's stayed there for a while' and life goes back to business as normal" (FI.1). However, long waiting periods between hazard briefings was identified as a source of frustration, with one interviewee reasoning that was not healthy for people (1 LI) and three people likening it to waiting for a cancer diagnosis (1 LI; 1 MG; 1 S).

The landslide that occurred in Seyðisfjörður—200 kilometres north-east of Freysnes—in December 2020 was understood by government officials to compound the psychosocial effects of the unstable Svínafellsheiði slope. A municipal authority explained that "it's so big in Svínafellsheiði, I cant imagine how it's going to happen. And then you see what happens in Seyðisfjörður and I realise 'oh, my God, Svínafellsheiði is bigger, and there is ice and water and everything involved'" (MG.2). She reflected that "when there is a disaster going on, and you are living in another place that has a similar threat, and I think it creates anxiety and maybe depression" (MG.2).

Foreign and local inhabitants found various mechanisms to try to cope with the uncertainty and risk associated with the slope. Different approaches were referred to in the interviews:

> This fracture has been there for years now and everybody is fine, I can't wait until they finish this [risk management process] (LI.1).
>
> I grew up with the thought that everything can be dangerous. You cannot live in fear because if you want to avoid the danger, where should you go? Anything can happen. Some places in Iceland you can have snow avalanches, some places you can have volcanic eruptions, some people can drown in the sea and the most dangerous is always the traffic (LI.2).
>
> Maybe we need to move away from this area but when nobody knows anything, why be super stressed about it because there is nothing we can do about it. It is like with Öræfajökull, we can't be unhappy the whole time. We decide that we want to live here for various reasons and then we take it as it comes (LI.3).
>
> We never know what's going to happen and we don't know if it's going to fall down in 10 years, 20 years or tomorrow. Of course, it's not tomorrow. It's just hypothetical to say that (LI.6).

These interview excerpts shed light on the different coping mechanisms used by people included placing the situation in the context of other risks, trusting that others will manage the risk, and drawing on uncertainty about the form and timing of a landslide to downplay any immediate threat (2 LI; 1 FI; 1 GG; 1 PB). Having a "tight knit" and "small closed community" in which people "rely on each other" was also mentioned as an important collective coping mechanism (LI.3).

People in the local community were engaged and active in risk management processes. Every local inhabitant interviewed as part of this research had attended at least one public briefing about the unstable slope, which were typically followed by engaged informal discussions among participants. Several local inhabitants also assisted scientific monitoring trips to the slope instability. Furthermore, every person approached as part of this study was willing to discuss the unstable slope and how they had been affected by the risk. Overall, people were willing to engage in discussions about the risk when questioned or when attending forums devoted to the topic.

However on a day-to-day basis, several local inhabitants mentioned that they intentionally avoided dwelling on the risk presented by the slope. One interviewee explicitly stated that "it's like an unwritten contract that we don't talk about it" (LI.6), another mentioned that it was "best not to think about it" (FI.7). This tendency to not talk about the unstable slope was more prominent among older people living in the area, while younger demographics, especially those trained as guides, were more likely to discuss the risk of the slope and how they were affected by it. There was no obvious difference by gender. A risk manager compared this reaction to the "typical Icelandic reaction to volcanic risks". She mentioned that it initially appeared that people "did not let it [the risk of an eruption] bother them, but then when you dig in deeper you can find that it does, you know they are thinking of it all the time but they don't talk about it" (RM.3). By not talking about it on a day-to-day basis, people avoid reinforcing the uncertainty and compounding the anxiety felt by themselves and others. This was understood to be a way to maintain a level of normalcy and gain respite from daily routine.

6.4.2 Establishment of the no-build zone

In 2018, the municipal council put a freeze on all new construction in areas deemed at-risk from the Svínafellsheiði mountainside, including Freysnes and some sections of Svínafell. The no-build approach was communicated orally to the affected people during public risk briefings in October, and was instituted by halting building plans submitted to the municipal government for approval. People were told that the no-build zone would remain in place until a full risk assessment was conducted by the Icelandic Meteorological Office (Veðurstofa Íslands), however it was not clear how long this would take (2 MG). There was no official planning policy disseminated clarifying what area specific were affected, the duration and other details of the no-build zone (1 LI; 1 MG). The verbal approach to communication was no doubt influenced by the low population density and small number of house or business owners affected. Building proposals that were halted included a large tourism hub approximately three kilometres north-west of Freysnes (1 LI; 2 MG; Figure 1) as well as other smaller plans for construction. In effect, the no-build zone stopped "any sort of developments in the area people thought was at risk" (MG.1), this included the construction of new buildings and the extension of existing buildings.

The stated aim of the no-build zone was to prevent more people and infrastructure being exposed to the risk, especially for long daily periods such as people sleeping in the area (2 LI). An increase in structures was also understood to compound future challenges of evacuation or compensation if residents were moved permanently from the area (1 PB). While there was a clear understanding of the difficulties that the no-build zone would place on the people affected, a municipal authority explained that "the common goal is to keep people safe, or as safe as we can" (MG.1). However, municipal authorities were aware of the potential negative effects and challenges that it may cause for affected people:

> People have land and they only have that piece of land. And they want to build or do something on their land to increase its value or increase the value of their companies. They don't have another piece. That's the piece they have and of course they want to build or change and do something in their own land (MG.1).

In-line with national regulations, hazard and risk assessments for the Svínafellsheiði slope were conducted by the Icelandic Meteorological Office. Several factors made the risk assessment atypical. The main risk to people and infrastructure stems from the secondary hazard of flooding or a potential tsunami triggered by the landslide, rather than from the landslide itself (1S). This further complicates the hazard modelling, as well as raising questions about whether it falls under landslide or flooding risk management policies. The hazard risk is likely to increase over time as the proglacial lake is predicted to continue expanding. A scientist explained:

> With the melting of the ice, and the lake growing bigger, the hazard increases. As a result, you have to look at the timeframe, which makes everything more complicated (S.5).
>
> How much of the snow or the ice will melt in the next 30 years? We have a rough estimate based on the past 30 years, but we have no idea how the climate will be. Will it be warmer? Will it be colder? After 10 years, we will have to look again 30 years into the future (S.5).

As such, the risk assessment hinges on how the proglacial lake is affected by changes to the climate in the coming decades. To inform land planning, it is necessary to predict the evolution of a landslide risk over longer time periods of years or decades. Cascini et al. (2005) explain that this is particularly challenging for landslides when there are a large number of variables at play. This is compounded when it is the first of a particular type of hazard in an area, where the interaction of different variables including glacial retreat and rock types is understudied. The rapid expansion of the tourism sector in the district also meant that exposure rates had the potential to increase substantially due to new constructions. This heightened the urgency with which the risk assessment was conducted, as businesses were expanding to meet the demands of tourists (1S).

The risk assessment was presented to the community through public briefing sessions conducted in Icelandic in two phases: the analysis of the current situation was presented in October 2019, then the analysis of the future scenarios was presented in September 2020 (1S). The results predicted that the run-out zone would be narrower than the initial area covered by the no-build zone, but that this exposed area would increase over time as the proglacial lake expands (1 MG). As a consequence of the findings of the risk assessment, the no-build zone was lifted and by early 2021 the permission process for the large tourism hub had been reinitiated (2 MG). At this point, the approach of municipal decision-makers shifted from a no-build zone to the consideration of flood barriers to protect future infrastructure (1 MG).

The current approach of the Avalanche and Landslide Compensation Fund in Iceland represented an additional factor to be taken into account by municipal decision-makers. Based on the way the Fund is implemented, compensation only covers areas that have been zoned as urban (i.e. in towns or cities). It does not cover areas zoned as rural or commercial such as Freysnes and Svínafell (2 MG). A municipal authority explained:

> The inhabitants know this is a danger they face, but because they're in a rural area, the government does not buy the houses. In Seyðisfjörður, people live in a town so they can ask the government to buy the house and the people can go live somewhere else. But in Iceland, when you are in a rural area, then you cannot use that option (MG.2).

Another municipal authority questioned this approach: "I don't know why it is like that, because the danger was not known when it was built" (MG.2). This limits the different choices available to decision-makers and may have affected their decision to establish a no-build zone. Furthermore, the Fund does not cover commercial operations even in residential areas. It therefore, remains unclear how local business owners would be compensated in the event of one or many temporary evacuations (1 RM). In the past with other natural disasters including volcanic eruptions and earthquakes, "people have just lost a lot of money" (RM.2). If businesses exposed to the Svínafellsheiði slope were evacuated in a similar manner, this would come at a considerable loss of earnings and reputational cost.

6.4.3 Response to the no-build zone

Interviews with local inhabitants reveal that the no-build zone has affected the psychosocial wellbeing, and undermined the coping mechanisms of people living and working in the area. The no-build zone had a direct impact on the plans of several people: a family was not able to build a new room following the birth of their third child, instead their three children share a single room (1 LI); a man who had planned to expand his sheep farm reflected that he "cannot follow their dream because of this rockslide" (LI.16); and others put long-standing business plans on hold (1 LI). The no-build zone also limited the future job opportunities available to some foreign inhabitants (1 FI).

Information provided in several interviews, as well as through written correspondence with local inhabitants and staff, indicated that the no-build zone compounded psychosocial effects on people living in the affected areas. A local inhabitant wrote about her experience:

> Since the meeting about rockslide, it has been very difficult time for us here because we are not allowed to look towards the future. It looks like we are in such a dangerous place. My questions are more about the future. My questions are not about how the rockslide can happen, but whether we are allowed to continue living here. We are not allowed to build anything here, our future plan is nothing…. …If we need to close our company, we need to stop taking reservation for guests, we have to fire staff, find ourselves a place to stay, send our sheep to the slaughterhouse. It will take some time. We will need some help for that. But if we need to leave, I want to have this area closed for everybody because of the danger. For all of us, is this a terrible situation, sleepless nights, depressing time and all our thoughts about the future. All of us (not only me or you) need to find a way out of this, to talk about the best outcome for everybody. We have our next generation nearby, and they would like to take over but if they are not allowed, they need to know as soon as possible (LI.16).

The locus of the uncertainty portrayed in the above written correspondence was not how and when the mass movement might occur, but rather the effect of risk management decisions on people's lives. After explaining that they were not allowed to build in the area due to the no-build zone, she went on to say that "our future plan is nothing". In a follow-up interview, she mentioned that "it's not enough to try to protect everybody, you need to have your future plan" (LI.1). In this way, the no-build zone directly undermined peoples long-term vision, plans and perceived stability of living in the area, making people feel that their lives were on hold until further information became available (1 LI), which in this case took more than two years. This was also recognised as being an issue by scientists, and municipal government authorities (2 MG; 1 S).

During the period in which the no-build zone was in place, municipal authorities and scientists were aware that it was having an adverse effect on people in the area:

> The inhabitants were calling us and saying "when is it going to be ready? I have to go on building". And we asked Veðurstofa [the Icelandic Meteorological Office] "when are you going to do this?" That was the dilemma in the beginning, then when everyone realised that it [the potential landslide] was not a small thing but a very, very, very big thing. We all got settled, and we realised we just had to wait because it's a really complicated thing (MG.2)

The uncertainty is always difficult for people. Should we build? Should not build? Should we try to sell? Will we get anything for the house? Will somebody buy it? All sorts of things go through your head if you're in that position. It happens during the uncertainty phase, in this case it was almost two years. And then when you have the answer, if it's bad or good at least you have an answer, and then you can start to plan for the future (S.5).

Another local inhabitant reflected that people affected by the no-build zone "have been trapped, they haven't been able to do anything" (LI.3). Others felt that it placed an unfair burden on people trying to cope with the risk of the unstable slope (2 LI). The interviews indicated that there was a lot of empathy and support within the community for people affected by the no-build zone. It was clear from the interviews that the no-build zone significantly increased the long-term uncertainty for people living and working in the area, and had a direct adverse effect on the psychosocial wellbeing of these people; these effects were exacerbated by risk communication during this period.

A commonly expressed frustration was that risk management commitments were not delivered in a timely manner or according to the pre-arranged schedule. For example, people recalled that in October 2018, the local community was informed that they would receive an update the following spring. In an interview the following year, a local inhabitant explained "now it is July and I think springtime is over. Maybe they are going to wait until the monitoring has been conducted for one year and I think that is in September or October, but why are they promising us springtime if it’s not true” (LI.1) Another person was told that she would receive an email with further information from risk managers, which never came (1 LI). Scientists explained that the meeting was postponed for multiple reasons including delays in the risk assessment, which was finally available in summer when government decision-makers were on summer vacation. There was an understanding that this delay affected local people: “of course people were frustrated, they were waiting to finally get some answers and then you postpone it by a few months, when they are still living in an uncertainty bubble” (S.5). People in the community were aware of the challenges facing risk managers and scientists, especially due to the scale and unprecedented nature of the hazard. However, the inability to deliver risk management actions on time heightened the uncertainty that people experienced and began to erode trust in risk management processes. A municipal authority suggested that:

> It would have been useful for the affected people, since there was a no-building and no-planning policy in place, compounded that they should have received some timeline of how it would proceed, even though it changed in the process. It would have been useful to have a timeline and a continuing discussion throughout the process (MG.1).

She went on to explain that it was “a really long time to wait and to not know about your future. I think for humanity’s sake, there should have been more discussion” (MG.1). Another municipal authority reflected that “we could have done it better and we could have had more conversation with the residents, and delivered better information sooner” (MG.2).

At the October 2019 meeting, local inhabitants were asked if they would prefer more regular updates (1S). As a result, the Icelandic Meteorological Office began issuing monthly reports including monitoring information about movement in the slope in Icelandic and English for the local community. Subsequent public briefings held in October 2020 and April 2021 were conducted online due to COVID restrictions. A scientists presenting findings mentioned that the online format created additional challenges because “you don’t see people’s reaction, whether they are understanding the content or not, and how they are affected by the news” (S.5).

In addition to issues with the timing of communications, the lack of a clear public policy on the no-build zone compounded uncertainty. For example, people directly affected by the zoning were uncertain not only about the timeline of the zoning but also what exactly was covered "it is holding us back from building a sheep house because we don't know if we can. If we will be able to get the permits because we were on a no-build zone" (LI.12).

Everyday activities and plans that were stymied by the land use restrictions acted as regular reminders of the no-build zone, and, in turn, the landslide risk. When asked how often she thought about the unstable slope, a local inhabitant explained "I just think about it when I'm pissed off, when it's stopping me" (LI.1). This suggests that while people in the community tried to maintain a level of normalcy in day-to-day work and life, the no-build restrictions meant that people were more regularly reminded of the situation and driven to talk and think about the risk.

Risk managers and municipal authorities had not discussed the psychosocial impact of the unstable slope on people in the community or whether they should extend psychosocial support (2 MG). When asked if there was a need for psychosocial support in the community, a municipal government worker responded:

> When you mention it, and in context with what's happening in Seyðisfjörður, I think it would be a good idea, and it's a thing that would be nice to offer to them here and let them know that it's there if needed, and that they can use that kind of support or get someone to talk to them about things like that (MG.2).

At the time of writing this article, psychosocial support had not been extended to people at risk due to the unstable Svínafellsheiði slope.

6.5 Conclusions

There is consensus in the disaster risk management literature about the importance of psychosocial support in the aftermath of natural disasters, however, the psychosocial effects of pre-impact risk mitigation measures, including risk zoning, are less clear. Land use policies implemented after disasters have been linked to heightened ethnic tensions, increased mistrust and perceived discrimination (Ingram et al., 2006, Hyndman, 2008, Santos et al., 2015). There is a dearth of studies on the land use policies employed to mitigate disaster risk.

This ethnographic study illustrates how a no-build zone designed to prevent a further increase in risk had both direct and indirect adverse effects on the psychosocial wellbeing of those affected. People exposed to the risk of the Svínafellsheiði slope instability displayed a high level of resilience overall, however, they also drew on coping mechanisms to negotiate the uncertainty experienced. This study finds that the no-build approach led to frustration about a perceived inability to make changes to home and businesses, people feeling that their future was uncertain or on hold, and people questioning their future in the area. These frustrated plans constantly called attention to the risk posed by the landslide, which meant that local affected people were less able to find respite through day-to-day routine and occupation.

While public risk meetings were conducted and understood to represent an important component of risk management of the Svínafellsheiði slope, this study showed that the timing of these meetings was often dictated by the availability of new scientific information. Uncertainty about the timing of future meetings compounded the risk uncertainty experienced by local people. Furthermore, information about the no-build zone was issued verbally. The low number of people affected by the policy, undoubtedly contributed to this approach. However, the lack of clear documented guidelines about the land use restrictions generated further uncertainty and aggravated the psychosocial challenges experienced by local inhabitants. The no-build zone aimed to protect people in the future from the risk of the unstable Svínafellsheiði slope, but had unplanned immediate repercussions for the psychosocial wellbeing and coping mechanisms of people in the area.

This study has examined the psychosocial effects of the no-build zone imposed in response to the unstable Svínafellsheiði slope in the Öræfi district of Iceland. Key policy recommendations include:

- Integrate consideration of psychological wellbeing into land use planning and risk management initiatives. Decision-makers and municipal planners should take into account the coping mechanisms employed in communities at risk, and consider how land use restrictions will affect psychosocial wellbeing.
- Publish the details of land use restrictions. Municipal authorities should record and make publicly available the details of land use restrictions that directly affect local inhabitants. This includes maps of what areas are covered, details of exactly what building activities are included, and a clear timeline for when the restrictions will be reviewed.
- Conduct public risk management briefings on a regular basis for large-scale ongoing risks (e.g. every six months). If further scientific or hazard assessment information is not yet available, the meetings

should still be conducted and this information conveyed. These meetings represent an important forum for two-way communication through which local people can voice their concerns with authorities, and authorities can gain a better understanding of the situation, needs, and psychosocial wellbeing of affected people. Effective and reliable risk communication is particularly important when a community is facing a new hazard.
- Extend psychosocial support to people affected by no-build zones or other inhibitive pre-impact risk management measures. In Iceland, the existing psychosocial support initiatives implemented in the post-impact phase by DCPEM, could be offered especially when a small group of people are facing an existential threat.

In addition, the Icelandic government should extend the Avalanche and Landslide Fund to cover all residential premises in Iceland, regardless of whether they are situated in urban or rural areas.

In 2005, the World Bank estimated that five per cent of the global population was exposed to landslides (Dilley et al., 2005). As the frequency and magnitude of landslides and other natural hazards increases, so will the need for effective disaster risk management approaches. Land use planning represents one of the most effective methods to prevent landslide disasters by decreasing the exposure of people and assets. This study shows that understanding the psychosocial effects land use planning is crucial.

7 Communicating risk in glacier tourism

This section contains the peer-reviewed journal article:

Matti, S., Ögmundardóttir, H., Aðalgeirsdóttir, G., and Reichardt, U. (2022). Communicating risk in glacier tourism: A case study of the Svínafellsheiði fracture in Iceland.' *Mountain Research and Development*. https://doi.org/10.1659/MRD-JOURNAL-D-21-00051.1

Abstract
Every day in early summer 2018, an estimated 1,000 tourists went on guided tours of Svínafellsjökull, an outlet glacier in southeast Iceland. However, this changed on 22 June 2018, when a warning was issued against glacial travel due to the risk of a large landslide due to a fracture in the surrounding mountainside. Tourists often entrust tourism employees with responsibility for their safety; however, there is a dearth of research into the ways in which tourism employees receive and respond to risk communication. These dynamics were explored in this ethnographic study, which drew on 50 semistructured interviews and extensive participant observation. The results indicate that despite demographic shifts, Icelandic inhabitants remain the basic unit on which risk management processes are centred, with repercussions for the ways in which exposure is calculated and risk is communicated. Tourists and tourism employees have a limited understanding of the risk and emergency protocols compared with local inhabitants. We argue that, for their own safety and that of customers, risk communication needs to be tailored to the needs of tourism employees, including guides and hospitality workers. The recommendations that emerge from this research can guide risk communication strategies in other mountainous regions of the world where tourism is an important source of livelihoods.

Keywords
Climate Change; Large Landslide; Glacier; Risk Communication; Tourism; Iceland

7.1 Introduction

Given the natural beauty and accessibility of Svínafellsjökull (64.0186°N; 16.8215°W), an outlet glacier of Vatnajökull in southeast Iceland, it is unsurprising that it emerged as one of the most popular destinations in the country for glacier hiking (Figure 11). During the early summer 2018 peak season, an estimated 1,000 tourists went on guided tours of the glacier each day. However, this changed on 22 June 2018, when local police together with the Department of Civil Protection and Emergency Management (DCPEM) issued a warning against travel on Svínafellsjökull due to the risk of a large landslide caused by a fracture in the surrounding Svínafellsheiði mountainside. Guided glacier tours were discouraged, and tourists were "advised to stop only for a short while at viewpoints by the glacier tongue" (IMO, 2018a, p. 1). In the days that followed, all guiding operations shifted to nearby glaciers.

Figure 11: Tourists at the Svínafellsjökull viewing area (Photo: Stephanie Matti, 2019).

The emergence of the Svínafellsheiði fracture is part of a global trend whereby climate change has contributed to the decline of glaciers, snow, and permafrost in recent years (Hock et al., 2019). This has led to changes in the frequency, magnitude, and location of natural hazards, as well as the emergence of landslide risk where there was no record of previous events

(Hock et al., 2019). People are also increasingly exposed to these hazards due to growing populations and tourism (Hock et al., 2019). Examples of how climate change-related glacial retreat has interrupted tourism include: altering rockfall dynamics on Fox and Franz Josef Glaciers in New Zealand, and on the Rhône Glacier and Mer de Glace in the European Alps (Purdie et al., 2015; Salim et al., 2021); shifting routes on Everest (Watson & King, 2018); and the disappearance of Bolivia's Chacaltaya Glacier (Kaenzig et al., 2016).

Risk management literature indicates that the vulnerability of tourists to natural hazards is often exacerbated by language barriers, limited interaction with locals, high mobility, and a predisposition to prioritise positive holiday experiences (Bird et al., 2010; Becken & Hughey, 2013). Several studies have found that in times of crisis, tourists entrust tourism employees with responsibility for their safety (Leonard et al., 2008; Bird et al., 2010; Aliperti & Cruz, 2019). Despite the importance of tourism employees in managing and responding to disasters related to natural hazards, there is a dearth of research on how this demographic receives and responds to risk communication. Furthermore, while a sizable body of literature emphasises the importance of local inhabitants participating in risk management processes (e.g. Pelling, 2007; Cadag & Gaillard, 2012; Cadag et al., 2017), such analysis has not been conducted for tourism employees.

This article addresses these gaps by examining how Icelandic risk management processes interfaced with the tourism sector in the case of the Svínafellsheiði fracture. We paid particular attention to foreign tourism employees, who constitute a large proportion of tourism employees in the area. A key finding is that despite demographic shifts, local Icelandic inhabitants remained the basic unit on which risk management processes were centred, with repercussions for the ways in which exposure was calculated and risk was communicated. Both tourists and tourism employees had a limited understanding of risk and emergency protocols compared with local inhabitants. We argue that for their own safety, and the safety of customers, risk communication needs to be tailored to the needs of tourism employees, including mountain guides and those in hospitality positions. The policy recommendations that emerge from this research can guide the development of risk communication strategies in nature tourism destinations facing sudden, large-scale hazards, including avalanches, flash floods, landslides, and volcanic eruptions.

The remainder of this article is structured as follows. The next section provides an overview of the relevant background to risk communication and how it relates to the Icelandic tourism sector. The research design, including the study methodology, study area, and risk management strategies, is then described. Next, the results are presented and discussed. Finally, the conclusions are presented.

7.2 Background

7.2.1 Risk communication

Risk communication is widely accepted as a key strategy for mitigating vulnerability and reducing the effects of disasters (Paton, 2006). The term “risk communication” refers to interactive flows of information to notify people of the probability of a hazard occurring, likely consequences, and mitigation actions (Plough & Krimsky, 1987). Since the 1980s, the theory and practice of risk communication have shifted from a top-down flow of information from experts to the public to a broader approach that takes into account community participation, cultural factors, social relationships, and trust (Khan et al., 2017; Lin et al., 2020).

Risk communication strategies are more effective when tailored to intended audiences (Paton, 2006; Seeger, 2006). Factors that affect how people engage with, and act upon, risk communication include, but are not limited to, cultural background (Lindell & Perry, 2004), trust in risk management authorities (Haynes et al., 2008), confidence in emergency procedures (Barberi et al., 2008), duration of exposure to risk (Stancu et al., 2020), and level of social capital (Cadag et al., 2017; Anderson-Berry et al., 2018). Social capital refers to the networks of relationships among people who live and work in a particular society. As communities become more diverse, the social context in which information is received is characterised by increasingly varied experiences, beliefs, needs, expectations, and interpretations of risk (Paton, 2006; Lin et al., 2020).

Participatory risk communication involves community members engaging in two-way dialogue with risk managers; it also provides an opportunity for both groups to raise and understand concerns (Pelling, 2007; Cadag & Gaillard, 2012; Demeritt & Nobert, 2014; Cadag et al., 2017). When local inhabitants are not familiar or do not recognise response and evacuation plans in advance, these protocols are less likely to be followed during an emergency (Voight, 1990; Carey et al., 2012). A sizable body of literature indicates that community participation improves the implementation and quality of risk management (e.g. Pelling, 2007; Cadag & Gaillard, 2012; Cadag et al., 2017; Kerstholt et al., 2017). One criticism of participatory risk communication is that it reinforces existing power dynamics within a community, for example, through the exclusion of marginalised groups or disadvantaged individuals (Cadag et al., 2017; Nguyen et al., 2017).

7.2.2 Risk communication in Iceland

Situated in the North Atlantic Ocean, Iceland is prone to a range of hazards, including avalanches, volcanoes, earthquakes, landslides, floods, and extreme weather. DCPEM is responsible for preparing for and managing risks due to natural hazards (Parliament of Iceland, 2008). At the local level, police are responsible for developing and implementing preparedness and response strategies together with Regional Civil Protection Committees (Parliament of Iceland, 2008).

In Iceland, information about risks and emergency protocols are shared through different media, including broadcasters, public meetings, email, telephone calls, brochures, face to face, government websites, social media, the Safe Travel website, and the 112 (national emergency number) mobile application (Bird & Gísladóttir, 2020). Public meetings conducted by risk managers with presentations by scientists have been espoused as a particularly effective way to communicate information to local residents, listen to their concerns, build trust, and learn from local knowledge (Guðmundsdóttir, 2016). Emergency response and evacuation drills have also been trialled for some volcanic hazards (Bird et al., 2010). Authorities typically rely on risk communication rather than access restrictions to promote personal safety in Icelandic glacial, volcanic, and geothermal landscapes (Bird & Gísladóttir, 2020).

7.2.3 Risk communication in tourism

Both tourism and risk management literatures indicate that the tourism sector globally is poorly prepared for disasters related to natural hazards (e.g. Prideaux et al., 2003; Hystad & Keller, 2008; Bird et al., 2010). Reasons include unclear communication by emergency management authorities, a lack of formal consideration of tourism in risk management, poor adoption of risk management protocols by tourism businesses, and a passive approach by tourism businesses toward risk management (e.g. Glaesser, 2003; Cioccio & Michael, 2007; Hystad & Keller, 2008; Becken & Hughey, 2013).

Tourists visiting hazardous environments have different perceptions of and aversions to risk. Visitors to volcanic sites often: adopt their own precautionary measures; hope nothing dangerous will happen when they are in the area; rely on having enough time to get to a safe location; and expect hazards will be managed by tourism operators (Erfurt-Cooper, 2010; Purdie et al., 2015). However, studies of volcanic tourism indicate tourists are not always provided with sufficient information to make informed decisions about their personal safety (Knafou, 2019; Bird & Gísladóttir, 2020). This was the case for the Whakaari/White Island disaster, when 21 tourists and guides died in a volcanic eruption in December, 2019, despite an increased eruption alert (March et al., 2020). Tourism operators may fear that communicating risk with tourists will lead to a reduction in demand and associated profits (Bird & Gísladóttir, 2020); however, a reputation for unsafe practices can have the same effect (Purdie et al., 2015). There have been calls to improve risk management within the tourism sector, including tourism disaster spokespeople, dedicated web pages, disaster drills, mainstreaming risk management into training, and tourism-oriented risk communication strategies (e.g. Hystad & Keller, 2008; Bird et al., 2010; Becken & Hughey, 2013; Mair et al., 2016; Aliperti & Cruz, 2019).

Iceland has experienced a dramatic increase in tourism in the last decade, from 448,000 foreign visitors in 2010 to over 2.2 million in 2017 (Icelandic Tourist Board, 2018). By 2019, tourism was the most important source of foreign currency earnings and the largest provider of jobs in the country (Müller et al., 2020). The number of foreign tourism employees rose from 2,427 in 2008 to 10,551 in 2019 (Halldórsdóttir & Júlíusdóttir, 2020). An estimated 30 per cent of staff in the sector—and 75 per cent of staff in hotels and guesthouses—are not from Iceland (Statistics Iceland cited in Wendt, 2019. Foreign workers are often employed in low-paid, low-skilled jobs, on short-term or temporary contracts (Skaptadóttir & Wojtynska, 2019). Foreign tourism employees typically have strong social ties with their co-workers but few connections to Icelandic society beyond their employer (Wendt, 2019; Halldórsdóttir & Júlíusdóttir, 2020). English is often the main language of communication (Mirra, 2019), with almost half of all foreign tourism employees reporting inadequate or non-existent Icelandic language skills (Hauksson, 2019).

The few studies available suggest that tourism employees and foreigners are commonly overlooked in risk communication. In Japan, researchers found that disaster management structures were not well adapted to the needs of foreigners, for whom language barriers and inexperience with emergency protocols can lead to panic and confusion during disasters (Sakurai & Adu-Gyamfi, 2020). In Iceland, Bird et al. (2010) found that tourism companies operating in an area with significant volcanic risk had not provided emergency training for their employees.

Glacier guides constantly observe and respond to hazards, including steep and slippery terrain, crevasses, rockfalls, extreme weather, and river crossings (Purdie et al., 2015). In addition, climate change has made glacier tourism in some regions more dangerous and challenging for both clients and guides (Purdie et al., 2015; Salim et al., 2021), adding new and large-scale hazards to the existing risks.

7.3 Research design

7.3.1 Methodology

This article is based on ethnographic fieldwork conducted in the Öræfi district of Iceland between August 2018 and April 2021 (see Annex 1). Fifty semi-structured interviews were conducted with 52 people (25 female; 27 male) identified through purposive sampling. The participants included 14 Icelandic local inhabitants, nine foreign glacier guides, nine tourists, seven foreign inhabitants working in the tourism sector, three risk management experts, three scientists, two municipal government officials, two tourism experts, two search and rescue coordinators, and one park ranger. While some tourism employees in the area were Icelandic, most were foreigners. This research focused on the latter, with comparisons made between tourists and local inhabitants. While most interviews were conducted with individuals, five were conducted with two people at the same time, and one interview was conducted with four people together at their request. Some participants were interviewed twice. All interviews were conducted in English, except one, which was held in Icelandic, with a translator. The interviews typically took between 60 and 90 minutes and were conducted face to face (47 interviews) or online, due to regulations related to the coronavirus-19 (COVID-19) pandemic (three interviews).

The core issues covered in the interviews with people living or working in Öræfi included their role in the community, understanding of the hazard, perception of risk information, and involvement in risk management. The questions were open-ended to allow important issues, perceptions, and ideas to be raised and discussed. The interviews were recorded, transcribed, and analysed using QSR Nvivo 12®. The results were analysed through a bottom-up, inductive approach to allow themes, commonly held views, and connections to emerge from the data (Hammersley & Atkinson, 2007). Data coding was initially open to facilitate the identification of themes and categories, but it became increasingly focused over time (Esterberg, 2002). In some cases, further interviews were conducted to shed light on a specific topic or to saturate identified categories (Hammersley & Atkinson, 2007). To ensure anonymity, interviewees were broadly categorised and coded as local inhabitants (LI), foreign inhabitants excluding glacier guides (FI), glacier guides (GG), municipal government authorities (MG), scientists (S), risk managers (RM), tourism experts (TE), and tourists (T).

The interview findings were triangulated with data gathered through participant observation conducted during two scientific monitoring missions (October 2018 and August 2019), three formal public risk briefings (October 2018), and 12 additional study trips to the field site. The first author conducted active research while working as a glacier guide in the community between April and October 2019.

7.3.2 Study site and overview of risk management

Svínafellsjökull is an outlet glacier of Öræfajökull, an ice-covered volcano that extends south from the massive Vatnajökull ice cap, in the Öræfi district of southeast Iceland (Evans, 2016; Figure 1). Between 1890 and 2010, Svínafellsjökull retreated approximately 800 metres and decreased in volume by 30 per cent (Hannesdóttir et al., 2015). This is part of a global trend of recent decline in glaciers due to climate change (Hock et al., 2019). As glaciers retreat, they provide less buttressing support for over-steepened valley flanks, leaving them susceptible to failure (Seneviratne et al., 2012; Hock et al., 2019).

The fracture in the Svínafellsheiði mountainside is understood to be 1.7 kilometres long (see orange dots in Figure 2 for approximate location) and widening at a rate of up to 1.3 centimetres per year (Sæmundsson et al., 2019). The potential landslide volume is estimated to be from 60 to 100 million cubic meters (Sæmundsson et al., 2019). A large landslide resulting from the fracture could fall up to 400 metres onto the surface of the glacier, with glacial ice incorporated into the body of material moving downhill. The Icelandic Meteorological Office (IMO) has warned that such a slide may sweep water from the proglacial lake "creating a fast-flowing slurry of rock, ice, water and even air" (IMO, 2018a, p. 1). The risk to downhill settlements and infrastructure is predicted to increase over coming decades as the proglacial lake grows (IMO, 2020b).

Recent decades have seen dramatic changes as the community shifted from a dependence on agriculture to large-scale tourism (Welling & Abegg, 2019). The population of Öræfi was reported to be 151 people in, 2018 (Statistics Iceland, 2019); however, this does not include most non-Icelanders living and working in the area. Until June 2018, Svínafellsjökull was one of the most important sites for glacier tourism activities in the country (Welling et al., 2020). Some 37 per cent of tourists who visited the area joined a guided glacier tour, while 76 per cent viewed glaciers at a "short distance" (Welling et al., 2020).

The neighbouring hamlet of Freysnes (63.9907°N; 16.8969°W) and the westernmost sections of Svínafell (63.9792°N; 16.8913°W) are potentially at risk from the hazard. Freysnes lies approximately 800 metres southwest of the proglacial lake, while Svínafell lies 600 metres southeast (Figure 2). Freysnes consists of 17 buildings, including a hotel, petrol station, cafeteria, search and rescue coordination centre, farm, and several houses; it is traversed by the country's main highway, referred to locally as the Ring Road. In 2018, approximately 80 people lived in Freysnes, including 25 Icelanders and 55 foreigners working in tourism-oriented hospitality jobs (LI.1). Most foreign tourism employees were from central Europe, including the Czechia, Hungary, Poland, and Slovakia. People working in these positions were provided with accommodation and lived full-time in Öræfi during the peak season.

In June 2018, before operations shifted to other glaciers, four main companies conducted daily commercial glacier walks on Svínafellsjökull. Typically, in peak summer season, an estimated 1,000 tourists went on the glacier every day (GG.2). Some 80 to 100 glacier guides and support personnel lived in temporary accommodation in Skaftafell (64.0704°N; 16.9752°W), six kilometres northwest of Freysnes. Most glacier guides were from countries with strong mountaineering traditions. While some glacier guides were highly skilled and experienced, most had less than two years of glacier guiding (complete participation field notes, 2019). Some guides were based in the district permanently, while others worked on shifts of up to two weeks. There was a high staff turnover rate among glacier guides, with many only working one or two seasons (complete participation field notes, 2019).

On an average day in summer 2018, an estimated 1,500 people spent time in the area exposed to the Svínafellsheiði hazard, including 1,000 on glacier tours or staying at the hotel, 100 foreign tourism employees, 25 local inhabitants, and 1,200 people passing on the road, many of whom also participated in glacier activities (Matti & Ögmundardóttir, 2021). The vast majority of people living in the at-risk area were foreign tourism employees. When glacier tours shifted from Svínafellsjökull, they still passed areas exposed to the risk for approximately 15 minutes each way on the road. As a result, the overall number of people exposed to the hazard on an average day remained similar, but the level of risk decreased significantly.

Planning and risk management related to the Svínafellsheiði fracture were coordinated by local police, DCPEM, and Regional Civil Protection Committees, with hazard monitoring conducted by the IMO and University of Iceland. Risk communication activities took the form of emails and risk meetings with local residents, as well as announcements in the media, on government websites, and through the Safe Travel website (www.safetravel.is). Large warning signs were erected on access routes (Figure 6), and information boards were set up at viewpoints. During the first year of this research, businesses pushed back on the idea of displaying information about the fracture at accommodation venues, fearing it would discourage tourists. Boards were later developed and displayed by tourism businesses in collaboration with risk managers.

Risk meetings in Öræfi were conducted with different—often overlapping—audiences. These included closed workshops with members of the community living in the immediate vicinity, meetings of the Regional Civil Protection Committee, and townhall briefings open to the public. In addition, in December 2020, a meeting was held for managers of tourism businesses operating in the area. Table 1 lists the public meetings conducted in the area or online (due to COVID-19 restrictions) during the study period. All meetings were conducted in Icelandic (correspondence with risk manager, 8 June 2021).

A large landslide from Svínafellsheiði could fall with little warning (S.2; RM.2). This has complicated emergency protocols, including evacuations. A phone alert system allows DCPEM to send emergency alerts to all mobile phones in a given area (RM.2). However, a risk manager warned that the landslide may have "already collapsed, and when the message arrives, it's too late" (RM.2). At the time of writing, these messages were only available in Icelandic and English, but a system was being developed to allow translations in up to 10 languages (RM.1). In 2018, there were discussions about setting up a siren system in high-risk areas; however, as of September 2021, no such system had been established. Experience from New Zealand suggests that using sirens as a warning system can "confuse or frighten tourists without providing clear instructions for what to do" (Becken & Hughey, 2013, p. 81). As of early 2021, the emergency protocol was to exit the area either to the east or west by vehicle, or to take shelter in Freysnes. With the risk set to escalate in coming decades due to the expansion of the lake, taking shelter in Freysnes will no longer be an option. There was no written response plan available.

7.4 Results

7.4.1 Focus on Icelandic inhabitants

Foreign tourism employees and tourists represented the vast majority of people exposed to the risk. However, risk managers and scientists initially underestimated the number of people exposed from both groups (GG.5; LI.3; S.5). For example, a guide recalled how a scientist appeared "surprised" during a public briefing in early 2018, when he was informed about the daily number of tourists visiting Svínafellsjökull (GG.5). The guide explained the scientist had estimated there to be "20, 30, or 40 people on the glacier every day," but the guide clarified that "in the summer there can be hundreds and hundreds of people each day" (GG.5). In an interview, one scientist referred to there being 100 people on the glacier each day, which still drastically underestimated the scale of glacial tourism (S.1). Another interviewee explained that "foreign workers are a group of people that definitely get left out in decisions and information about these kinds of things"; she believed that it was because "people outside the area don't realise how many people live here" (LI.3).

In later public meetings, more accurate figures were cited; however, the focus on Icelandic inhabitants persisted. In late 2018, a risk manager described the Öræfi district as a "sparsely populated area" (RM.3); while another estimated the people living close by the hotel at "about 10" (RM.2). In both cases, these estimations appeared to only account for Icelandic inhabitants. Foreign tourism employees, who constituted the largest demographic residing in the area, were not included. A scientist reflected that "maybe risk managers should have looked at the demographics of people" in the area before making risk management decisions (S.5). Several interviewees reasoned that the risk management system in Iceland has not adapted to the expansion of the tourism sector over the preceding decade (GG.2; GG.3; LI.1; S.5). One scientist explained that "it's a relatively recent phenomenon that foreign workers come here to work in tourism; it started on a larger scale five or six years ago. I think they are not taken into consideration, not because risk managers don't want to include them, but because the bureaucracy is lagging behind" (S.5).

The focus on Icelandic local inhabitants was also evident in risk management policies and funding structures. In Iceland, acceptable risk for floods and avalanches is calculated based on time spent in different residential and commercial buildings at risk (IMO, 2020b; Parliament of Iceland, 2000). The applicability of this system to tourists is undermined by the different behaviour patterns of tourists. The government had not established a policy on acceptable risk limit for tourists; it was also unclear how risk was evaluated for temporary foreign tourism employees (IMO, 2020b). Local-level policing remained staffed and funded based on the Iceland population, despite the impact of tourism on the number and diversity of people in the area, leaving police severely understaffed and struggling with an immense workload (RM.2; RM.4). Risk managers acknowledged that procedures should change in light of the influx of tourism, including the review of emergency plans across the country (RM.2).

7.4.2 Understanding risk and emergency protocols

No tourist interviewed was aware of the risk of a large landslide falling onto Svínafellsjökull. Of the eight tourists interviewed at the Svínafellsjökull viewpoint, only one had read the warning signs on the access road, but they had misinterpreted the warning to be about small-scale rockfall (T.1; Figure 6). Another tourist mentioned safety was a top priority during their trip. However, when asked about the warning signs, she had understood them to include "some tourist information, some history information about this place, and probably some safety warning," but explained that "we didn't read them" (T.8). Another tourist intentionally ignored the signs: "Sometimes it better not to know what's happening around you... sometimes you want to cut yourself off" (T.5). A third tourist mentioned that natural hazards were among the experiences that attracted him to the country, and that if there was a risk that he "wouldn't like to hear about it" (T.6). In identifying risks in the area, the tourists interviewed focused on the most visible and immediate risks such as slipping on ice, falling into cold water, small-scale rockfall, or weather conditions (T.1; T.7; T.8). During these interviews, a wide range of risk aversity among tourists was evident.

Communicating risk information with tourists in Iceland is complicated by the large number of tourists on short visits to Iceland who have little previous experience with the terrain and hazards of the country. Risk managers drew attention to the low risk knowledge of most tourists visiting Svínafellsjökull and Iceland (RM.1; RM.3). Tourists lacked an understanding of emergency protocols beyond normal instincts to avoid debris and move to higher ground (T.1–T.8), which is not an appropriate response given the massive scale of the hazard and the degree of exposure at the viewpoint. This was unsurprising given the almost total lack of awareness that tourists showed about the potential risk of a large landslide onto the glacier.

A common sentiment expressed by foreign tourism employee and local inhabitant participants was feeling responsible for the safety of others, including clients, tourists, staff members, and family members. This was particularly pronounced among glacier guides, hotel receptionists, and tourism managers (GG.4; GG.6; GG.8; LI.1; LI.3; LI.6; FI.6). A local inhabitant reflected that "if you have a company, then you're always responsible for the people who are working for you, and you're also a bit responsible for your guests" (LI.6). A glacier guide also explained that "I feel like I have responsibility for other people, even if they are not on my tour" (GG.6).

All local inhabitants interviewed had a comprehensive understanding of the fracture and emergency protocols (LI.1–LI.16). Local inhabitants frequently referred to the findings presented in risk briefings and were aware of recent developments (LI.1–LI.16). However, there was some initial disagreement between scientific and local knowledge about what areas would likely be affected (Matti & Ögmundardóttir, 2021). One local inhabitant reasoned that floodwaters from the glacier have "always come down these two rivers... why would this be any different?" (informal discussion, 24 October 2018). Based on their risk knowledge, some local inhabitants had developed personal response plans (LI.1; LI.12). All local inhabitants were aware that a warning of imminent collapse would come through the DCPEM phone alert system (LI.1–LI.16). Some expressed concerns about poor mobile reception (LI.1; LI.3; LI.13), whether they would wake up to a message sent at night (LI.3), and about how tourists would react to such a message (LI.1).

By comparison, foreign tourism employees varied greatly in their understanding of the risk and how to respond. All those interviewed who had lived in the area for less than a year had heard of the fracture but were aware that they lacked a comprehensive understanding of the risk: "I don't know very much about this" (FI.2); "I know about the fracture but I don't know exactly what caused it or what is actually happening" (FI.4). Glacier guides and foreign tourism employees who had lived in the area for longer—especially those present when operations shifted from Svínafellsjökull—tended to have a stronger understanding. However, the knowledge of glacier guides and foreign tourism employees was typically less up-to-date, less evidence based, and less technical than that of local inhabitants (FI.3; FI.5; LI.3). Foreign tourism employees were also unsure of emergency protocols, including communications (Table 2) and response strategies (Table 3). Furthermore, a foreign tourism employee living in an area at risk mentioned that in the case of an emergency "most of us here don't have a car, so it's hard for us to go someplace" (FI.4).

Table 2: Understanding of emergency communication protocols by foreign tourism employees

- That's an interesting question. I don't know. I think maybe talk with people who know about what is happening there and what you should do, like [national park] rangers. And then do whatever they say (FI.2).
- Hopefully through a government source, but maybe the search and rescue teams or the park rangers or the police. I feel they should be a little bit more organised. I hope that if they were alerting people that something was happening, they would have a plan in place. I wouldn't expect a personal communication but a general announcement, maybe over the radio, or the [national park] rangers talking to shift managers and then giving us instructions on how to evacuate people (GG.6).
- I would probably just hear about it from somebody else. I'm not entirely sure about how that would come to us. Either through the news, national park, or from another guide. I would hope that the company that we work for would be like quick on the uptake and send an email and make sure that everyone was out of the area (GG.7).

Glacier guides were aware and actively mitigated risks in the course of their work (GG.1–GG.8). Focus was placed on the type of risks experienced regularly, including crevasses, minor rockfalls, crossing rivers, poor crampon technique, poor weather, and unstable glacial features. Guides regularly engaged in discussion and training drills—especially crevasse rescues—with more experienced guides and management on how to manage these risks. A similar culture has been documented among guides in other adventure tourism activities, including ski touring (Grímsdóttir, 2004) and white-water rafting (Morgan & Fluker, 2006). However, there was virtually no discussion among guides of the Svínafellsheiði fracture and risk of a large landslide. One glacier guide also noted that his company did not have a record of the names of all tourists going on glacier walks, so in case of a landslide "we could have easily had 200 people buried, we actually wouldn't even know their names" (GG.3).

7.4.3 Communication channels

Official risk meetings were the main channel by which local inhabitants received information about the Svínafellsheiði fracture and emergency protocols. Several local inhabitants re-evaluated their personal response strategies based on advice and updates given at these forums (LI.1; LI.2); this indicates that information provided was trusted and taken seriously. The main concern about meetings was that they were not conducted according to the pre-arranged timeline. For example, in October 2018, people were told that they would receive an update in spring 2019, yet it did not take place until the end of autumn (LI.1). The meetings were typically dialogic and participatory, with information from local inhabitants used to shape emergency protocols and risk management plans (RM.2; RM.4).

Table 3: Understanding of protocols by foreign tourism employees

- I don't think anything has been discussed about what we would do in that situation. As far as I know, nothing has been done about it. No protocols, nothing (FI.1).
- I would just try to escape by some means I guess if that is what needed to happen. I admit I haven't given it much thought. But yeah I would literally just try to get away. I would try to tell people on the way out what would be the danger zone, I would tell people to come with me (GG.4).
- I don't know. I want to say that I would yell at everyone to get in whatever bus or car and get out of there as soon as possible... I guess if you're driving along you could take a right [south], go through some fences, get as much distance between you and the landslide as possible, head towards the sea. Who knows if that works? That would be the first thing that comes to mind (GG.5).
- We have the volcano plans, but I don't think we have landslide plans. If we have a landslide that comes down and it blocks the ring road, I don't think we have any plan of what do to (GG.7).
- I don't imagine you would have much time. It would be like "it's coming, get out of the way." I would help with evacuation efforts because as far as I can tell... but I'm not sure actually. I don't know whether we would be affected. I don't know whether our office would be affected. I don't know (FI.1).

While the townhall-style briefings were public, email invitations were sent almost exclusively to Icelanders (email communication, local police, 28 November 2019). All local inhabitants interviewed were aware of the meetings, and most had attended. By comparison, most foreign tourism employees were not aware that the briefings occurred; the few who were aware of the meetings understood them to be conducted "in Icelandic for locals" (FI.6). Some local inhabitants expressed concern about the exclusion of foreign inhabitants from formal risk management processes and communication channels. One woman declared that "it's not good enough that some people are left out... I think there's a big information gap between locals and people that are living here as foreigners" (LI.3).

Foreign tourism employees working in hospitality typically received information about the fracture from their employer or other staff members (FI.1; FI.3; FI.5; FI.6). One interviewee accessed information through mainstream media outlets (FI.3). Some employers were proactive in providing information to employees, including one who maintained that the "more information you can give to the staff is better... we try to update them as much as possible" (LI.1). This included in-house meetings and updates on employee-specific social media pages (LI.1). However, some foreign tourism employees had not received any information about the risk from their employer. For example, one woman explained: "I wasn't informed about anything like this when I came here. After some time, I heard something but not officially and not how we should proceed if it happens" (FI.2). Furthermore, when asked if foreign tourism employees would be in direct contact with risk managers, one local business owner responded that they are "probably going to come to us as they don't know where to get information" (LI.6). There was no evidence of information about the fracture being provided to glacier guides by their employers. Instead, developing an understanding of the risk was viewed by guides as something they have to personally "put the time into" (GG.4). Some experienced glacier guides had attended a scientific briefing at the University of Iceland in early 2018 in their free time, but they had not received any subsequent updates (GG.4; GG.6; GG.7).

Risk managers acknowledged that they "relied on locals" to "tell your employees about the hazard" (RM.2). However, at least one local hotel was managed by a foreigner who did not attend the briefings (LI.3), and even the most proactive employers did not update their staff after each briefing (FI.6). The information passed to employees was left to the discretion of employers (R.2; FI.6). There was no evidence of risk managers providing tourism employers with material or support on how to inform their staff or of tourism businesses requesting this information.

Foreign tourism workers typically had very limited interaction with local inhabitants. One interviewee mentioned that "I don't get a chance to talk much with local people, and we have this language barrier" (FI.4). An Icelandic local inhabitant explained that it was a "very split community between the people who have always been here, who speak Icelandic, and then all the young people, who are glacier guides or working at the hotels and don't speak Icelandic" (LI.3). Opportunities for interaction were also affected by job position, with those working in housekeeping understood to have less interaction and access to information than people at reception (FI.3). Risk managers acknowledged that as a foreign worker, "you could come to work in a hotel cleaning the rooms and you will have absolutely no idea about the risk you could be facing" (RM.2). Experienced glacier guides generally had more social capital and more regular contact with local inhabitants, especially locals who had also worked as guides (GG.2; FI.1; FI.3). In recent years, large glacier guiding companies had reduced wages and working conditions, which reduced the hiring of Icelandic staff and led to the emergence of small local operations, both of which eroded opportunities for regular interaction between Icelandic and foreign glacier guides (LI.3).

Tourism operators were concerned about how risk management decisions were made, including the choice to shift operations from Svínafellsjökull. Interviewees felt that risk management and communication would have been conducted differently with a better-established sector of the Icelandic economy. One manager argued that, "if this was somewhere else and there was a fish factory in the way, it would have been dealt with in a very different way... but since it's just a bunch of guides, and they don't understand tourism, they are just like 'yeah just go somewhere else'" (GG.3).

Foreign tourism employees and glacier guides expressed interest in attending public briefings if they were conducted in English. One interviewee explained, "I live here, so it's also about me, of course I would like to go" (FI.6). Another reasoned:

> It's important that everyone in the area at risk is informed and knows what they can do and how they can help because, in those sorts of situations, it needs to be all hands on deck. There should be common knowledge among anyone living in the area temporarily or permanently.

An interviewee noted that the tone of the invitation message was important; she recommended that it be pitched as a responsibility to learn how to respond rather than a general conversation about the fracture (FI.1). Another interviewee further stated that if it were not pitched like this, it would not be considered a priority for tourism managers or employees (GG.6). A local inhabitant recommended that for future hazards, a basic written evacuation plan should be provided at the first briefing (LI.1).

7.5 Discussion

Most tourists visiting the Svínafellsjökull viewing area interviewed for this study did not sufficiently understand the risk posed by the fracture or how to respond in the case of a large landslide. Even the one interviewee who had read the sign had misunderstood the warning and vastly underestimated the scale of the hazard. Similar problems of tourists "walking straight past warning signs, taking no notice of the information displayed" were reported at the high-risk Reynisfjara beach in Iceland (Iceland Monitor, 2016). Communicating information about the risk of Svínafellsheiði to tourists was complicated because: there were many significant risks in the area; it was not a tourist attraction, unlike other hazards such as volcanic eruptions and crevasses; it was not visible to visitors; and it was the first time this type of hazard has been managed in Iceland. Tourists generally understand that volcano sites are potentially dangerous, and they choose how much safety information to seek and precautionary measures to take (Bird & Gísladóttir, 2020); by comparison, most tourists were not even aware they were potentially exposed to a large landslide.

In the case of an emergency, most tourists stated they would depend on people living or working in the area to keep them safe. In their study of Bolivian mountaineering, Mackenzie and Kerr (2012) found that the expectation that risks will be managed and safety ensured is more pronounced on guided tours. Our results indicate that, while tourism employees and guides feel responsible for the safety of clients, many are poorly informed about the risk and emergency protocols. This trend is more pronounced among newcomers and those with little social capital in the community. Glacier guides tend to focus on managing risks that they encounter more frequently. This may reflect: the massive scale of the Svínafellsheiði hazard; the feeling that they are unable to personally control or mitigate the hazard; the focus of management and fellow guides on other risks; and a lack of involvement in official risk communication structures.

Despite significant demographic changes driven by tourism, Icelandic inhabitants remain the primary unit upon which risk management processes are based. In the case of the Svínafellsheiði fracture, this was evident in initial exposure calculations and communication strategies. Official risk communication was oriented toward local inhabitants and, to a lesser degree, tourists. If foreign tourism employees received any information, it was generally in the form of ad hoc and informal communications from their employer. Language and mode of invitation represented significant barriers for foreign tourism employees to attend official briefings. While some studies have examined language as a barrier to effective risk communication, most have focused on how this excludes tourists rather than tourism employees (Erfurt-Cooper, 2010).

Risk communication that depends on informal and personal relationships can exclude demographic groups, and exacerbate existing power inequalities and vulnerabilities. Foreign tourism employees typically have lower social capital, especially those who do not interact with the public through their work. This is problematic, as research has found that lower social capital and reduced access to risk information lead to more risk-taking behaviour in the event of a disaster (Cadag et al., 2017; Anderson-Berry et al., 2018). Icelandic employers are typically older and more financially stable, while foreign tourism employees are younger and heavily dependent on their employer for salary, accommodation, and sometimes visas. Having foreign tourism employees depend on Icelandic employers for risk information reinforces the social, financial, and workplace power of Icelandic employers. The arrangement can also increase the burden on employers grappling with the risk and how it affects their livelihoods.

Risk communication channels available to foreign tourism employees were generally unidirectional, such as mainstream media, and informal, such as information conveyed by employers. Foreign tourism employees were hindered from developing a direct relationship and building trust with risk managers and scientists; in addition, there was no clear avenue for them to contribute their knowledge to risk management strategies. This increases the chances that emergency protocols do not take into account their particular circumstances, for example, vehicle ownership. Erfurt-Cooper (2010) similarly found that volcanic risk management that focuses on local inhabitants can result in emergency rescue and evacuation systems that do not take into account tourists and other demographics.

Risk communication in the case of Svínafellsheiði was further inhibited by the lack of written emergency procedures. Perry and Lindell (2003) argued that it is not uncommon for risk managers in small communities to depend on “informal, personal relationships for risk identification, assessment and reduction” rather than written protocols. However, the provision of written guidelines in English and other common languages would encourage greater access to information. Research in Japan found that a lack of experience with emergency protocols ahead of time contributes to panic and confusion in the case of a crisis (Sakurai & Adu-Gyamfi, 2020). The consequences are compounded as foreign tourism employees are often also responsible for the safety of large numbers of tourists.

This research highlights the need for risk communication and training initiatives that specifically target tourism employees and glacier guides. These should be conducted in English, incorporate simulations/drills, and be based on the understanding that employees will likely have some responsibility for the safety of clients. In Japan, a simulation-based exercise was conducted to train tourism and hospitality staff on keeping tourists calm and communicating risk and evacuation procedures in the event of a volcanic eruption (Suzuki, 2020). Given the high staff turnover in Öræfi, we recommend conducting interactive training simulations on a regular basis, for example, every six months.

Several crises in guided tourism have raised questions about culpability and criminal negligence. On 27 July 1999, 21 tourists and guides died in a flash flood while canyoning near Interlaken, Switzerland. In the subsequent court case, six managers and senior guides were convicted of manslaughter due to culpable negligence for putting profits before safety, ignoring warning signs, and not sufficiently training junior guides to assess flood risk (Morgan & Fluker, 2006). On 7 January 2020, 39 tourists were stranded in a severe storm on Langjökull, Iceland's second largest ice cap, on a guided snowmobile trip. More than 200 search and rescue volunteers rescued the tourists, some of whom spent more than seven hours in the storm. Similar questions were raised—including by the Minister for Tourism—about the decision to run the trip despite a severe weather warning (Ćirić, 2020). Both cases underscore the importance of training tourism employees and guides on risk management and safety, communicating risk effectively, and implementing safety protocols.

Our results support calls for an expansion of targeted risk management actions for the tourism sector (Becken and Hughey, 2013; Ziegler et al., 2021). In their study of the Himalayas, Ziegler et al. (2021) suggested that licenses or certificates could be used to demonstrate that guides or tourism workplaces adhere to safety standards. A similar initiative could be explored in Iceland. A further exploration of this goes beyond the scope of this study.

Such initiatives will better position tourism employees and guides to inform tourists of risks faced. Tourists who survived the Whakaari/White Island disaster reported that they received no information about the risk and, as a result, could not make informed decisions about their safety (March et al., 2020). We agree with Bird and Gísladóttir's study, which found that some tourists will continue to ignore warning signs, pursue thrill-seeking behaviour, and lack local knowledge, so we must "find other ways to reach them" (2020, p. 10). It is crucial that tourists are equipped with sufficient knowledge to make decisions about their own safety. Reducing risks and improving the safety of tourists and tourism employees are not only ethical pursuits, but they also are important for long-term business sustainability.

7.6 Conclusion

In this conclusion, we explore how the results of this research can help to improve risk communication for the Svínafellsheiði fracture and for hazards in other nature tourism hubs around the world. Some features of the specific context should be taken into account. This research relates to a large-scale, potentially fatal, sudden-onset hazard, which has a high degree of uncertainty. The lessons are more likely to be applicable to other such hazards, for example, volcanic eruptions, avalanches, flash floods, and landslides. Tourists in Öræfi are exposed to a multitude of potentially fatal hazards that require customised risk management communication and informed decisions and actions. Even risk-averse tourists are likely to focus on more visible, frequent, and well-known hazards to which they are exposed for longer periods. Tailoring risk communication and preparation to tourism employees is more crucial for large-scale but less frequent and less visible hazards. The lessons will be particularly relevant for nature and adventure tourism hubs where large portions of tourism employees face language and cultural barriers when accessing government risk communication (e.g. the Alps, Japan, and Scandinavia). This case also represents the first time the risk of a large landslide onto a glacier has been managed in Iceland.

The case of the Svínafellsheiði fracture suggests that risk assessment and management processes focused heavily on the scientific basis of risk, while assessments of exposure and vulnerability were built on sweeping and dated assumptions. It should be standard practice in the initial phases of a risk assessment to develop a profile of who is exposed, existing vulnerabilities, and power dynamics within the community, perceived responsibilities in the event of an emergency, and access to evacuation infrastructure. Risk management strategies must expand from the narrow focus on nationals, especially in the context of mass tourism. Semistructured interviews and ethnographic fieldwork represent useful methodological tools for exploring these dynamics.

Authorities in Iceland rely on risk communication rather than access restrictions to ensure tourist safety, as much of the sector is based on experiencing glacial, volcanic, and geothermal landscapes, all of which have inherent risks (Bird & Gísladóttir, 2020). Our results call for tailoring risk communication and training to the needs of tourism employees, guides, and tourists, as well as local inhabitants. At a minimum, this should include written emergency protocols, participatory risk briefings, and regular simulation-based training in the main language(s) of operation. This should be part of a broader push for increased dialogue and coordination between tourism operators and risk managers. This requires commitment backed by earmarked resources from the government and tourism operators.

With tourism destinations in glacial and mountainous environments increasingly exposed to hazards due to climate change (Tsai & Chen, 2011; Mair et al., 2016), ensuring the safety of all people is essential. Important questions for future research include: How can guides and guiding operations adapt efficiently and respond to newly emerging hazards? How can technology be harnessed to tailor risk communication to different audiences? What level of risk understanding is required for informed consent in the context of tourism?

8 Planned relocation due to landslide-triggered tsunami risk in recently deglaciated areas

This section contains the journal article:

Matti, S., Reichardt, U., Cullen, M., & Vigfúsdóttir, A. (n.d.). Planned relocation due to landslide-triggered tsunami risk in recently deglaciated areas. Submitted to *International Journal of Disaster Risk Reduction,* (under review).

Abstract
Climate change is contributing to the magnitude, frequency and location of natural hazards, including landslides and landslide-triggered tsunamis. As the costs of protecting against a given risk increase, relocation may become the only feasible option despite the socio-economic, human security and cultural consequences. The relocation of people represents one of the most complex governance challenges generated by climate change. This article contributes to the literature by presenting insights and lessons from two case studies of unprecedented landslide-triggered tsunami risk that have not previously been described in the relocation literature: the unstable Svínafellsheiði slopes in south-east Iceland, and Karrat and Uummannaq Fjords in north-west Greenland. Our results draw attention to the need for planned relocation to be conducted in-line with international best practice, including those relating to the active involvement of affected people in decision-making, ensuring adequate compensation, and clarifying relocation planning schedules. This has occurred against a backdrop of colonial power dynamics, urbanisation trends, and the rise of tourism in these locations. Based on the findings, we recommend that that the role of government pivot from determining risk management and relocation options, to providing a structure to underpin and support community agency.

Keywords
Landslide, Tsunami, Greenland, Iceland, Svínafellsjökull, Karrat Fjord, Uummannaq Fjord, Planned relocation.

8.1 Introduction

Climate change is contributing to the magnitude, frequency and location of natural hazards, including landslides and landslide-triggered tsunamis (Hock et al., 2019; UNDRR, 2015). As the costs of protecting against a given risk increase, relocation may become the only feasible option despite the socio-economic, human security and cultural consequences (IPCC, 2022). The relocation of people represents one of the most complex governance challenges generated by climate change (Bronen, 2021). Planned relocation guidelines emphasise the importance of multi-stakeholder decision-making, especially the active involvement of affected communities (Weerasinghe, 2014; Bower & Weerasinghe, 2021). While the theory and practice of planned relocation in the context of climate change mostly addresses flooding and sea level rise (e.g. Kousky, 2014; Koslov, 2013; Bronen, 2011; Siders, 2013; Isle de Jean Charles, 2021), a smaller body of research examines landslide-related hazards (e.g. Sultana & Tan, 2021; Baert et al., 2020; Misanya & Øyhus, 2014). This article contributes to the literature by presenting insights and lessons from two case studies of landslide-triggered tsunami risk that have not previously been described in the relocation literature.

The incidence of large landslides in high mountain areas and the Arctic is rising due to effects associated with climate change such as glacial retreat, permafrost degradation, and changes in precipitation (IPCC, 2012; Hock et al., 2019). Large landslides into oceans or waterways give rise to the potential for tsunamis (Dahl-Jensen et al., 2004; Buchwał et al., 2015). Indeed, most tsunamis in the Arctic have occurred due to landslides in coastal fjord systems, where constraining topography amplifies wave height with highly localised effects (Strzelecki, 2018 et al.; Strzelecki & Jaskólski, 2020; Strzelecki, 2018). However, with climate change, glacial lakes inland are developing closer to steep and unstable mountain slopes, where landslide-triggered tsunamis and flooding also pose local risks (Hock et al., 2019). For instance, landslide-triggered tsunamis have devastated coastal communities in Norway (Hermanns et al., 2006), and inland communities in Italy (Ward & Day, 2011) and Tajikistan (Ambraseys & Bilham, 2012). One consequence of climate change is that landslide-triggered tsunami risk now exists in places where there is no record of previous events (Hock et al., 2019). This article focuses on two such examples.

In the past five years, both Iceland and Greenland have started managing the risk of landslide-triggered tsunamis for the first time (Helgason et al., 2018; Strzelecki & Jaskólski, 2020). In the Öræfi district of south-east Iceland, a fracture in the Svínafellsheiði mountainside was the first indication that a large section of the slope was unstable. If the slope fails, the resulting landslide is predicted to contain 60 million cubic metres of bedrock (Sæmundsson et al., 2019). The landslide may remain deposited on the surface of the glacier below, however, it could also incorporate ice from the glacial surface, and flow down to cause flooding or a tsunami from the proglacial lake.[9] The mass of rock, ice, water and air in motion could endanger people and infrastructure (IMO, 2018a; Sæmundsson, 2018). Risk management measures for the unstable Svínafellsheiði slopes have focused on risk assessment, mitigation and emergency protocols, with little focus on planned relocation.

In Greenland, a tsunami triggered by a landslide in Karrat Fjord on 17 June 2017 left four people dead, and led to the evacuation of Nuugaatsiaq, Illorsuit and Niaqornat villages. Nuugaatsiaq and Illorsuit remain uninhabited. The Karrat Fjord tsunami "is the first known example of an Arctic tsunami which directly impacted an inhabited Arctic settlement and forced its evacuation" (Strzelecki & Jaskólski, 2020, p. 2531). In 2021, 176 residents in six villages of the adjacent Uummannaq Fjord were found to be living in tsunami-risk areas, and were offered government support to relocate (KNR, 17 June 2021a).

In this article, we analyse how landslide-triggered tsunami risk has been managed in relation to Svínafellsheiði in Iceland, and the Karrat and Uummannaq Fjords in Greenland, with a particular focus on relocation decision-making processes. We argue that there is a need for planned relocation to be conducted in-line with international best practice, including those relating to the active involvement of affected people in decision-making, ensuring adequate compensation, and clarifying relocation planning schedules. This has occurred against a backdrop of colonial power dynamics, urbanisation trends, and the rise of tourism. This article identifies lessons from these cases that can inform risk management and relocation processes, especially for societies facing historically unprecedented hazards in sparsely populated areas.

This article is composed of four sections. The first examines literature and guidance about planned relocation, and provides an overview of risk management systems in Iceland and Greenland. The second section covers the methodology. The third section presents the two case studies, and unpacks the risk management and relocation decision-making dynamics. Finally, the conclusion outlines lessons and provides recommendations.

[9] The Svínafellsjökull proglacial lake refers to a body of water dammed by the glacier and rock moraines during glacial retreat.

8.2 Background

8.2.1 Planned relocation

Disaster risk is composed of the physical likelihood of a hazard event occurring, as well as the exposure and vulnerability of people to the hazard (Kelman et al., 2015; Wisner et al., 2004). The main strategies used to manage landslide-induced tsunami risk fall into three corresponding categories: reduce the hazard potential through engineering and nature-based solutions such as slope stabilisation; reduce exposure through land use planning, early warning systems and planned relocation; and reduce vulnerability through community-based disaster response initiatives (Hock et al., 2019). The focus of this article is on planned relocation, whereby people are moved to a safer location. Bower and Weerasinghe define planned relocation as "the planned, permanent movement of a group of people from identifiable origin(s) to identifiable destination(s), predominantly in association with one or more hydrometeorological, geophysical/geological, or environmental hazard(s)" (2021, p. 7). The terms managed retreat, and resettlement refer to similar conceptualisations of people movement (Bower & Weerasinghe, 2021). Planned relocation is distinct from evacuation, which involves the rapid physical movement of people to a safer area in order to protect them from an imminent threat. Relocation may occur after evacuation when places of origin are no longer habitable and continued presence in place of evacuation is not feasible (Weerasinghe, 2014).

Planned relocations can be situated on a continuum from voluntary to forced, depending on the level of freedom for individuals, households and communities to participate, and the extent of coercion employed (Bower & Weerasinghe, 2021). The use of coercive measures include the withdrawal of services from exposed communities and the expropriation of property, which make relocation processes less voluntary and contrary to certain rights (Hanna et al., 2018). Research identifies a wide range of highly personalised reasons why some people prefer not to relocate, even when hazards intensify or become more frequent. These reasons include strong historic, cultural or livelihood ties to the land, enjoyment of life in the area, place attachment that can become central to identity, underestimation of risk, and overestimation of protective measures (Siders et al., 2019).

Lessons learned include that relocated communities are more likely to consider their relocation "successful" if they are well informed, participate in decision-making during all phases, are adequately compensated, and feel that they have some control over the choice of destination and process of movement (McAdam & Ferris, 2015). Cullen argues that relocation requires a "governance framework that underpins and supports, not dictates, community agency" and leads to "improved local resilience and empowerment, and also better potential to preserve culture, identity, mental and physical health as well as the natural environment itself" (2022, p. 13).

According to a report published by the UN Office of the High Commissioner for Refugees (Weerasinghe, 2014), best practice for planned relocation include, but are not limited to, the following steps:

- identify affected people early and ascertain vulnerabilities;
- ensure free and informed consent of people affected;
- enable participation of affected people in decision-making processes;
- embed planned relocation in legal framework and government plans;
- ensure adequate funding and equitable compensation schemes;
- establish criteria to determine when relocation planning should start;
- follow a human rights-based approach; and
- ensure sustainability by paying attention to site selection, livelihoods, integration.

Approaches to planned relocation can be situated within changes to the prevailing risk management paradigm. Since the 1970s, the theory and practice of disaster risk management has shifted from a 'top-down' government-led model towards a more 'people-centred' model that emphasises the participation of stakeholders, especially affected people (Gaillard et al., 2007; Scolobig et al., 2015; UNDRR, 2015). Research has shown that allowing affected people to input knowledge, raise concerns, and enhance their capacities improves the quality and implementation of risk management, and reduces underlying vulnerabilities (Demeritt and Nobert, 2014; Pelling 2007; Maskrey 2011; Cadag & Gaillard 2012). Furthermore, the incorporation of local and indigenous knowledge contributes to community resilience, by helping identify signs to trigger early warnings, anticipate potential hazards, and improve disaster recovery (Khailani & Perera, 2013; Hiwasaki et al., 2015; Cadag et al., 2017). Workshops and consultations conducted with flood-affected residents in the Lockyer Valley, Australia, were an important avenue for risk management authorities to understand the population's needs, and ensure participation in the subsequent relocation process (Okada et al., 2014). By contrast, public information sessions conducted in flood-affected areas of St George, Australia, were widely viewed as involving one-way communications and, as a result, missed out an opportunity to consult community members, draw on local knowledge and address their concerns (Okada et al,. 2018). Positioning the relocation areas proximate to the original location was understood to facilitate access to existing community networks and social services (Okada et al., 2014).

The costs of implementing relocation poorly are high. Relocations—especially those which are government mandated and involve movement to unfamiliar areas—can weaken social, cultural and community connections, disrupt livelihoods, affect culture and kinship ties, negatively impact health and wellbeing, and in some cases lead to higher mortality rates among people affected people (Bronen, 2015). Relocation can make it easier for authorities to restrict civil liberties, and, as a result, may cloak other objectives (Akabayashi and Hayashi, 2012).

Urbanisation and colonial power dynamics also represent sources of relocation pressure. For centuries there have been connections between increased globalisation, and the movement of people from rural to urban areas (Dybbroe, Dahl and Müller-Wille, 2010). King et al. found that the departure of just 10 per cent of a community may be "devastating to marginally viable small and rural settlements where outmigration of young families exacerbates an already present economic decline" (2014, p. 89). Urbanisation has increased in recent decades in both Iceland and Greenland due to policies of centralising services under the justification of more efficient delivery (Hendriksen, 2013). Research suggests this trend is tapering off in polar regions due to improved access to communication technology in rural areas, unwillingness to move, inability to relocate, attachment to place, and growth in tourism (Dybbroe, Dahl & Müller-Wille, 2010; Huntington et al., 2018; Bjarnason et al., 2021).

Iceland gained full independence from Denmark in 1944, while Greenland remains part of the Kingdom of Denmark. The situation faced by Iceland did not fit neatly into the dualistic colonised-coloniser situation, and there was not a similar history of forced relocation as occurred in Greenland (Loftsdóttir, 2012a). Forced relocation under colonialism, especially in relation to tribal and indigenous people, renders relocation of traditionally marginalised communities deserving of thoughtful consideration (Holle, 2019). Climate change already leaves indigenous people more vulnerable to relocation, loss of agency and diminishing cultural attachment to place (Cullen, 2022). This is exacerbated by systematic and historical impediments to access justice and the realisation of human rights (Cullen, 2022). Colonial power dynamics typically favour migration over local desires to adapt in place to preserve national identity and sovereignty (Bordner et al., 2020).

8.2.2 Risk management in Iceland and Greenland

In Iceland, DCPEM coordinates measures to prevent physical injury to the public, damage to the environment and property, and provide emergency assistance (Parliament of Iceland, 2008, Articles 12 & 13). DCPEM is positioned within the Ministry of Justice, with responsibilities delegated by the National Commissioner of Police at the national level. The District Police Commissioners are in charge of civil protection operations within the country's nine police districts (Parliament of Iceland, 2008). Civil Protection Committees are responsible for emergency management at the municipal level. DCPEM supervises assistance between districts, and coordinates assistance from Government agencies to municipalities. The Icelandic Association for Search and Rescue and the Icelandic Red Cross support risk and emergency management.

At the time of writing, it was unclear whether the unstable Svínafellsheiði slope risk would be classified as a landslide or a flood, with significant implications for the applicable relocation framework. Regulations for landslides and avalanches are more prescriptive than for floods. Measures to prevent damage and accidents caused by avalanches and landslides in Iceland are outlined under Act 49/1997 on Protective Measures Against Avalanches and Landslides (Parliament of Iceland, 1997, Article 1). The Chief of Police, in consultation with DCPEM, can order housing to be vacated due avalanche or landslide risk (Parliament of Iceland, 1997, Article 7). Municipal governments can also recommend the Avalanche and Landslide Committee to purchase or transfer the buildings (Parliament of Iceland, 1997, Article 11). The municipal government becomes the owner of purchased assets but further use is subject to approval at the ministerial level (Parliament of Iceland, 1997, Article 11). If there is no agreement with residents on the purchase of the building, the municipal government can take possession in accordance with the Expropriation Act (Parliament of Iceland, 1997, Article 11). The cost of purchase is based on the market price of comparable buildings in the municipality outside risk areas (Parliament of Iceland, 1997, Article 14). In practice, the Avalanche and Landslide Fund is only used to cover areas that have been zoned as urban, and does not cover rural or commercial zonings such as those in Freysnes and Svínafell (MG.2).

There were several indications that the relocation of people from Freysnes and the westernmost farms of Svínafell was under consideration by risk management authorities. Early in the study period, one risk manager mentioned that "if its decided that this area is too dangerous to live in then the fund would buy all the houses" (RM.2). However, in later interviews and informal discussions, scientists, risk managers and municipal officials discussed the challenges of using the Avalanche and Landslide Fund to compensate people for their homes in the case of relocation, both due to the type of hazard and the zoning of the area (MO.1, S.5). Modelling of the flood risk due to the unstable slope presented at the 22 October 2020 risk briefing showed that by 2070, Freysnes was predicted to be affected by a large flood with about five minutes of notice (IMO, 2020). This increased risk further raises the prospect of relocation. However, there was little discussion of planning for relocation in the public briefings.

As a self-governing territorial entity within the Kingdom of Denmark, responsibility for risk preparedness in Greenland is split between the Government of Greenland (*Naalakkersuisut)*, Danish authorities (including the military and police), and municipal authorities within Greenland (Parliament of Greenland, 2010). The response to accidents and disasters is led by the Greenlandic police—which is part of the National Police of Denmark—and operations are directed by the Chief of Police in Greenland. Municipal Emergency Preparedness Commissions manage emergency services, and develop contingency plans for each of Greenland's five municipalities. An Emergency Preparedness Commission, established by the Government of Greenland, advises Government about emergency preparedness matters, and compiles a contingency plan for Greenland (Parliament of Greenland, 2010).

Rescue preparedness measures in Greenland are outlined under Act 14 on Rescue Preparedness in Greenland and on Fire and Explosion Prevention Measures. The Act covers different aspects of evacuation (e.g. Parliament of Greenland, 2010, Article 35), but provides little guidance on relocation processes. It does establish that emergency services have the right to demolish buildings if it is deemed necessary to stop the spread of injury (Parliament of Greenland, 2010, Article 16). Act 25 on Expropriation also outlines that the Government of Greenland can expropriate private property, if the transfer of property by amicable agreement has first been sought (Parliament of Greenland, 1992, Article 1). Compensation to the property owner is determined by a committee of four or five independent people, including members appointed by the national and municipal governments (Parliament of Greenland, 1992, Article 2).

8.3 Methodology

This article presents a case study analysis of two communities exposed to landslide-triggered tsunami risk: the Svínafellsheiði slope in Iceland, and the

Karrat and Uummannaq Fjords in Greenland. It builds on an ethnographic study about risk management of the Svínafellsheiði unstable slope, which focused on the role of local knowledge (Matti & Ögmundardóttir, 2021), effects on psychosocial wellbeing (Matti et al., 2022a), and risk communication with foreign tourism employees (Matti et al., 2022b). This article expands the scope of the research to draw insights from Greenland: another Arctic territory which has also started to manage landslide-triggered tsunami risk for the first time in the last five years. This section outlines the methodology employed by describing both the case selection, and data sources.

8.3.1 Case selection

There are several factors—including scale, political history and hazard type—that make the two cases sufficiently comparable for analysis. The communities affected are similar in size: 151 people officially live in the Öræfi district (Figure 12),[10] with approximately 80 people in areas exposed to the hazard; 99 people were living in Nuugaatsiaq and 75 in Illorsuit before the tsunami in 2017 (Svennevig et al., 2020); most exposed communities in Uummannaq Fjord have similarly small populations (Table 4; Figure 13). The case study locations are isolated; the nearest town with approximately 5,000 people or more is almost 300 kilometres from Öræfi, and 450 kilometres from Karrat Fjord. Iceland has the lowest population density in Europe with 3.5 inhabitants per square kilometre (Bjarnason et al., 2021), while Greenland is the most sparsely populated territory in the world with just 0.025 inhabitants per square kilometre (Rygaard, 2008; Icelandic Ministry of Foreign Affairs, 2020). Combined with high rates of urbanisation (Bjarnason et al., 2021; World Bank, 2022), this results in extremely low population densities in rural areas in both cases. Greenland and Iceland are neighbouring islands in the North Atlantic polar region (IPCC, 2022) with recent experiences of Danish colonialism. There are also important similarities regarding the type of hazard, with both cases involving the risk of a tsunami triggered by a large landslide from over-steepened slopes destabilised by glacial retreat, and permafrost degradation. In both instances, the main threat to people stems from the risk a tsunami rather than from the landslide itself (Strzelecki & Jaskólski, 2020; IMO, 2020b). Large landslides have already occurred from the same unstable slopes in both Svínafellsheiði (2013), and Karrat Fjord (2017).

[10] These official statistics do not include most non-Icelanders living and working in the area

Table 4: Updated risk to Karrat and Uummannaq Fjord villages

Settlement	Population in 2020[1]	Residents offered relocation[2]	Warning time[3]	Maximum wave height[4]	Maximum inundation height[5*]
Nuugaatsiaq	0 (formerly 99)	99	7 min	28 m	32-74 m
Illorsuit	0 (formerly 75)	75	13 min	9 m	19-43 m
Niaqornat	35	35	23 min	4 m	9-17 m
Qaarsut	174	113	26 min	5 m	9-23 m
Uummannaq	1407	10	30 min	10 m	6-14 m
Saattut	223	8	35 min	No data	5-10.5 m
Ukkusissat	154	3	26 min	No data	5.5-7.5 m
Ikerasak	233	7	38 min	No data	4.5-11 m

*Table 4 sources: [1] StatBank Greenland, 2022; [2] KNR, 17 June 2021a; [3] KNR, 11 May 2021a; [4] Refers to the tsunami height relative to normal sea level at the time of the tsunami; KNR, 11 February 2021; [5] *Inundation height refers to the elevation of seawater relative to a given datum e.g. mean sea level (IOC, 2019) (KNR, 11 May 2021c).*

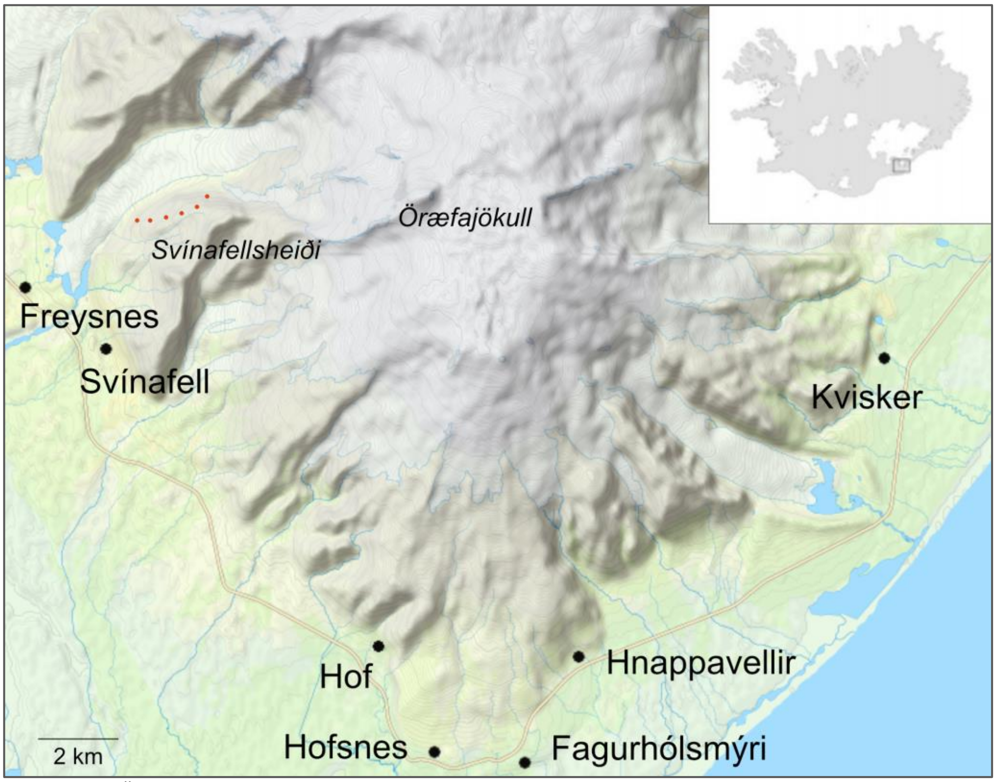


Figure 12: Öræfi district in south-east Iceland with Svínafellsheiði slope instability in orange (Base map: GLIMS; detail added by Stephanie Matti)

There are also important differences between the cases that warrant mention. The 2013 landslide from Svínafellsheiði had no effect on people or infrastructure in the area. By comparison, the 2017 tsunami in Karrat Fjord caused fatalities, large-scale destruction, and the evacuation of entire communities. The Karrat and Uummannaq Fjords are home to indigenous Kalaallit people, many of whom are connected to the land and location through local hunting and fishing grounds. In Iceland, several families have long histories in the Öræfi district (with some dating back to 1300 AD), but they do not identify as indigenous; most livelihoods in the area are tourism-based.

Figure 13: Karrat and Uummannaq Fjords in Greenland with unstable landslide complexes in orange (Base map: GLIMS; detail added by Stephanie Matti)

The Government of Iceland recently published a report on the potential of increased collaboration between Iceland and Greenland including in relation to emergency response (Icelandic Ministry of Foreign Affairs, 2020). In discussing the expanded tsunami risk in May 2021, the Chairman of the Government of Greenland also talked about the need for expanded cooperation with neighbouring countries on emergency preparedness (KNR, 12 May 2021c). Both Governments have collaborated with the Government of Norway, which has long-standing experience of managing landslide-triggered tsunamis. There is also potential for collaboration between government agencies and affected communities in Iceland and Greenland, who are exposed to a historically unprecedented risk, and who are working out procedures for planned relocation.

8.3.2 Data sources

For the Svínafellsheiði case, a purposive sampling method was used to identify 52 people (25 females; 27 males) who participated in a series of 50 semi-structured interviews (Matti et al., 2022b). The interviewees were: 14 Icelandic local inhabitants, seven foreign inhabitants, nine glacier guides, nine tourists, three risk management experts, three scientists, two municipal Government officials, two tourism experts, two search and rescue coordinators, and one national park ranger (see Annex 1). All interviews were conducted in English except one conducted in Icelandic through a translator. The interviews were typically between 60 and 90 minutes in length. All interviews and field notes were recorded, transcribed, and openly coded (Priest et al., 2002). Participants were provided with a description of the research, information about the researchers, and the mode of audio-recording. Informed consent to participate was audio-recorded in all cases. To ensure anonymity, sources were broadly categorised and coded as local inhabitants (LI), foreign inhabitants (FI), glacier guides (GG), municipal government authorities (MG), scientists (S), and Government officials (GO). The dearth of media coverage of the Svínafellsheiði case, including local perspectives, necessitated this interview-based data collection approach.

The academic literature on the tsunami risk in Karrat and Uummannaq Fjords was squarely focused on the scientific basis of the hazard. In reviewing the literature, we found only one study that examined the human side of the situation in any detail. Strzelecki and Jaskólski (2020) covered the immediate environmental, infrastructure, and socio-economic impact of the 2017 tsunami. We did not find any studies that examined risk management, nor any academic literature on the expanded risk in Uummannaq Fjord. A review of the relevant government and press outlets showed that Kalaallit Nunaata Radioa (KNR)— Greenland's government-funded public service radio—had by far the most extensive coverage of the case.

The present study was based on an analysis of 55 news articles published online on KNR (see Annex 3). The articles were selected by reviewing all entries under the search "Karrat", and examining all those from the first tsunami on 17 June 2017 onwards. All were published in Kalaallisut and Danish; for the purpose of this study, the Danish versions were translated into English using online translation software, with quality checks conducted by a bilingual research assistant. Articles from other press outlets were used to corroborate some of the information that the KNR articles contained. The KNR articles covered different perspectives and frequently incorporated extensive quotations from local inhabitants, and Government officials at the municipal and national levels. As a public broadcaster, the tone of the articles was measured, avoiding some of the sensationalism present in other sources (e.g. Vice, 2021). Some topics were followed through successive articles, giving insight into different perspectives, and the evolution of risk management processes. These articles represent a source of data that has until now not been utilised for scholarly research. The authors acknowledge the shortcomings and potential bias inherent in depending on media articles from a single source. However, this study represents an initial step to research risk management processes in a setting where the financial and logistical barriers to research are high. There is a clear need for follow-up research conducted in Greenland in-line with recommendations for community-based participatory research in Greenland (Rink and Reimer, 2019).

That different types of data sources inform these two case studies places limits on the extent to which direct cross-case comparisons can be made. However, the purpose of this article is to draw initial insights and lessons from broadly similar hazards and responses to them, rather than to conduct a direct comparison. Nevertheless, the extensive use of personal quotations in the KNR articles enables some insight into individual perspectives, in a similar way to those uncovered in the Svínafellsheiði interviews.

8.4 Svínafellsheiði, Iceland

In 2014, farmers discovered a fracture in the Svínafellsheiði mountainside (Figure 12). Subsequent investigation revealed that it was part of a 1.7 kilometre long fracture that expanded at a rate of 1.3 centimetres per year between 2016 and 2018 (Sæmundsson et al., 2019). When the unstable Svínafellsheiði slope collapses, an estimated 60 million cubic metres of bedrock is predicted to fall on the surface of the glacier (Sæmundsson et al., 2019). The landslide may remain deposited on the glacial surface; however, there is a chance that such a large landslide could incorporate ice from the glacial surface, and then cause flooding or a tsunami from the proglacial lake. If this happens, the resulting mass of rock, ice, water and air in motion could pose and infrastructure downhill (IMO, 2018a; Sæmundsson, 2018). A landslide roughly a quarter of the size caused a tsunami 75 metres high when it fell on the Icelandic glacier Steinsholtsjökull in 1967 (Sæmundsson & Margeirsson, 2016; Kjartansson 1967). The primary hazard for people residing in the area stems from a potential flooding and tsunami rather than the landslide itself (IMO, 2020b). The risk is predicted to increase coming decades as the lake expands due to the effects of climate change (MG.1; S.5). It is not possible to predict with any certainty when the landslide will occur (S.2); the timing of slope failures notoriously difficult to predict in any context (Carey et al., 2012).

Freysnes is located 800 metres from the proglacial lake, Svínafell lies two kilometres further south-east. Both Freysnes and the western-most farms of Svínafell are predicted to be exposed to the risk in coming decades (IMO, 2020b). In early 2018, there were about 80 people living in Freysnes, most of whom were foreign tourism employees. In recent decades, the economy of the area has shifted from a dependence on agriculture and fishing, to large-scale tourism with 27,455 tourists visiting the Svínafellsjökull glacier in 2018 (Welling & Abegg, 2019; Welling, 2020). In early summer 2018, an estimated 1,500 people spent time in the area exposed to the hazard each day, including an estimated 1,000 tourists on glacier tours Svínafellsjökull, as well as over 100 tourism employees (Matti & Ögmundardóttir, 2021).

In the interviews conducted as part of this study, residents gave several reasons why they chose to live in the area despite the risk. Many local inhabitants were from families that had resided there for generations, with one family tracing their history in the area back to 1300 AD (Matti & Ögmundardóttir, 2021). Another resident mentioned that “this is my life here, my heart is here” (LI.4). The environment was also described as powerful, and demanding respect (LI.1; LI.6). There was a deep sense of community, with interactions described as “kind”, “respectful” and “supportive” (LI.2; LI.10). Some interviewees were more resigned to the risk, noting that “we want to live here because of various reasons and then you just take it as it comes” (LI.3) and that “it is best to live here as usual, if we are not going then we have to just keep on” (LI.4).

8.4.1 Risk management

Public meetings organised by Government authorities represented the main forum through which local residents interfaced with Government risk management agencies (Figure 7). These included closed meetings with members of the community living in the immediate vicinity, meetings of the Regional Civil Protection Committee, and town hall briefings open to the public. In total, nine meetings were held on five dates between October 2018 and October 2020 (Matti et al., 2022b). All of the Icelandic inhabitants interviewed as part of this research had attended at least one of these meetings.

Participant observation undertaken as part of this study indicated that there was a clear distinction between the dialogic workshops conducted with people directly exposed to the risk, and the larger town hall meetings. Even the seating plan was prescient of the engagement fostered. The closed workshops with people affected, and the Regional Civil Protection

Committee, involved some updates by Government officials and scientists, however, the bulk of the time was spent with people engaging in dialogue about risk management plans (GO.2; GO.4; participant observation, 24 October 2018). A smaller number of people were seated around a table and the focus of the meeting was on active discussion (participant observation, 24 October 2018). The stated aim of Government officials was to collectively guide risk management processes through input from affected people (GO.3). Government representatives mentioned afterwards that the meeting had been particularly productive in terms of planning. However, several people living in the area who attended the workshop commented in subsequent interviews that they felt official risk management processes in general did not sufficiently incorporate their opinions, including in relation to discussions of relocation (LI.2; LI.3). In contrast to the workshop, the town hall meeting involved experts presenting information to the public, and allowing them to ask questions or raise issues at the end of the meeting. The people attending the town hall meeting were informed about the risk but were not actively engaged in the decision-making process.

The Icelandic Government's risk management approach was perceived differently from person to person. Some local inhabitants felt that the meetings were conducted in an informative and collaborative manner (LI.2), but not everyone felt that their concerns were taken seriously and given appropriate follow-up. One local inhabitant who attended the hall meeting explained that "when we ask, they are like "yeah, yeah, that's a good idea" but then nothing happens" (LI.15). At the time of writing, in April 2022, there were no publicly available emergency response plans or risk assessments, and information had only been provided orally. When asked about lessons learnt about the risk management processes, a local inhabitant explained that for a similar risk the future, the response should be to "make a plan ASAP, talk to the people who live in the area. Ask them how they feel and what they want to do" (LI.3).

At the 24 October 2018 public meeting, Government officials did not recommend residents relocate pre-emptively due to the Svínafellsheiði risk (public meeting, 24 October 2018). This topic was not covered in detail in subsequent risk management meetings during the study period (personal communication with local inhabitant, 8 May 2022). Mitigation measures have focused on other measures including an emergency alert system. Due to the proximity of inhabited areas to the slope, the warning time once a landslide begins is extremely limited (S.2; GO.2). As a result, warning systems are orientated towards technical monitoring of movement in the slope and ascertaining thresholds that warn of imminent collapse. The

Government established a system to send an alert to all mobile phones in an area exposed to an urgent emergency event (DCPEM, 2018a). Residents expressed concerns about poor mobile reception (LI.1; LI.3; LI.13), whether they would wake up to a message sent at night (LI.3), and whether tourists would know how to respond to such a message (LI.1). In 2018, the Government discussed setting up a siren system in high-risk areas (GO.2); however, as of September 2021, no such system had been established. Government authorities recommended emergency response protocols involved exiting the area by vehicle or taking shelter in Freysnes (public meeting, 24 October 2018).

As the risk escalates in coming decades due to the predicted expansion of the proglacial lake, Icelandic Government officials explained during a public meeting that sheltering in place would no longer represent an advisable response strategy (IMO, 2020a). One Government representative suggested that an alternative could be partial evacuation, in which tourists would have to leave the area but local residents could stay, and be prepared for an emergency evacuation (GO.2). Yet this too has its problems. There was no indication that public authorities had prepositioned emergency supplies for a rapid response, and one local resident questioned the wisdom of locating the local search and rescue base in the area exposed to the hazard (LI.3). One person interviewed had prepositioned personal emergency supplies, following the advice provided by the Icelandic Red Cross, but expressed her belief that other people in the community had not taken similar action (LI.12). Another option could be to trigger the landslide intentionally using explosives. However, scientists advised against this, warning that such an approach is highly unpredictable and risks forming new instability in the slopes (S.2).

Nevertheless, some measures have been implemented to reduce local exposure to the risk. On 22 June 2018, local police advised "against travel on Svínafellsjökull due to landslide danger. In particular, guided tours on the glacier are discouraged. Travellers are advised to stop only for a short while at viewpoints by the glacier tongue" (IMO, 2018a, p. 1). Guided tours on Svínafellsjökull glacier were discontinued, and warning signs erected on access roads. Still, most tourists continue to pass the exposed area by vehicle, as there are no alternate routes heading east through the district. As a result, the number of people exposed has remained largely unchanged, but the period and degree of exposure decreased significantly.

In the period between 2018 and 2020, a "no-build zone" was established to prevent a further increase in people and infrastructure exposed (Matti et al., 2022). Government officials spoke to local residents to inform them of the no-build zone, but no written information was provided, making the exact parameters of the policy unclear. The no-build zone had negative repercussions for the psychosocial wellbeing of people in the area including perpetuation of feelings of frustration, and that their future was on hold (Matti et al., 2022).

Only two interviewees discussed relocation. When questioned about what she would do if the authorities recommend relocation, one resident responded “I don’t know. I don’t know. I have no idea. Of course I would really like to continue to stay here, but there is not much available land nearby” (LI.1). This was complicated by a lack of clarity about the potential relocation regulations that would apply based on whether the risk is classified as a landslide or a flood; as well as by the national Landslide and Avalanche Fund not covering compensation for loss and damage caused by landslides in rural areas such as the Öræfi district. A representative of the municipal government was critical of this policy, mentioning that each residence exposed to the risk was:

> a home of people, there is a lot of money invested there, and it has been there for a long time. And this hazard comes in and you don’t get any compensation from the Government because where it is situated. I don’t know why it is like that, because the danger was not known when it was built (MG.2).

The tourism industry was mentioned as a reason for hastening the risk assessment process: “in the south you have all the tourism booming, and everybody wants to do something to provide service for the tourists, so there was more urgency regarding that” (S.5). Yet the focus of government-led risk management processes has been on residents rather than businesses in the area. Furthermore, despite tourism-driven demographic shifts, local Icelandic inhabitants remained the “basic unit on which risk management processes were centred, with repercussions for the ways in which exposure was calculated and risk was communicated” (Matti et al., 2022b). For instance, some residents questioned how the authorities communicated the risk to tourism employees who were temporary residents. A glacier guide reflected:

> I feel uncomfortable about the number of foreign workers in the area exposed to Svínafellsheiði. People who are constantly living and working on site, they don’t necessarily have this deeper intergenerational understanding that this is their home. You have

> people who drive past once in their life, and then people who live there their whole life and are resigned to it. But this category of people who live there for some months or years, that is difficult. There is also the economic incentive, nobody wants to make decisions to leave when their livelihoods are affected (GG.5).

All of the local inhabitants interviewed had a comprehensive understanding of the risk and emergency response procedures based both on scientific and local knowledge (Matti & Ögmundardóttir, 2021; LI.1-16). By comparison, the foreign tourism employees living and working in the area interviewed for this study displayed a wide spectrum of understanding of the risk, and how to respond (Matti et al., 2022b). Government officials acknowledged that foreign inhabitants were not always adequately informed, explaining the difficulties faced given language and cultural barriers, and high staff turnover rates (GO.2). Very few of the tourists interviewed as part of this research were aware of the risk or how to respond in the case of imminent collapse, and none understood the scale of the hazard (T.1-8).

Local residents raised concerns about how dynamics with the municipal council affected official risk management processes. One resident explained that it felt like a hassle for municipal officials to attend the public meetings because of the distance they had to travel (LI.3). Another resident felt that "local people here we try to find solutions" while the municipal government staff "just work from nine to five and they don't realise the situation" (LI.1). The same resident perceived that this was part of a trend in which municipal governments "kind of take over the countryside because there are less and less people living in the countryside" (LI.1). She felt that the municipal government would prefer if the affected people would move to the urban centre in the area (LI.1). In 2019, people in the Öræfi district established a community association to represent their interests vis-à-vis municipal and national authorities. The chairperson of the Öræfi association stated that "we are a group of people who live here in the area, so we can have a voice" (LI.3).

8.5 Karrat and Uummannaq Fjords, Greenland

8.5.1 Karrat Fjord

On 17 June 2017, the village of Nuugaatsiaq in Karrat Fjord of north-western Greenland experienced a tsunami triggered by a large landslide 32 kilometres away. It left four people dead, nine injured, and most buildings damaged or destroyed (KNR, 13 April 2022a; Figure 13). Prior to the tsunami, there were no known unstable slopes in the area (Svannevig et al., 2020). All 75 residents from Nuugaatsiaq and 99 residents from nearby Illorsuit were evacuated to the regional centre of Uummannaq, and were later informed that they would not be able to return due to the ongoing tsunami risk (Svennevig et al., 2020; Strzelecki & Jaskólski, 2020; KNR, 20 July 2019). Residents of Niaqornat were also evacuated after the tsunami but were able to return soon afterwards.

The Governments of Greenland and Denmark made an initial commitment of DKK 110 million to the tsunami response (approximately USD 16 million) (KNR, 1 September 2017; KNR, 15 August 2017). For households evacuated from Nuugaatsiaq and Illorsuit, the municipal government offered to build a house in a new location that they would be able to rent (KNR, 20 July 2019). The 40 houses built were owned by the municipality (KNR, 20 July 2019). Each eligible household was given some limited choice over where the house allocated to them would be constructed; houses were ultimately built in four different locations (KNR, 15 July 2020). There was no indication that people were given the option of supported relocation outside the municipal area. In choosing where to relocate, one resident reasoned that for her family "there just must not be too many people" (KNR, 23 May 2021) another couple chose to relocate to Saattut because they found it "reminiscent of our former settlement Illorsuit, in terms of how and when the sea freezes occasionally, and how autumn and summer develop" (KNR, 20 July 2019). People who owned homes in the affected villages but also had a second habitable house elsewhere received DKK 50,000 (approximately USD 7,000) as compensation for their house in Nuugaatsiaq or Illorsuit (KNR, 22 August 2018).

The Government recommended against people returning to Illorsuit and Nuugaatsiaq. In a 2018 news article: "The Greenland Emergency Preparedness Commission considers that citizens should still not return to Nuugaatsiaq and Illorsuit, and should not move in the immediate vicinity of these danger areas" (KNR, 21 August 2018). In May 2021, this approach was softened with a Government official clarifying that "no one stops them from moving back to the village. If they have decided to live there, it is not forbidden" (KNR, 26 May 2021). Some people continue to return to the now abandoned villages to fish and hunt (KNR, 4 September 2018). However, government jobs, electricity and water would not be restored to Illorsuit (KNR, 26 May 2021), with the justification that it would expose employees to unacceptable risk (KNR, 26 May 2021). Telephone lines and internet connections were also unlikely to be restored (Sermitsiaq, 2022).

Several KNR articles indicate that evacuation and subsequent relocation had negative effects on psychosocial wellbeing of the people affected. Children showed signs of trauma years later including increased anger and crying, difficulties sleeping, intensified anxiety, and self-harm (KNR, 23 May 2021). Four years after the tsunami, one child was still "getting anxious, tensing his muscles really hard and starting to bleed out of his nose while shouting and crying that he would like to return to Nuugaatsiaq" (KNR, 23 May 2021). Among adults, alcohol use increased with one resident explaining that "the new life has been too much, and social problems have arisen in the wake of the evacuation" (KNR, 22 June 2018). The tight-knit nature of the communities was viewed as an important support network in the aftermath of the disaster, enabling "grieving together and carrying the sorrow as a community" (Vice, 2021, p. 1). Limited psychological support has been made available to those who were evacuated (KNR, 23 May 2021).

People who were evacuated expressed different opinions about where they would prefer to live. Many—especially those from Illorsuit—were keen to return (KNR, 12 April 2022; KNR, 11 February 2021). One resident stated that "Even though it's about to be four years ago, our desire to return home remains" (KNR, 11 February 2021). An association called *Peqatigiiffik Illorsuarmiu*t was formed by people from Illorsuit to support the community, including advocating for return (KNR, 11 February 2021). Other former residents preferred to remain in the new place they had settled, with one person explaining that "We have to adapt so that we do not have to experience something similar again… If a snow sparrow can escape with its young to a safer place, why should we humans not be able to do the same" (KNR, 17 June 2021b).

8.5.2 Uummannaq Fjord

In May 2021, the National Geological Survey of Denmark and Greenland announced that four unstable slopes had been identified: three close to area that caused the 2017 tsunami (*Karrat complex*), and a fourth approximately 50 kilometres south (*Kangerluasuk complex*) (KNR, 13 May 2021b; Figure 13). It then updated the worst-case tsunami scenarios, which this article has replicated in Table 4. Municipal planning was revised on the basis of the new risk assessments (KNR, 13 April 2022a). A total of 176 residents from seven settlements were deemed to live in houses exposed to this tsunami risk, and the municipal government offered those households voluntary relocation support (KNR 17 June 2021a; KNR 11 May 2021a; KNR 23 May 2021). These included all inhabitants from Niaqornat and the majority from Qaarsut (KNR 11 May 2021a).

The support offered by the municipal government included free emergency accommodation in Uummannaq, rehousing in rental accommodation, and termination of existing mortgages from government-backed financiers (KNR 14 July 2021). There was no policy to relieve mortgages from commercial banks (KNR 14 July 2021). People were given some choice over the location to which they would move, but destinations depended on housing availability in an already highly constrained rental market (KNR 11 May 2021a). The former municipal bailiff in the village of Nuugaatsiaq was sceptical that many residents would take up the offer:

> The citizens of the area are independent. They have their own houses, and for them it is not attractive to move to rental housing, which is otherwise expensive. It is in itself nice to give that opportunity, and it is a nice gesture. But there is already a shortage of housing in Uummannaq. There is also a shortage of harbour and fishing places, and therefore it is doubtful whether the 176 people will accept the offer (KNR, 12 May 2021b).

Of those offered relocation assistance, 46 initially agreed to relocate. However, some were then informed verbally by municipal authorities that their homes would be demolished after they relocated. This information was not communicated in writing (KNR, 25 June 2021). The Government later retracted that position and issued an apology (KNR, 26 June 2021). Two weeks later, the Government of Greenland announced that people would not have to give up their home in order to access the relocation scheme (14 July 2021). While some people look up the offer and chose to relocate (KNR, 29 June 2021), 15 residents who initially accepted the offer, changed their mind after the incident, and decided to stay in their homes despite the risk (KNR, 1 July 2021). One resident explained:

> I was otherwise ready. I wanted to move because I live alone. If I had to flee in the middle of the night or during the day, I could not do anything. Now, I have decided to stay here… I have absolutely no confidence in the Government and Avannaata Kommunia [municipal government] anymore (KNR, 29 June 2021).

The relocation assistance offered to people from Uummannaq Fjord was not received well by some from Nuugaatsiaq and Illorsuit who acquiesced to relocation, because they were not offered the option of being able to return to their community. A resident from Illorsuit explained:

> I got really jealous when I heard about it the other day. They are really lucky that they get the opportunity to choose for themselves… …We had no rights then. We were forced and carried away from there without being told where we were being flown to (KNR, 12 April 2022).

Residents from Uummannaq Fjord who chose not to accept the voluntary relocation offer gave various justifications for their decision. One woman noted that she had helped build her house in 1994, and that she has always lived in the village, and she has "many emotions in the house, which has been her home for the past 27 years" (KNR, 25 Jun 2021). The uncertainty associated with acquiring rental accommodation were also dissuasive (KNR 12 May 2021b). Finally, some residents did not believe that they would be at risk if they remained (KNR 13 April 2022b; KNR 11 May 2021b). Those wanting to return to Illorsuit mentioned their pride in the surrounding nature (KNR, 13 April 2022b), and recent community developments before the 2017 tsunami including an expansion of the shopping centre and plans for a new health that were underway before the evacuation, as reasons for wanting to return (KNR, 12 April 2022).

Various measures have been employed to mitigate the tsunami risk. Risk management and contingency plans were updated (KNR, 13 April 2022a; KNR, 12 April 2022). While the feasibility of an automated early warning system was being assessed (KNR, 11 May 2021a), people were stationed nearby several villages to monitor for tsunami signs (KNR, 11 February 2021; KNR, 11 May 2021a). Awareness raising campaigns about warning signs and emergency response protocols were conducted (KNR, 12 April 2022). A system of emergency sirens was established in the municipality, and tested through regular evacuation exercises (KNR, 13 April 2022a). Questions have been raised about the coverage of sirens, with one resident explaining that she can "only hear the siren when her windows are open" (KNR, 17 June 2021a). Different solutions were being investigated including extending the siren system, increasing the volume, installing sirens in individual houses, and establishing an SMS alert system (KNR, 23 June 2017; KNR, 17 May 2021). Escape routes, and emergency shelters have been constructed to facilitate emergency evacuation to higher ground, and emergency provisions have been prepositioned (KNR, 13 April 2022a; KNR, 30 May 2021). Concern was expressed about the location of the regional health centre, a village power station and planned emergency accommodation in exposed areas (KNR, 17 May 2021; KNR, 16 May 2021). Scientists advised against detonation of the landslides (KNR, 13 May 2021b).

8.5.3 Public engagement in official risk management

Public meetings organised by the Greenlandic Government represented the central forum whereby affected communities interacted with government risk management processes (Figure 14). Meetings were as follows:

- July 2017 with evacuees (KNR, 30 June 2017);
- August 2018 with evacuees in Uummannaq about housing options (KNR, 22 August 2018);
- May 2021 with separate meetings for all affected communities about the updated risk assessment (KNR, 12 May 2021a); and
- June 2021 with affected people about upcoming relocations (KNR, 24 June 2021).

At these meetings, information was typically presented by government officials, with input from scientists, followed by the opportunity for the public to ask questions. Citizens asked for decisions to be justified and expressed their dissatisfaction with decisions that were made (KNR, 17 June 2018; KNR, 13 May 2021a). Approaches proposed by citizens included building residential houses higher on slopes in communities at risk (KNR, 11 February 2021) or requests to return to Nuugaatsiaq and Illorsuit (KNR, 17 June 2018). There were reports that people did not receive responses to complaints lodged with the Government of Greenland and municipal government about the condition of housing to which they would be relocated (KNR, 13 May 2021a). However, the policy reversal and apology for the plan to demolish the original houses of relocated people represented a case in which municipal authorities directly responded to objections raised by residents that were published in the press (KNR, 25 June 2021). Additional information was not available in the KNR reports about the extent to which the ideas proposed by residents affected official decision-making.

The KNR articles provide some insight into decision-making processes and power dynamics. Decisions to not reopen Nuugaatsiaq and Illorsuit were reported as being made variously by the Government of Greenland, municipal government, or the Emergency Preparedness Commission (KNR, 30 June 2017; KNR, 17 July 2017; KNR, 4 September 2018; KNR, 23 June 2017). In these statements, risk management decisions were never portrayed as being made jointly with affected people. Instead, risk management announcements refer to the government as “we” and the affected people as “they” (e.g. KNR, 17 July 2017). The Chairman of the Government of Greenland explained that:

> Transparency is important for the Government of Greenland, even if it causes people to worry. We are sharing this information and making sure that we meet with the affected residents face-to-face and tell them about the options that are open to them (KNR, 12 May 2021c).

While government officials mentioned the voluntary nature of 2021 relocations (KNR, 12 May 2021a), there was no indication in the KNR articles that affected people were involved in developing the available choices. A review of government websites and the literature did not yield any documents that shed further light on the subject. In 2021, the community association *Peqatigiiffik Illorsuarmiut* secured DKK 2 million (approximately USD 300,000) in funding from the Danish Ministry of Finance. However, the funding was blocked by the Government of Greenland, which announced that it was because the funding was "about activities in Illorsuit itself, and we have not been able to support that" (KNR, 15 December 2021). The association responded that the funding would be used to hire a lawyer to help people from Illorsuit gain full control of their rights, to help feel safe again, and support them in determining their next stages in life (KNR, 15 December 2021; KNR, 14 December 2021).

Figure 14: Public meeting conducted in Niaqornat. Despite the unprecedented tsunami risk, no residents showed interest in relocating from the village during the meeting (Photo: Sermitsiaq, 2021).

8.6 Discussion

Hazard-induced relocation can have far-reaching consequences for the people involved. The relocation of the Nuugaatsiaq and Illorsuit communities after the 2017 tsunami in Karrat Fjord has had some negative mental and physical consequences, as well as disrupting livelihoods, and undermining housing security. The relocation process for communities exposed to the tsunami risk in Uummannaq Fjord has been more voluntary, however, elements of the planning process have damaged trust in government authorities. The process of relocation planning due to the Svínafellsheiði slopes has not progressed to the same extent, yet some risk mitigation measures implemented exacerbated frustration, and insecurity (Matti et al., 2022a). There are clear lessons that can improve planned relocation processes in the cases studied.

Government risk management agencies in Iceland and Greenland have invested in hazard research and various mitigation measures. The governments in both have weighed the relative benefits of mobile versus siren alert systems. Siren systems are understood to be a faster mechanism by which to warn people in the event of an imminent emergency event. However, mass tourism complicates risk communication in the Öræfi district, as a study from New Zealand found that using sirens as a warning system can “confuse or frighten tourists without providing clear instructions for what to do” (Becken & Hughey, 2013, p. 81). Other initiatives implemented to communicate risk to tourists visiting Iceland include the 112 mobile application and safetravel.is (Bird & Gísladóttir, 2020), as well as evacuation drills in areas exposed to volcanic risk (Bird et al., 2010). Emergency response simulations conducted in the Greenlandic communities likely increase the understanding of residents about how to react when they hear the alert system. Similar simulations conducted with Icelandic and foreign inhabitants of the area could improve risk preparedness in the Öræfi district. Managing the risk of the Svínafellsheiði slopes was further complicated by the short distance between the slopes and the exposed communities, resulting in an extreme short warning time once an event has begun.

In recent years, acceptable risk has been quantified for avalanche risk in Iceland. The calculations are based on the likelihood of being killed by an avalanche when staying in a given house (Arnalds et al., 2004). This draws on extensive historical research about past avalanche events. Part of the difficulty with landslide-triggered tsunamis risk stemming from unstable slopes of Svínafellsheiði, and Karrat and Uummannaq Fjords, was that before the detection of the cases presented here, there had been a dearth of research into such events in either Iceland or Greenland. While scientific assessments indicate that the risk from the Svínafellsheiði slope will increase in coming decades, there was no clear outline of thresholds that would initiate different phases of the planned relocation process. In the Uummannaq and Karrat Fjords, maps were published showing the potential height of inundation above sea level (run-up height) under different tsunami scenarios (KNR, 16 May 2021). However, it was unclear whether Greenland had a similar system established for quantifying acceptable risk. Such an approach could help ground decisions in evidence that takes into account the likelihood of a hazard, the likelihood of being killed due to the hazard, the effects of mitigation measures etc. Applying a standardised approach to all communities may help affected people understand why some have been offered different relocation options. The development of such criteria for landslide-triggered tsunamis in Iceland could also contribute towards the development of a mechanism for determining when different stages of the relocation process should occur (Weerasinghe, 2014).

Public meetings were a key forum through which local inhabitants were informed about the relevant hazard, associated risks and emergency response protocols. In both cases, the public meetings involved briefings by government officials and scientists to members of the affected population, with time allocated for questions and comments thereafter. The meeting with people living in the area directly exposed to the Svínafellsheiði risk was more dialogic but fell short of meaningful engagement in risk management decision- . In Greenland, the available options were delineated by the Government, municipal authorities and/or members of the Emergency Preparedness Committee. Yet, KNR articles suggest that even when communities were vocal about their preferences—e.g. requests to allow returns to Nuugaatsiaq and Illorsuit—these were not offered as options by government officials. People evacuated after the Karrat Fjord tsunami were given some choice over their relocation destination, while the 176 people in Uummannaq Fjord were given the choice whether or not to accept a voluntary relocation package. Informal discussions indicated that people exposed to the Svínafellsheiði risk similarly felt disempowered by the official risk management processes.

Some aspects of the cases covered in this research are not in-line with international planned relocation best practice, which stress the importance of affected people being actively engaged in decision-making through all phases of relocation planning. The role of the government should be to provide a structure to underpin and support, rather than dictate, community agency. Lessons can be drawn from attempts at planned relocation conducted elsewhere including, for example, New Zealand and the United States (Hanna et al., 2018; Simms et al., 2021; Bronen, 2015).

New Zealand's Matatā community, for instance, was affected by debris flows in 2005, which destroyed 27 houses and damaged 87 houses. Between 2006 and 2021, most of the almost 700 residents relocated, some with the assistance of a government buy-out initiative launched in 2016 (Hanna et al., 2018). The relocation of the Matatā community was underpinned by legal regulations that removed existing land use rights, and withdrew services from the community in order to mitigate the risk to service providers. As a result, some people affected did not perceive that the relocation process was voluntary, while the associated loss of agency undermined community trust in the relocation process, and created a sense of manipulation for the affected people (Hanna et al., 2018). Similar dynamics were evident in the cases studied in this article, with top-down approaches proving less successful and, in some instances, counterproductive. For example, the initial plan to demolish the houses of people relocated from Uummannaq Fjord had the effect of eroding trust in the risk management process, and ultimately resulted in a number of people changing their decision and instead electing not relocate. Similarly, while the Government of Greenland allows people to return to Illorsuit, the suspension of public service jobs and utilities acts as a proxy ban. The no-build policy in the areas exposed to the Svínafellsheiði risk, was not developed in consultation with the people affected, and resulted in dissatisfaction towards government risk management agencies.

In the United States, 85 members of the Biloxi-Chitimacha-Choctaw tribe of Isle de Jean Charles in Louisiana relocated after coastal land loss reduced the island by more than 98 per cent (Simms et al., 2021). Members of the community were actively involved in developing relocation plans over a period of 16 years. In 2016, a relocation proposal developed by the community received US$ 48 million in funding; it represented the first federal comprehensive grant for voluntary community relocation in the United States (Simms et al., 2021). The Biloxi-Chitimacha-Choctaw Tribe have produced a community field guide to engagement, resilience and resettlement, which aims to "provide possible ways for communities to help maintain control of the planning process and its narratives" (Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe, 2019, p. 5). A report by the US Government Accountability Office drew attention to the relocation process, and emphasised how the community engagement process could be used to help the US federal government establish planned relocation protocols (United States Government Accountability Office, 2020).

In many respects, the Karrat and Uummannaq Fjord resettlement processes are anomalous among the relocation literature. Unlike the relocations from Isle de Jean Charles, Matatā, and the Icelandic avalanche regulations, relocated people were not provided with their own house elsewhere, or a buyout scheme based on the market rate for similar properties outside the exposed area. Instead they were offered rental accommodation, which *increased* the insecurity faced by relocated persons. The challenges associated with relocation were exacerbated by limited access to commensurate housing or land. The problem of insufficient housing is widespread in Greenland. In the capital Nuuk, for example, the waiting time for housing can be more than a decade (Christensen et al., 2017). The natural environment in Greenland stymies easy construction with all building materials necessarily imported, resulting in prohibitive building costs (Cullen, 2022). A major challenge faced in the Karrat and Uummannaq Fjord relocation processes was the shortage of available rental properties, with the poor quality and low availability of housing constituting important considerations for people considering voluntary relocation. Furthermore, rental accommodation was less attractive for people who already owned their home in exposed areas.

In the Öræfi district, there was a lack of commensurate land available in the immediate vicinity of the existing communities. The properties exposed to the risk of Svínafellsheiði were particularly well located to service tourism in the area. Identifying other similarly well-positioned locations remains a challenge. However, the housing market elsewhere in Iceland was not saturated to the same extent as in Greenland, which facilitates greater flexibility of relocation options. The areas exposed to the unstable Svínafellsheiði slope were zoned as rural, and, as a result, were not eligible for compensation through the Icelandic Avalanche and Landslide Fund (*Ofanflóðasjóður*) (Parliament of Iceland, 1997). At the time of research, government officials were continuing to investigate different funding and compensation options to cover possible future relocation, but no clear approach was conveyed to the people affected (GO.2). This lack of clarity created further uncertainty for the people affected.

Risk management processes in both case studies have occurred against a backdrop of rapid urbanisation. The proportion of the Icelandic population living in rural farmlands fell from 88 per cent in 1890 to seven per cent by 1980 (Hall, Jónsson & Agnarsson, 2002). In the past decade, the trend of population decline in rural farming areas has stopped and, in some areas, started to reverse in recent years due to the growth of nature tourism (Bjarnason et al., 2021). The Icelandic government has identified the need for more equal access to basic services for people across the country, and developed plans to address depopulation outside the capital area (Parliament of Iceland, 2018). The Greenlandic population living in rural areas fell from 50 per cent in 1950 to 13 per cent by 2019 (Statbank Greenland, 2019), and the total number of inhabited places dropped from 183 in 1938 to 74 in 2017 (Sermitsiaq, 2020a). In 2020, a Greenlandic member of the Danish Parliament proposed that the feasibility of moving people from small and isolated villages to bigger urban areas in Greenland be examined in order to improve access to social assistance, policing and judicial systems (Sermitsiaq, 2020b).

It is imperative that hazard-induced relocation is not used as a tool to support an urbanisation strategy, or other ulterior motives. The approach of offering people relocated from Karrat Fjord the choice to move to neighbouring villages with a similarly sized population helps offset this pressure. However, it should be noted that the population of the urban centre of Uummannaq has increased steadily in recent years. In Iceland, people in the affected communities drew attention to power dynamics with the municipal authorities, and described risk management processes in the context of declining services and representation in their area. It is telling that affected communities in both Öræfi and Illorsuit established community associations in the past five years to better represent their interests and advocate for their rights, including vis-à-vis municipal governments. These dynamics further underscore the importance of including the people directly affected in decision-making processes.

Framing discussions about planned relocation in Greenland are the intergenerational effects of colonialism on Indigenous people. In the early to mid-20th century, when Greenland was still under full Danish control, the Danish State actively pursued the concentration of Greenlandic people in permanent settlements often through forced relocation and dispossession (Christensen et al., 2017). From the 1950s through to the 1970s, numerous villages in Greenland were closed, with residents moved to larger urban areas often at considerable personal and social costs (Dzik, 2016). The IPCC has confirmed that across Greenland, climate change has led to a loss of indigenous knowledge and livelihoods (IPCC, 2022). Meanwhile, indigenous people around the world face systematic challenges accessing justice, realising the protection of human rights, while also being more vulnerable to dislocation, loss of agency and diminishing cultural attachment to place (Cullen, 2022). Framed against this context, ensuring that affected people lead and/or are directly involved in decision processes regarding relocation is paramount, and that a human rights based approach is pursued.

The sustainability of relocation rests on site selection, livelihoods and integration with the host community (Weerasinghe, 2014). In Iceland, livelihoods in the affected area are based on the area being a tourism hub, and are therefore highly site specific. A key challenge would be to identify another area that is not exposed to the hazard that has similar access to the tourism market. There are reports in Greenland of relocated people facing difficulties accessing fishing places, and being allocated mooring in the harbour. Furthermore, the loss of easy access to fishing and hunting grounds for relocated people added pressure on their traditional livelihoods, and was a source of tension with the host community (Birgisson, 2019). Finally, an important consideration in the sustainability of relocation sites is the exposure to future tsunami risk. At present, most assisted relocation in Karrat and Uummannaq Fjords due to the tsunami risk has occurred within the same municipality. However, the May 2021 risk assessment revealed that many of these communities were also exposed to tsunami risk. Continuing to be exposed to tsunami risk after relocation, and the threat of secondary relocation, further compound the potential repercussions for affected people. As research into unstable slopes continues to expand in Greenland, there is a high chance that the results indicate that more communities are exposed to tsunami risk (KNR, 5 January 2019).

8.7 Conclusion

Climate change has already increased hazard-induced relocation, and it will continue to do so as unprecedented risks compound. This conclusion explores how the results of this research can inform risk management and relocation planning for landslide-triggered tsunami risk for the cases studied, and for other societies considering planned relocation due to historically unprecedented hazards. The lessons are particularly applicable to hazards with a high degree of uncertainty about scale and timing and that occur in sparsely populated areas.

In the cases of the Svínafellsheiði slopes in Iceland, and the Karrat and Uummannaq Fjords in Greenland, the available risk management and relocation measures were determined by government agencies. Even when communities were vocal about their preferences, it was not clear how these were integrated into government risk management plans.

Lessons learned from these cases include:

- Pivot the role of government from dictating risk management and relocation options, to providing a structure to underpin and support community agency;
- Ensure that affected people lead decision-making relocation planning processes, or, at a minimum, be actively engaged in the process. This is particularly important among communities that have faced heightened relocation pressure due to urbanisation or colonial policies;
- Establish a system for quantifying acceptable risk for a range of hazards including landslide-triggered tsunamis. Applying a standardised approach to all communities may help affected people understand why some have been offered different relocation options;
- Develop a timeline for planning relocation early in the risk management process;
- Communicate risk and emergency response protocols with all people living and working in the area exposed to the hazard, including foreign employees including those working in tourism;
- Explore innovative solutions for continued service delivery together with the affected communities rather than withdrawing services from areas exposed to risk.
- Communicate coercive measures such as withdrawal of services or amendment of land use regulations in writing, in a language that the people affected understand and do so in good time with opportunity for input;
- Develop and fund equitable compensation mechanisms, that do not increase the financial and housing insecurity of affected people; and
- Draw lessons from best practice community-led relocation planning conducted elsewhere.

Hazard-induced relocation is set to increase globally due to the effects of climate change. Given the far-reaching consequences of relocation on the people affected improving relocation processes is crucial.

9 Conclusion

This PhD thesis contributes to the under-explored field of how societies manage historically unprecedented climate change-related risk. This has been accomplished by analysing the risk management of the two cases that have not been the subject of previous social scientific research: the unstable Svínafellsheiði slope in south-east Iceland; and landslide-triggered tsunami risk in Karrat and Uummannaq Fjords of Greenland. The lessons and recommendations of the present PhD thesis are likely to be most applicable to large-scale and uncertain hazards such as volcanic eruptions, avalanches, flash floods, and landslides. The lessons will also be more relevant for nature and adventure tourism hubs where tourism employees face language barriers accessing official information. This research builds on and contributes towards an increasingly rich social science literature on risk management in Iceland that has emerged over the past decade (Gísladóttir & Jóhannesdóttir, 2016; Bird & Gísladóttir, 2014; Jóhannesdóttir & Gísladóttir, 2010; Bird et al., 2011; Margreth et al., 2014; Pagneux et al., 2011; Jóhannsdóttir, 2019).

Eriksen (2020) proposed that anthropology’s holism and context specificity can be useful for studying the complex and interconnected reality of climate change issues. This PhD thesis represents an example of how digging into a particular climate change-related issue, using grounded theory ethnography, can shed light on the different social factors that underpin risk, and contribute to a more detailed understanding of the different vulnerabilities at play. Concepts emerged through the ethnographic research, such as the psychosocial impact of the no-build policy, that I had no prior understanding or preconceptions of. As such, I felt that grounded theory facilitated research that was open and receptive to the lived experiences of people. An evident shortcoming of this PhD is that ethnographic research was not conducted for communities exposed to landslide-triggered tsunami risk in Greenland; this is a priority for future research.

The uncertainty and challenges involved in the management of the unstable Svínafellsheiði slope were compounded by the dearth of research into, and historic experience of, landslides onto glaciers in Iceland. The importance of local knowledge is recognised under the Sendai Framework, which calls on countries to complement scientific knowledge with local knowledge when developing and implementing DRRM strategies and policies (UNDRR, 2015).

Meanwhile, McWilliam et al. argue that “local knowledge for DRR is particularly important in countries where government capabilities are limited” (2020, p. 1). This study found that local knowledge can also be valuable in developed countries with well-established risk management processes, and when dealing with new types of climate change-related risk. In the Öræfi district, for example, the local practice of sheep gathering led to the discovery and identification of the unstable Svínafellsheiði slope, while local knowledge also contributed to the understanding of warning signs and potential impact.

A key finding of this thesis is the need for government risk management authorities to communicate risk and emergency protocols with different demographics, especially people living and working in the Öræfi district who do not speak Icelandic. An initial step when conducting risk management activities should be to develop a detailed understanding of exposure demographics, vulnerability and language competency. During the study period, the COVID-19 pandemic brought these issues to the fore on a national level. The main website with risk information about the pandemic, www.covid.is, was first available in Icelandic; it was then translated into English and Polish, and afterwards into Arabic, Farsi, French, German, Kurdish, Lithuanian, Spanish and Thai. A government risk manager mentioned in informal discussions that this was the first time that an Icelandic website had been officially translated into such a variety of languages (personal communication, January 2021). O’Brien and Cadwell argue that the idea of risk communications being delivered to all language communities in a society becomes even more pronounced during pandemics because “no one is safe until everyone is safe” (2022, p. 3). I felt that this change was also indicative of a broader shift of understanding within society that government services and essential information needed to be translated into more languages in response to increasing diversity in Iceland. These reflections contribute to a growing body of recently published literature on the sociolinguistics of risk communications, and specifically how the COVID-19 response led to the deployment of a more diverse range of languages in different countries including Ireland (O’Brien & Cadwell, 2022), and Qatar (Ahmad & Hillman, 2021).

Authorities in Iceland rely on risk communication rather than access restrictions to ensure tourist safety, as much of the sector is based on experiencing glacial, volcanic, and geothermal landscapes, all of which have inherent risks (Bird & Gísladóttir, 2020). This thesis calls for tailoring risk communication and training to the needs of different demographics, especially tourism employees and guides, who tourists are likely to depend on for safety in the event of an emergency. Toyada and Kanegae (2014) argue that community members are typically first responders when a disaster occurs, empowering people living and working the community. Risk communication with tourism employees and glacier guides in Öræfi should include written emergency protocols, participatory risk briefings, and regular simulation-based training in the main language(s) of operation. At a minimum, risk managers should develop information products and coach employers on how to communicate information about the risk and emergency protocols to their employees, especially when there is a high turn-over of staff. Access to information about a large-scale risk in one’s place of residence or place of work should not depend on employer/employee power dynamics or individuals having a sufficient level of social capital.

These findings support the recommendation of Bird et al. (2010) that tourism employees in areas exposed to the Katla volcano undergo emergency training and evacuation exercises on an annual or bi-annual basis when operating in risk zones, leading to certification. This approach should be expanded to cover other hazards in tourism hubs, such as the unstable Svínafellsheiði slope. The research by Bird et al. was published over a decade ago, this suggests that risk management authorities could better engage with key recommendations from the academic literature, incorporate lessons learnt into risk management practice, and adapt these to other types of hazards within the Icelandic context. This requires the allocation of sufficient financial and human resources to risk management authorities, that are already stretched due to the massive growth of tourism in the past decade, and the diverse range of hazards experienced across Iceland.

The mode of risk communication can have far reaching repercussions for how risk management measures are received, especially in the case of coercive measures such as the withdrawal of services or amendment of land use regulations. The decision to implement a no-build zone in areas exposed to the risk of the unstable Svínafellsheiði slope was conveyed verbally. Similarly, in the Greenlandic village of Nuugaatsiaq, people offered relocation support were informed verbally that their homes would be demolished afterwards. In both cases, the information was not communicated in writing. Perry and Lindell (2003) found that the practice of conveying risk information verbally rather than in writing is not uncommon in small communities. In both communities studied for this research, the information had adverse psychosocial effects for the people involved, contributed to frustration, and eroded trust in risk management processes. Based on these findings, I recommend that risk management measures always be communicated in writing to the people affected.

Disaster management has shifted towards a greater emphasis on risk reduction, however, psychosocial research and interventions remain squarely focused on response and recovery phases (Gray et al., 2021). Hu et al. (2017) argue that pre-impact psychosocial reactions are varied and often difficult to assess. This PhD research draws attention to the adverse effects that the no-build zone had on psychosocial wellbeing, leaving the people affected feeling that their future was uncertain or on hold, and acting as a persistent reminder of the unstable slope. This research highlights the need for psychosocial wellbeing to be integrated into all phases of risk management. This includes extending psychosocial support to people affected by inhibitive pre-impact risk management measures such as no-build zones or relocation.

Greenland and Iceland started to manage landslide-triggered tsunami risk for the first time during the past five years. There is a broad consensus in the literature that relocation is most successful where people are fully involved in, and in control of, decision-making processes related to their resettlement (King et al., 2014; McAdam & Ferris, 2015; Okada et al., 2018). Based on the analysis presented in this thesis, conducting risk management meetings in communities is not enough. The people affected need to be actively engaged in decision-making during all phases of relocation planning. These findings support the position of Cullen (2022) that the role of the government should be to provide a structure to underpin and support, rather than dictate, community agency; this is particularly important during planned relocation due to the far-reaching consequences for the people involved.

There remains a significant gap in the risk management literature about how societies manage historically unprecedented risk. Avenues for further anthropological research include: expanding the case study literature on the management of newly emerging risks; exploring the development of community-focused planned relocation frameworks; and analysing the psychosocial impacts of DRRM measures throughout all phases of risk management. Expanded investment is needed to support societies to manage an increasing range of historically unprecedented climate change-related risks.

References

Abu-Lughod, L. (2006). Writing against culture. In H. Moore & Sanders (Eds.), *Anthropology in theory: Issues in epistemology* (pp. 466–479). Malden, MA: Blackwell.

Adger, N., Barnett, J., Brown, K., Marshall, N., & O'Brien, K. (2012). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change, 3*. https://doi.org/112-117 https://doi.org/10.1038/nclimate1666

Adger, W., Pulhin, J., Barnett, J., Dabelko, G., Hovelsrud, G., Levy, M., Oswald Spring, Ú., & Vogel, C. (2014). Human security. In C. Field, V. Barros, D. Dokken, K. Mach, M. Mastrandrea, T. Bilir, M. Chatterjee, K. Ebi, Y. Estrada, R. Genova, B. Girma, E. Kissel, A. Levy, S. MacCracken, P. Mastrandrea, & L.White (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the 5th assessment report of the IPCC.* Cambridge, UK: University Press. pp. 755-79.

Afifi, T., Afifi, W., Merrill, A., & Nimah, N. (2016). Fractured communities: Uncertainty, stress, and (a lack of) communal coping in Palestinian refugee camps. *Journal of Applied Communication Research, 44*(4): 343-361. https://doi.org/10.1080/00909882.2016.1225166

Ahmad, B., Alam, A., Bhat, M., Ahmad, S., Shafi, M., & Rasool, R. (2017). Seismic risk reduction through indigenous architecture in Kashmir Valley. *International Journal of Disaster Risk Reduction, 21*: 110-117. https://doi.org/10.1016/j.ijdrr.2016.11.005

Ahmad, R., & Hillman, S. (2021). Laboring to communicate: Use of migrant languages in COVID-19 awareness campaign in Qatar. *Multilingua, 40*(3): 303-337. https://doi.org/10.1515/multi-2020-0119

Akabayashi, A., & Hayashi, Y. (2012). Mandatory evacuation of residents during the Fukushima nuclear disaster: An ethical analysis. *Journal of Public Health, 34*(3): 348–351. https://doi.org/10.1093/pubmed/fdr114

Albris, K. (2018). Disaster governance and the rise of social media: Ethnographic perspectives from Germany. In G. Forino, S. Bonati & L. Calandra (Eds.), *Governance of risk, hazards and disasters.* London: Routledge.

Aliperti, G., & Cruz, A. (2019). Investigating tourists' risk information processing. *Annals of Tourism Research, 79*(102803). https://doi.org/10.1016/j.annals.2019.102803

Altman, I., & Low, S. (2012). *Place Attachment.* New York, NY: Springer.

Ambraseys, N., & Bilham, R. (2012). The Sarez–Pamir earthquake and landslide of 18 February 1911. *Seismological Research Letters, 83*(2): 294–314. https://doi.org/10.1785/gssrl.83.2.294

American Anthropology Association (2015). *AAA statement on humanity and climate change*. Retrieved from http://s3.amazonaws.com/rdcms-aaa/files/production/public/FileDownloads/pdfs/cmtes/commissions/CCTF/upload/AAA-Statement-on-Humanity-and-Climate-Change.pdf

Anderson, L. (2011). Analytic autoethnography. In P. Atkinson & S. Delamont. *SAGE Qualitative Research Methods*. Los Angeles, CA: Sage.

Anderson-Berry, L., Achilles, T., Panchuk, S., Mackie, B., Canterford, S., Leck, A., & Bird, D. (2018). Sending a message: How significant events have influenced the warnings landscape in Australia. *International Journal of Disaster Risk Reduction, 30*: 5-17. https://doi.org/10.1016/j.ijdrr.2018.03.005

Anonymous (1290). The story of burnt Njal. In G. da Sent (Trans.), S. Thordarson (Ed.), *Icelandic saga database*. Retrieved from http://www.sagadb.org/brennu-njals_saga.en

Arnalds, Þ., Jónasson, K., & Sigurðsson, S. (2004). Avalanche hazard zoning in Iceland based on individual risk. *Annals of Glaciology, 38*(1): 285-290. https://doi.org/10.3189/172756404781814816

Asian Development Bank (2016). *Reducing disaster risk by managing urban land use: Guidance notes for planners*. Philippines: Asian Development Bank.

Atkinson, P. (1997). *Clinical experience: The construction and reconstruction of medical reality*. Aldershot, UK: Ashgate.

Aðalgeirsdóttir, G., Jóhannesson, T., Björnsson, H., Pálsson, F., & Sigurðsson, O. (2006). Response of Hofsjökull and southern Vatnajökull, Iceland, to climate change. *Journal of Geophysical Research-Earth Surface, 111*(3). https://doi.org/10.1029/2005JF000388

Aðalgeirsdóttir, G., Magnússon, E., Pálsson, F., Thorsteinsson, T., Belart, J., Jóhannesson, T., Hannesdóttir, H., Sigurðsson, O., Gunnarsson, A., Einarsson, B., Berthier, E., Schmidt, L., Haraldsson, H., & Björnsson, H. (2020). Glacier changes in Iceland from ~1890 to 2019. *Frontiers of Earth Science, 8*(574754). https://doi.org/10.3389/feart.2020.523646

Baer, H., & Reuter, T. (2015). Anthropological perspectives on climate change and sustainability: Implications for policy and action. *Brief for Global Sustainable Development Report 2015.* Retrieved from https://sustainabledevelopment.un.org/content/documents/5834GSDR_brief_anthropology_SD_baer_reuter_rev.pdf

Baert, M., Kervyn, M., Kagou, A., Guedjeo, C., Vranken, L., & Mertens, K. (2020). Resettlement preferences from landslide prone areas in Cameroon: Willingness to move, reasons to stay. *Land Use Policy, 95*. https://doi.org/10.1016/j.landusepol.2019.04.036

Baldursson, S., Guðnason, J., Hannesdóttir, H., & Thórðarson, T. (2018). *Nomination of Vatnajökull National Park for inclusion in the World Heritage List*. Iceland: Vatnajökull National Park. Retrieved from https://whc.unesco.org/en/list/1604/documents/

Ballantyne, C. (2002). Paraglacial geomorphology. *Quaternary Science Reviews*, *21*: 1935–2017. https://doi.org/10.1016/S0277-3791(02)00005-7G

Barberi, F., Davis, M., Isaia, R., Navec, T., & Riccia, T. (2008). Volcanic risk perception in the Vesuvius population. *Journal of Volcanology and Geothermal Research, 172*(3): 244–258. https://doi.org/10.1016/j.jvolgeores.2007.12.011

Barnes, J., Dove, M., Lahsen, M., Mathews, A., McElwee, P., McIntosh, R., Moore, F., O'Reilly, J., Orlove, B., Puri, R., Weiss, H., & Yager, K. (2013). Contribution of anthropology to the study of climate change. *Perspectives, 3*. https://doi.org/10.1038/NCLIMATE1775

Becken, S., & Hughey, K. (2013). Linking tourism into emergency management structures to enhance disaster risk reduction. *Tourism Management, 36:* 77-85. https://doi.org/10.1016/j.tourman.2012.11.006

Bentley, T., & Page, S. (2008). A decade of injury monitoring in the New Zealand adventure tourism sector: A summary risk analysis. *Tourism Management, 29*(5): 857-869. https://doi.org/10.1016/j.tourman.2007.10.003

Berkes, F. (2017). *Sacred Ecology*. New York, NY: Routledge. https://doi.org/10.4324/9780203123843

Bernard, R., Wutich, A., & Ryan, G. (2016). *Analyzing qualitative data: Systematic approaches* (2nd Ed.). Los Angeles, CA: Sage.

Bird, D., & Gísladóttir, G. (2012). Residents' attitudes and behaviour before and after the 2010 Eyjafjallajökull eruptions—a case study from southern Iceland. *Bulletin of Volcanology, 74:* 1263–1279. https://doi.org/10.1007/s00445-012-0595-z

Bird, D., & Gísladóttir, G. (2014). Southern Iceland: Volcanoes, tourism and volcanic risk reduction. In P. Erfurt-Cooper (Ed.), *Volcanic tourist destinations, geoheritage, geoparks and geotourism*. Berlin, Germany: Springer-Verlag.

Bird, D., & Gísladóttir, G., (2020). Enhancing tourists' safety in volcanic areas: An investigation of risk communication initiatives in Iceland. *International Journal of Disaster Risk Reduction,* 50(101896). https://doi.org/10.1016/j.ijdrr.2020.101896

Bird, D., Gísladóttir, G., & Dominey-Howes, D. (2009). Resident perception of volcanic hazards and evacuation procedures. *Natural Hazards and Earth System Sciences, 9:* 251-266. https://doi.org/10.5194/nhess-9-251-2009

Bird, D., Gísladóttir, G., & Dominey-Howes, D. (2010). Volcanic risk and tourism in southern Iceland: Implications for hazard, risk and emergency response education and training. *Journal of Volcanology and Geothermal Research, 189*(1-2): 33-48. https://doi.org/10.1016/j.jvolgeores.2009.09.020

Bird, D., Gísladóttir, G., & Dominey-Howes, D. (2011). Different communities, different perspectives: Issues affecting residents' response to a volcanic eruption in southern Iceland. *Bulletin of Volcanology, 73*(9): 1209–1227. https://doi.org/10.1007/s00445-011-0464-1

Bird, D., Jóhannesdóttir, G., Reynisson, V., Karlsdóttir, S., Guðmundsson, M., & Gísladóttir, G. (2017). Crisis coordination and communication during the 2010 Eyjafjallajökull eruption. In C. Fearnley , D. Bird, K. Haynes, W. McGuire, & G. Jolly (Eds.), *Observing the volcano world. Advances in volcanology.* Barcelona, Spain: Springer.

Birgisson, J. (2019). Psychological aid following natural disasters in Iceland and Greenland. *NSSA Workshop Coping with Disasters*. Retrieved from https://nordress.hi.is/nssa-worskhop-coping-with-disasters-presentations-online/

Bjarnason, T., Stockdale, A., Shuttleworth, I., Eimermann, M., & Shucksmith, M. (2021). At the intersection of urbanisation and counterurbanisation in rural space: Microurbanisation in Northern Iceland. *Journal of Rural Studies, 87*. https://doi.org/10.1016/j.jrurstud.2021.09.009

Björnsson, D., & Zoega, G. (2017). Seasonality of birth rates in agricultural Iceland. *Scandinavian Economic History Review, 65*(3): 294-306. https://doi.org/10.1080/03585522.2017.1340333

Björnsson, H., & Pálsson, F. (2008). Icelandic glaciers. *Jökull, 58*: 365–386.

Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (1994). *At risk: Natural hazards, people's vulnerability and disasters*. New York, NY: Routledge.

Bonnard, C., Forlati, F., & Scavia, C. (2004). *Identification and mitigation of large landslide risks in Europe.* Singapore: CRC Press.

Bordner, A., Ferguson, C., & Ortolano, L. (2020). Colonial dynamics limit climate adaptation in Oceania: Perspectives from the Marshall Islands. *Global Environmental Change, 61*. https://doi.org/10.1016/j.gloenvcha.2020.102054

Botterill, D., & Platenkamp, V. (2012). *Key concepts in tourism research*. London, UK: Sage.

Bower, E. & Weerasinghe, S. (2021). *Leaving place, restoring home: Enhancing the evidence base on planned relocation cases in the context of hazards, disasters, and climate change.* Platform on Disaster Displacement (PDD) and Andrew & Renata Kaldor Centre for International Refugee Law. Retrieved from https://disasterdisplacement.org/leaving-place-restoring-home-enhancing-the-evidence-base-on-planned-relocation-cases-in-the-context-of-hazards-disasters-and-climate-change-2

Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper (Ed.), *APA handbook of research methods in psychology*. Washington, DC: American Psychological Association.

Brázdil, R., Demarée, G., Deutsch, M., Garnier, E., Kiss, A., Luterbacher, J., Macdonald, N., Rohr, C., Dobrovolný, P., Kolář, P., & Chromá, K. (2010). European floods during the winter 1783/1784: scenarios of an extreme event during the 'Little Ice Age'. *Theoretical and Applied Climatology, 100*: 163–189. https://doi.org/10.1007/s00704-009-0170-5

Brinkmann, S. (2013). *Qualitative interviewing: Understanding qualitative research.* Oxford: Oxford University Press.

Brinkmann, S., & Kvale, S. (2015). *Interviews: Learning the craft of qualitative research interviewing* (3rd ed.). Los Angeles, CA: Sage.

Bronen, R. (2011). Climate-induced community relocations: Creating an adaptive governance framework based in human rights doctrine. *N.Y.U Review of Law and Social Change 35(*2): 101-148.

Bronen, R. (2015). Climate-induced community relocations: Using integrated social-ecological assessments to foster adaptation and resilience. *Ecology and Society, 20*(3). http://dx.doi.org/10.5751/ES-07801-200336

Bronen, R. (2021). Rights, resilience and community-led relocation: Creating a national governance framework. *N.Y.U. Review of Law & Social Change, 45*.

Buchwał, A., Szczuciński, W., Strzelecki, M. C., Long, A. J. (2015). New insights into the 21 November 2000 tsunami in West Greenland from analyses of the tree–ring structure of Salix glauca. Polish Polar Research 36, pp. 51-65.

Burby, R. (1998). *Cooperating with nature: Confronting natural hazards with land-use planning for sustainable communities.* Washington DC: Joseph Henry Press/National Academy of Sciences.

Burby, R., Deyle, R., Godschalk, D., & Olshansky, R. (2000). Creating hazard resilient communities through land-use planning. *Natural Hazards Review, 1*(2): 99-106. https://doi.org/10.1061/(ASCE)1527-6988(2000)1:2(99)

Cadag, J., Driedger, C., Garcia C., Duncan, M., Gaillard, J., Lindsay, J., & Haynes, K. (2017). Fostering participation of local actors in volcanic disaster risk reduction. In C. Fearnley, D. Bird, K. Haynes, W. McGuire & G. Jolly (Eds.), *Observing the volcano world: Advances in volcanology*. Barcelona, Spain: Springer. https://doi.org/10.1007/11157_2016_39

Cadag, J., & Gaillard, J. (2012). Integrating knowledge and actions in disaster risk reduction: The contribution of participatory mapping. *Area, 44*(1): 100–109. https://doi.org/10.1111/j.1475-4762.2011.01065.x

Callison, C. (2014). *How climate change comes to matter: The communal life of facts*. Durham, UK: Duke University Press.

Carey, M. (2010). *In the shadow of melting glaciers: Climate change and Andean society*. New York, NY: Oxford University Press.

Carey, M., Huggel, C., Bury, J., Portocarrero, C., & Haeberli, W. (2012). An integrated socio-environmental framework for climate change adaptation and glacier hazard management: Lessons from Lake 513, Cordillera Blanca, Peru. *Climatic Change, 112:* 733–767. https://doi.org/10.1007/s10584-011-0249-8

Carter, C. (2006). Playing with risk? Participant perceptions of risk management implications in adventure tourism. *Tourism Management, 27*: 317–325. https://doi.org/10.1016/j.tourman.2004.10.005

Cascini, L., Bonnard, C., Corominas, J., Jibson, R., & Montero-Olarte, J. (2005). Landslide hazard and risk zoning for urban planning and development. In O. Hungr, R. Fell, R. Couture, & E. Eberhardt (Eds.), *Landslide Risk Management*. Florida, FL: CRC Press.

Charmaz, K. (2006). *Constructing grounded theory*. London, UK: Sage.

Charmaz, K., & Mitchell, R. (2001). Grounded theory in ethnography. In P. Atkinson, A. Coffey, S. Delamont, J. Lofland, and L. Lofland (Eds.), *Handbook of ethnography,* London: Sage.

Chen, R., & Cheng, H. (2020). Applying traditional knowledge to resilience in coastal rural villages. *International Journal of Disaster Risk Reduction, 47:* 1-7. https://doi.org/10.1016/j.ijdrr.2020.101564

Choy, T., & Zee, J. (2015). Condition—suspension. *Cultural Anthropology*, *30*(2): 210–223. https://doi.org/10.14506/ca30.2.04

Christensen, J., Arnfjord, S., Carraher, S., & Hedwig, T. (2017). Homelessness across Alaska, the Canadian north and Greenland: A review of the literature on a developing social phenomenon in the circumpolar north. *Arctic*, *70*(4): 349-358. https://doi.org/10.14430/arctic4680

Cioccio, L., & Michael, E. (2007). Hazard or disaster: Tourism management for the inevitable in Northeast Victoria. *Tourism Management*, *28*(1): 1-11. https://doi.org/10.1016/j.tourman.2005.07.015

Ćirić, J. (2020). *Mountaineers of Iceland admits mistakes.* Retrieved from https://www.icelandreview.com/travel/mountaineers-of-iceland-admits-mistake/

Cohen, E. (2009). Death in paradise: Tourist fatalities in the tsunami disaster in Thailand. *Current Issues in Tourism*, *12*(2): 183-199. https://doi.org/10.1080/13683500802531141

Crate, S. (2008). Gone the bull of winter? Grappling with the cultural implications of and anthropology's role(s) in global climate change. *Current Anthropology*, 49(4): 569–595. https://doi.org/10.1086/529543

Crate, S., & Nuttall, M. (2009). *Anthropology and climate change.* Walnut creek, CA: Left Coast Press.

Creswell, J. (2007). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand Oaks, CA: Sage.

Cruikshank, J. (2005). *Do glaciers listen? Local knowledge, colonial encounters, and social imagination.* Vancouver, Canada: UBC Press.

Cullen, M. (2022 forthcoming). Climate change in Greenland and the complexity of human rights protection in practice. In P. Butler & J. Gauci (Eds.), *Small states and international law.* Leiden, Netherlands: Brill.

Cutter, S., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, *18*(4): 598-606. https://doi.org/10.1016/j.gloenvcha.2008.07.013

Cutter, S., Ismail-Zadeh, A., Alcántara-Ayala, I., Altan, O., Baker, D., Briceño, S., Gupta, H., Holloway, A., Johnston, D., McBean, G., Ogawa, Y., Paton, D., Porio, E., Silbereisen, R., Takeuchi, K., Valsecchi, G., Vogel, C., & Wu, G. (2015). Global risks: Pool knowledge to stem losses from disasters. *Nature*, *522*(7556): 27. https://doi.org/10.1038/522277a

Dahl-Jensen, T., Larsen, L. M., Pedersen, S. A. S., Pedersen, J., Jepsen, H. F., Pedersen, G., Nielsen, T., Pedersen, A. G., Von Platen-Hallermund, F., Weng, W. (2004). Landslide and tsunami 21 November 2000 in Paatuut, West Greenland. Natural Hazards, 31, pp. 277-287.

DCPEM [Icelandic Department of Civil Protection and Emergency Management] (2017). *Emergency evacuation plan – Öræfajökull version 1.0.* Retrieved from https://www.almannavarnir.is/utgefid-efni/

DCPEM [Icelandic Department of Civil Protection and Emergency Management] (2018a). *Fræðslu- og starfsdagur samráðshópa um áfallahjálp [Training and working for trauma care providers]*. Retrieved from https://www.almannavarnir.is/frettir/fraedslu-og-starfsdagur-samradshopa-um-afallahjalp/

DCPEM [Icelandic Department of Civil Protection and Emergency Management] (2018b). *Viðvörun vegna ferða á Svínafellsjökul*. Retrieved from https://www.almannavarnir.is/frettir/vidvorun-vegna-ferda-a-svinafellsjokul/

DeLyser, D. (2001). "Do you really live here?" Thoughts on insider research. *Geographical Review, 91*(1-2): 441–453. https://doi.org/10.1111/j.1931 -0846.2001.tb00500.x

Demeritt, D., & Nobert, S. (2014). Models of best practice in flood risk communication and management. *Environmental Hazards, 13*(4): 313-328. https://doi.org/10.1080/17477891.2014.924897

DeWalt, K., & DeWalt, B. (2002). *Participant observation: A guide for fieldworkers.* New York, NY: Altamira.

Dilley, M., Chen, U., Deichmann, U., Lerner-Lam, A., Arnold, M., Agwe, J., Buys, P., Kjekstad, O., Lyon, B., & Yetman, G. (2005). Natural disaster hotspots: A global risk analysis. *Disaster Risk Management Series, 5*: 34423. Washington, DC: International Bank for Reconstruction and Development/The World Bank and Columbia University.

Diolaiuti, G., & Smiraglia, C. (2010). Changing glaciers in a changing climate: How vanishing geomorphosites have been driving deep changes in mountain landscapes and environments. *Geomorphology Relief Process Environment, 16*(2): 131–152. https://doi.org/10.4000/geomorphologie.7882

Dominey-Howes, D., & Minos-Minopoulos, D. (2004). Perceptions of hazard and risk on Santorini. *Journal of Volcanology and Geothermal Research, 137*: 285–310.

Dujardin, S., Hermesse, J., & Dendoncker, N. (2018). Making space for experiential knowledge in climate change adaptation? Insights from planning officers in Bohol, Philippines. *Jàmbá: Journal of Disaster Risk Studies, 10*(1): 1–10. https://doi.org/10.4102/jamba.v10i1.433

Dybbroe, S., Dahl, J., & Müller-Wille, L. (2010). Dynamics of Arctic urbanization. *Acta Borealia*, *27*(2): 120-124, 10.1080/08003831.2010.527526

Dzik, A. (2016). Settlement closure or persistence: A comparison of Kangeq and Kapisillit, Greenland. *Journal of Settlements and Spatial Planning, 7*(2): 99–112. https://doi.org/10.19188/01JSSP022016

Eiser, R., Bostrom, A., Burton, I., Johnston, D., McClure, J., Paton, D., van der Pligt, J., & White, M. (2012). Risk interpretation and action: A conceptual framework for responses to natural hazards. *International Journal of Disaster Risk Reduction, 1:* 5-16. https://doi.org/10.1016/j.ijdrr.2012.05.002

Erfurt-Cooper, P. (2010). Introduction. In P. Erfurt-Cooper, & M. Cooper (Eds.), *Volcano and geothermal tourism*. UK: Earthscan.

Eriksen, S., Nightingale, A., & Eakin, H. (2015). Reframing adaptation: The political nature of climate change adaptation. *Global Environmental Change, 35*: 523–533. https://doi.org/10.1016/j.gloenvcha.2015.09.014

Eriksen, T. (2020). A better impact factor: Anthropology and climate change. *Anthropology Today,* 36(1).

Espiner, S. (2001). The phenomenon of risk and its management in natural resource recreation and tourism settings: A case study of Fox and Franz Josef Glacier, Westland National Park, New Zealand. *PhD thesis,* Lincoln, New Zealand: Lincoln University. Retrieved from https://researcharchive.lincoln.ac.nz/bitstream/handle/10182/638/Espiner_PhD.pdf?sequence=6

Esterberg, K. (2002). *Qualitative methods in social research.* Boston, MA: McGraw-Hill.

Evans, D. (2016). *Vatnajökull National Park (South Region): Guide to a glacial landscape legacy*. Reykjavik, Iceland: Prentsmidjan.

Everest, J., Bradwell, T., Jones, L., & Hughes, L. (2017). The geomorphology of Svínafellsjökull and Virkisjökull-Falljökull glacier forelands, southeast Iceland. *Journal of Maps, 13*(2). https://doi.org/10.1080/17445647.2017.1407272

Fiske, S. (2012). Global climate change from the bottom up. In C. Wasson, M. Butler, & J. Copeland-Carlston (Eds.), *Applying anthropology in the global village*. Walnut Creek, CA: Left Coast Press.

Furunes, T., & Mykletun, R. (2012). Frozen adventure at risk? A 7-year follow-up study of Norwegian glacier tourism. *Scandinavian Journal of Hospitality and Tourism, 12*(4): 324-348. https://doi.org/10.1080/15022250.2012.748507

Gaillard, J., Glantz, M., Kelman, I., Wisner, B., Delica-Willison, Z., & Keim, M. (2014). Taking the ‘naturalness’ out of natural disaster (again). *Natural Hazards Observer, 38*(3).

Gaillard, J., Liamzon, C., & Villanueva, J. (2007). ‘Natural’ disaster? A retrospect into the causes of the late-2004 typhoon disaster in Eastern Luzon. *Philippines Environmental Hazards, 7:* 257–70. https://doi.org/10.1016/j.envhaz.2006.11.002

Gaillard, J., & Mercer, J. (2012). From knowledge to action: bridging gaps in disaster risk reduction. *Progress in Human Geography, 37*(1): 93-114. https://doi.org/10.1177/0309132512446717

Gallagher, C. (2000). White like me? Methods, meaning and manipulation in the field of white studies. In F. Twine & J. Warren (Eds.), *Racing research, researching race: Methodological dilemmas in critical race studies*. New York, NY: New York University Press.

Garrido, J., & Saunders, W. (2018). Disaster risk reduction and land use planning: Opportunities to improve practice. In A. Shakoor, & K. Cato (Eds.), *IAEG/AEG Annual Meeting Proceedings, San Francisco, California, 2018*. Switzerland: Springer. https://doi.org/10.1007/978-3-319-93136-4.

Gibson, A., Culshaw, M., Dashwood, C., & Pennington, C. (2013). Landslide management in the UK—the problem of managing hazards in a ‘low-risk’ environment. *Landslides, 10*(5): 599–610. https://doi.org/10.1007/s10346-012-0346-4

Given, L. (2008). *The SAGE encyclopedia of qualitative research methods*. Thousand Oaks, CA: SAGE Publications.

Glaesser, D. (2003). *Crisis management in the tourism industry*. Amsterdam, Netherlands: Butterworth Heinemann.

Glaser, B. (1978). *Theoretical Sensitivity*. Mill Valley, CA: The Sociology Press.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Chicago, IL: Aldine.

GLIMS [Global Land Ice Measurements from Space] (2022). *GLIMS glacier database*. Retrieved from https://www.glims.org/maps/glims

Gould, D. (2011). *Climate change adaptation and local knowledge: A case study from the developed world*. London, UK: University of London. Retrieved from http://www.islandvulnerability.org/m/gouldmforweb.pdf

Gray, B., Eaton, J., Christy, J., Duncan, J., Hanna, F., & Kasi, S. (2021). A proactive approach: Examples for integrating disaster risk reduction and mental health and psychosocial support programming. *International Journal of Disaster Risk Reduction, 54*(2). https://doi.org/10.1016/j.ijdrr.2021.102051

Grímsdóttir, H. (2004). Avalanche risk management in back country skiing operations. *Masters thesis, University of British Columbia*. British Columbia, Canada; University of British Columbia Retrieved from https://open.library.ubc.ca/soa/cIRcle/collections/ubctheses/831/items/1.0099777

Grímsdóttir, H. (2008). Avalanche hazard mapping and risk assessment in Iceland. *International Snow Science Workshop*. Retrieved from https://arc.lib.montana.edu/snow-science/objects/P__8224.pdf

Gstaettner, A., Kobryn, H., Rodger, K., Phillips, M., & Lee, D. (2019). Monitoring visitor injury in protected areas: Analysis of incident reporting in two Western Australian parks. *Journal of Outdoor Recreation Tourism*, *25*: 143-157. https://doi.org/10.1016/j.jort.2018.04.002

Guðmundsdóttir B. (2016). Best practices in Icelandic crisis communication during volcanic eruptions: Development of a tentative framework. *Masters thesis, University of Iceland*. Reykjavik, Iceland: University of Iceland. Retrieved from https://skemman.is/bitstream/1946/24944/1/160604%20ENR%20thesis%20BNG%20FINAL.pdf

Guðmundsson, M., Pagneux, E., Roberts, M., Helgadóttir, Á., Karlsdóttir, S., Magnússon, E., Högnadóttir, Þ., & Gylfason, Á. (2016). *Jökulhlaup í Öræfum og Markarfljóti vegna eldgosa undir jökli*. Reykjavik, Iceland: Almannavarnir. Retrieved from https://www.almannavarnir.is/utgefid-efni/jokulhlaup-i-oraefum-og-markarfljoti-vegna-eldgosa-undir-jokli-forgreining-ahaettumats/

Gylfason, Á. (2018). Civil Protection and Emergency Management Agency. Presented at: *Landslides onto Glaciers: Research, Monitoring and Hazard Assessment*. Reykjavik, Iceland: University of Iceland.

Hall, A., Jónsson, Á., & Agnarsson, S. (2002). *Byggðir og búseta: Þéttbýlismyndun á Íslandi [Settlement and residence: Urbanization in Iceland]*. Masters thesis. Reykjavík: Hagfræðistofnun Háskóla Íslands. Retrieved from https://link.springer.com/chapter/10.1007/978-3-030-51552-2_5

Halldórsdóttir, Í., & Júlíusdóttir, M. (2020). *Aðstæður erlends starfsfólks í ferðaþjónustu Sjónarhorn stéttarfélaga og starfsfólks*. Retrieved from https://www.rmf.is/static/research/files/rmf_adstaedurerlendsstarfsfolks_2020_lokapdf

Hammersley, M., & Atkinson, P. (2007). *Ethnography: Principles in practice.* London, UK: Routledge.

Hanna, C., White, I., & Glavovic, B. (2018). Managed retreat governance: Insights from Matatā, New Zealand. *Report for the national science challenge: Resilience to nature's challenges*. Waikato, New Zealand:

University of Waikato. Retrieved from https://resiliencechallenge.nz/wp-content/uploads/2018/08/Hanna-White-Glavovic.-2018.-Managed-retreat-governance.pdf

Hannesdóttir, H., Aðalgeirsdóttir, G., Guðmundsson, S., Jóhannesson, T., Björnsson, H., Pálsson, S., Crochet, P., Ágústsson, H. & Sigurðsson, S. (2015). Downscaled precipitation applied in modelling of mass balance and the evolution of southeast Vatnajökull, Iceland. *Journal of Glaciology, 61*: 799–813. https://doi.org/10.3189/2015JoG15J024

Hannesdóttir, H., & Baldursson, S. (2017). *Melting glaciers: A natural laboratory to study climate change*. Reykjavik, Iceland: Vatnajökulsþjóðgarður.

Hannesdóttir, H., Björnsson, H., Pálsson, F., Aðalgeirsdóttir, G., & Guðmundsson, S. (2015). Changes in the southeast Vatnajökull ice cap, Iceland, between ∼1890 and 2010. *Cryosphere, 9*: 565–585. https://doi.org/10.5194/tc-9-565-2015.

Hannesdóttir, H., Björnsson, H., Pálsson, F., Aðalgeirsdóttir, G., & Guðmundsson, S. (2015). Variations of southeast Vatnajökull ice cap (Iceland) 1650-1900 and reconstruction of the glacier surface geometry at the Little Ice Age maximum. *Geografiska Annaler, 97*: 237–264. https://doi.org/10.1111/geoa.12064

Hannesdóttir, H., Sigurðsson, O., Þrastarson, R., Guðmundsson, S., Belart, J., Pálsson, F., Magnússon, E., Víkingsson, S., & Jóhannesson, T. (2020). Variations in glacier extent in Iceland since the end of the Little Ice Age. *Jökull, 639*. https://doi.org/10.33799/jokull2020.70.001

Hansen, K. (2016). *Why are there 72 inhabited places in Greenland? A Greenlandic perspective on vulnerability in Norden*. Retrieved from: https://archive.nordregio.se/

Harris, C. (2016). Acquisition of land during the Canterbury earthquake recovery. *FIG Working Week 2016 Recovery from Disaster Christchurch.* Retrieved from https://www.fig.net/resources/proceedings/fig_proceedings/fig2016/papers/ts04h/TS04H_harris_8093.pdf

Hastrup, K. (2012). The icy breath: Modalities of climate knowledge in the Arctic. *Current Anthropology, 53*(2): 226–244. https://doi.org/10.1086/665033

Hauksson A. (2019). *Íslenskukennslan fær falleinkunn.* Retrieved from https://www.ruv.is/frett/islenskukennslan-faer-falleinkunn

Haynes, K., Barclay, J., & Pidgeon, N. (2008). The issue of trust and its influence on risk communication during a volcanic crisis. *Bulletin of Volcanology, 70*(5):605–621. http://dx.doi.org/10.1007/s00445-007-0156-z

Head, L., & Gibson, C. (2012). Becoming differently modern: Geographic contributions to a generative climate politics. *Progress in Human Geography, 36*(6): 699–714. https://doi.org/10.1177/0309132512438162

Heath, S., Kass, P., Beck, A., & Glickman, L. (2001). Human and pet-related risk factors for household evacuation failure during a natural disaster. *American Journal of Epidemiology, 153*(7): 659-665. https://doi.org/10.1093/aje/153.7.659

Heleniak , T., Turunen, E., & Wang, S. (2020). Demographic changes in the Arctic. In Coates, K., & Holroyd, C. (Eds.), *The Palgrave handbook of Arctic policy and politics.* Online: Palgrave. https://doi.org/10.1007/978-3-030-20557-7

Helgadottir, A., Pagneux, E., James Roberts, M., Jensen, E., & Gislason, E. (2015). Öræfajökull volcano: Numerical simulations of eruption-induced jökulhlaups using the SAMOS flow model. In E. Pagneux, M. Gudmundsson, S. Karlsdóttir & M. Roberts. (Eds.), *Volcanogenic floods in Iceland: An assessment of hazards and risks at Öræfajökull and on the Markarfljót outwash plain*. Reykjavik, Iceland: IMO, IES-UI, NCIP-DCPEM.

Helgason, J., Morino, C., Conway, S., Sæmundsson, Þ., & Balme, M. (2018). *On the dynamics of permafrost-induced landslides in Iceland.* Paper presented at EUCOP5, Chamonix France. 23 June – 1 July 2018. Retrieved from https://www.researchgate.net/publication/327844370_On_the_dynamics_of_permafrost-induced_landslides_in_Iceland

Hendriksen, K. (2013). Grønlands bygder økonomi og udviklingsdynamik [Greenland's settlements economics and development dynamics]. *INUSSUK Arctic Research Journal, 3.* Retrieved from https://backend.orbit.dtu.dk/ws/portalfiles/portal/102349627/131206_groenlands_bygder_Endelig_Master_1.pdf 3

Hennink, M., Hutter, I., & Bailey, A. (2011). *Qualitative research methods.* Los Angeles: Sage.

Henriksen, H., Roberts, M., Keur, P., Harjanne, A., Egilson D., & Alfonso, L. (2018). Participatory early warning and monitoring systems: A Nordic framework for web-based flood risk management. *International Journal of Disaster Risk Reduction, 31*: 1295-1306. https://doi.org/10.1016/j.ijdrr.2018.01.038

Henstra, D., & McBean, G. (2005). Canadian disaster management policy: Moving toward a paradigm shift?' *Canadian Public Policy, 31*(3): 303-318. https://doi.org/10.2307/3552443

Hermanns, R., Blikra, L., Naumann, M., Nilsen, B., Panthi, K., Stromeyer, D., & Longva, O. (2006). Examples of multiple rock-slope collapses from Köfels (Ötz valley, Austria) and western Norway. *Engineering Geology, 83*(1–3): https://doi.org/94–108. 10.1016/j.enggeo.2005.06.026

Hewitt, K. (1983). *Interpretations of calamity from the viewpoint of human ecology*. Boston, MA: Allen and Unwin.

Hiwasaki, L., Luna, E., Syamsidik, & Marçal, J. (2015). Local and indigenous knowledge on climate-related hazards of coastal and small island communities in Southeast Asia. *Climatic Change, 128*: 35-56. https://doi.org/10.1007/s10584-014-1288-8

Hiwasaki, L., Luna, E., Syamsidik, & Shaw, R. (2014). *Local and indigenous knowledge for community resilience*. Jakarta, Indonesia: UNESCO. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000228711

Ho, Y., & Chang, D. (2021). To whom does this place belong? Whiteness and diversity in outdoor recreation and education. *Annals of Leisure Research*. https://doi.org/10.1080/11745398.2020.1859389

Hock, R., Rasul, G., Adler, C., Cáceres, B., Gruber, S., Hirabayashi, Y., Jackson, M., Kääb, A., Kang, S., Kutuzov, S., Milner, A., Molau, U., Morin, S., Orlove, B., & Steltzer, H. (2019). High mountain areas. In H. Pörtner, D. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (Eds.). *IPCC special report on the ocean and cryosphere in a changing climate.* Cambridge UK: Cambridge University Press, pp. 131–202. https://doi.org/10.1017/9781009157964.004.

Holle, M. (2019). The forced relocation of indigenous peoples in Greenland: Repercussions in tort law and beyond. *Copenhagen Business School Law Research Paper, 1940.* Retrieved from https://ssrn.com/abstract=3492655

Horrebow, N. (1758). *The natural history of Iceland*. J. Anderson (Trans.). London, UK: A. Lind.

Howe, C. (2015). Life above earth: An introduction. *Cultural Anthropology, 30*(2): 203–209. https://doi.org/10.14506/ca30.2.03

Höskuldsson, Á., & Thórðarson, T. (2007). The eruption of Öræfajökull 1362 and destruction of the district of Hérað, SE-Iceland. Presented *at Cities on Volcanoes*, 19–23 November 2007. Shimabara, Japan: Volcanological Society of Japan.

Hu, Z., Sheu, J., Yin, Y., & Wei, C. (2017). Post-disaster relief operations considering psychological costs of waiting for evacuation and relief resources. *Transportmetrica A: Transport Science, 13*(2): 108-138. https://doi.org/10.1080/23249935.2016.1222559

Huggel, C. (2009). Recent extreme slope failures in glacial environments: Effects of thermal perturbation. *Quaternary Science Reviews*, *28*: 1119–1130. https://doi.org/10.1016/j.quascirev.2008.06.007

Hugonnet, R., McNabb, R., Berthier, E., Menounos, B., Nuth, C., Girod, L., Farinotti, D., Huss, M., Dussaillant, I., Brun, F., & Kääb, A. (2021). Accelerated global glacier mass loss in the early twenty-first century. *Nature*, *592*: 726–731. https://doi.org/10.1038/s41586-021-03436-z

Hulme, M. (2011). Meet the humanities. *Nature Climate Change, 1*(4): 177–179. https://doi.org/10.1038/nclimate1150

Huntington, H., Loring, P., Gannon, G., Gearheard, S., Gerlach, C., & Hamilton, L. (2018). Staying in place during times of change in Arctic Alaska: The implications of attachment, alternatives, and buffering. *Regional Environmental Change*, *18* (2): 489–499, https://doi.org/10.1007/s10113-017-1221-6

Hyndman, J. (2008). The securitization of fear in post-tsunami Sri Lanka. *Annals of the Association of American Geographers, 97*(2): 361-372. https://doi.org/10.1111/j.1467-8306.2007.00542.x

Hystad, P., & Keller, P. (2008). Towards a destination tourism disaster management framework: Long-term lessons from a forest fire disaster. *Tourism Management, 29*(1): 151-162. https://doi.org/10.1016/j.tourman.2007.02.017

IASC [Inter-Agency Standing Committee] (2007). *IASC guidelines on mental health and psychosocial support in emergency settings, 2007.* Retrieved from https://interagencystandingcommittee.org/iasc-task-force-mental-health-and-psychosocial-support-emergency-settings/iasc-guidelines-mental

Icelandic Ministry of Foreign Affairs (2020). *Greenland and Iceland in the new Arctic.* Reykjavik, Iceland: Ministry of Foreign Affairs. Retrieved from https://www.government.is/library/01-Ministries/Ministry-for-Foreign-Affairs/PDF-skjol/Greenland-Iceland-rafraen20-01-21.pdf

Iceland Monitor (2016). *Iceland beach danger signs often ignored.* Retrieved from https://icelandmonitor.mbl.is/news/nature_and_travel/2016/04/26/iceland_beach_danger_signs_often_ignored/

Icelandic Planning Agency (2016). *National planning policy 2015–2026.* Retrieved from https://www.landsskipulag.is/media/pdf-skjol/Landsskipulagsstefna2015-2026_asamt_greinargerd.pdf (Accessed: 4 March 2021).

Icelandic Road Authority (2019). *Traffic and accident rates.* Retrieved from https://umferd.vegagerdin.is/ on 16 July 2019

Icelandic Tourist Board (2018). *Foreign visitor arrivals by air and sea to Iceland 1949-2017*. Retrieved from https://www.ferdamalastofa.is/static/files/ferdamalastofa/Frettamyndir/2018/mai/foreign-visitors-to-iceland-1949-2017.xls

Icelandic Tourist Board (2020). *Ten thousand departures of foreign passengers in September*. Retrieved from https://www.ferdamalastofa.is/en/moya/news/10-thousand-departures-of-foreign-passengers-in-august

Icelandic Tourist Board (2021). *108 thousand departures of foreign passengers in September*. Retrieved from https://www.ferdamalastofa.is/en/moya/news/108-thousand-departures-of-foreign-passengers-in-september

Illmer, D., Helgason, J., Jóhannesson, T., Gíslason, E., & Hauksson, S. (2016). *Overview of landslide hazard and possible mitigation measures in the settlement southeast of Fjarðará River in Seyðisfjörður*. Reykjavik, Iceland: Icelandic Meteorological Office Report. Retrieved from https://www.vedur.is/media/vedurstofan-utgafa-2016/VI_2016_006_rs.pdf

Iloka, N. (2017). Perceptions of ethnicity, local knowledge and sustainable livelihoods in relation to DRR: The case of Nsukka in South-East Nigeria. *Doctoral thesis*. Newcastle upon Tyne: Northumbria University. Retrieved from https://core.ac.uk/download/pdf/196577012.pdf

IMO [Icelandic Meteorological Office] (2018a). *Fractures in Svínafellsheiði and a potential rockslide on Svínafellsjökull.* Retrieved from https://en.vedur.is/about-imo/news/fractures-in-svinafellsheidi-and-a-potential-rockslide-on-svinafellsjokull

IMO [Icelandic Meteorological Office] (2018b). *Status of Öræfajökull volcano*. Retrieved from https://en.vedur.is/about-imo/news/status-of-oraefajokull-volcano.

IMO [Icelandic Meteorological Office] (2018c). *Large landslides since the middle of last century*. Retrieved from https://en.vedur.is/media/frettir-myndasafn-2018/Big_landslides_Table_ENG.pdf

IMO [Icelandic Meteorological Office] (2020a). *Hættumat neðan Svínafellsökuls: Fundur með íbúum [Risk assessment below Svinafellsjokull: Meeting with residents]*. Retrieved from https://www.youtube.com/watch?v=aqGAd9kuW6A

IMO [Icelandic Meteorological Office] (2020b). *Catalogue of Icelandic volcanoes*. Retrieved from http://icelandicvolcanos.is/#

IMO [Icelandic Meteorological Office] (2021). The landslide in Seyðisfjörður is the largest landslide to have damaged an urban area in Iceland. Retrieved from https://en.vedur.is/about-imo/news/the-landslide-in-seydisfjordur-is-the-largest-landslide-to-have-damaged-an-urban-area-in-iceland

IMO [Icelandic Meteorological Office] (2022). *News*. Retrieved from https://en.vedur.is/about-imo/news/

Ingram, J., Franco, G., Rio, C., & Khazai, B. (2006). Post-disaster recovery dilemmas: Challenges in balancing short-term and long-term needs for vulnerability reduction. *Environmental Science and Policy, 9*(7-8): 607-613 https://doi.org/10.1016/j.envsci.2006.07.006

International Working Group for Indigenous Affairs (n.d.). *Indigenous peoples in Greenland.* Retrieved from https://www.iwgia.org/en/greenland.html

Ioannides, D. (2019). Greenland's tourism policy making and the risk of overtourism. In C. Milano, J. Cheer, & M. Novelli (Eds.), *Overtourism: Excesses, discontents and measures in travel and tourism*. Boston, MA: Cabi. https://doi.org/10.1079/9781786399823.0209

IOC [Intergovernmental Oceanographic Commission] (2019). *Tsunami glossary 2019.* Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000188226

IPCC [Intergovernmental Panel on Climate Change] (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the IPCC*. [C. Field, V. Barros, T. Stocker, D. Qin, D. Dokken, K. Ebi, M. Mastrandrea, K. Mach, G. Plattner, S. Allen, M. Tignor, and P. Midgley (Eds.)]. Cambridge, UK: Cambridge University Press.

IPCC [Intergovernmental Panel on Climate Change] (2022). *Climate change 2022: Impacts, adaptation and vulnerability.* Retrieved from https://www.ipcc.ch/report/ar6/wg2/

Islandske Annaler (1888). In Storm, G. (ed.). *Islandske Annaler indtil 1578*. Christiania, Denmark: Grøndahl & søns bogtrykker.

Isle de Jean Charles (2021). *About the Isle de Jean Charles resettlement.* Retrieved from https://isledejeancharles.la.gov/about-isle-de-jean-charles-resettlement

Isle de Jean Charles Biloxi-Chitimacha-Choctaw Tribe (2019). *Preserving our place: A community field guide to engagement, resilience, and resettlement.* Retrieved from https://static1.squarespace.com/static/5672cfb1d82d5e366e753691/t/5dfc077ef8a68c27967cc40c/1576798088266/final+field+guide+reduced.pdf

Ives, J. (2007). *Skaftafell in Iceland: A thousand years of change*. Reykjavik, Iceland: Ormstunga.

Japan International Cooperation Agency (2017). *The urgent development study on the project on rehabilitation and recovery from Typhoon Yolanda in the Philippines.* Retrieved from https://openjicareport.jica.go.jp/pdf/12233979_03.pdf

Jasanoff, S. (2010). A new climate for society. *Theory, Culture and Society, 27*(2–3): 233–253. https://doi.org/10.1177/0263276409361497

Jóhannesdóttir, G., & Gísladóttir, G. (2010). People living under threat of volcanic hazard in southern Iceland: Vulnerability and risk perception. *Natural Hazards Earth and Systems Science, 10*: 407–420. https://doi.org/10.5194/nhess-10-407-2010

Jóhannesdóttir, G., & Gísladóttir, G. (2016). *Resident's risk perception of and response to SO_2 risk in east Iceland during the volcanic eruption in Bárðarbunga/Holuhraun 2014-2015*. Paper presented at EGU General Assembly 2016, held 17-22 April, 2016 in Vienna Austria. Retrieved from https://ui.adsabs.harvard.edu/abs/2016EGUGA..18.8137G/abstract

Jóhannesson, T., & Arnalds, Þ. (2001). Accidents and economic damage due to snow avalanches and landslides in Iceland. *Jökull, 50*: 81–94.

Jóhannsdóttir, G. (2019). Methods for coastal flooding risk assessments: An application in Iceland. Degree Project at the Department of Earth Sciences, Uppsala University. Retrieved from http://uu.diva-portal.org/smash/get/diva2:1369565/FULLTEXT01.pdf

Johnston, I. (2015). Traditional warning signs of cyclones on remote islands in Fiji and Tonga. *Environmental Hazards, 14*(3): 210–223. https://doi.org/10.1080/17477891.2015.1046156

Kaenzig, R., Rebetez, M., & Serquet, G. (2016). Climate change adaptation of the tourism sector in the Bolivian Andes. *Tourism Geographies, 18*(2): 111–128. https://doi.org/.1080/14616688.2016.1144642

Kalsnes, B., Nadim, F., Hermanns, R., Hygen, H., Petkovic, G., Dolva, B., Berg, H., & Høgvold, D. (2016). Landslide risk management in Norway. In K. Ho, S. Lacasse, & L. Picarelli, (Eds.), *Slope safety preparedness for impact of climate change*. Florida, FL: CRC Press. https://doi.org/10.1201/9781315387789-9.

Kanuha, V., (2000). "Being" native versus "going native": Conducting social work research as an insider. *Social Work, 45*(5): 439–447. https://doi.org/10.1093/sw/45.5.439

Kelman, I. (2015). Climate change and the Sendai Framework for Disaster Risk Reduction. *International Journal of Disaster Risk Science, 6*: 117–127. https://doi.org/10.1007/s13753-015-0046-5

Kelman, I., Gaillard, J.C., & Mercer, J. (2015). Climate change's role in disaster risk reduction's future: Beyond vulnerability and resilience.

International Journal of Disaster Risk Science, 6(21): 21-27. https://doi.org/10.1007/s13753-015-0038-5

Kerstholt, J., Duijnhoven, H., & Paton, D. (2017). Flooding in The Netherlands: How people's interpretation of personal, social and institutional resources influence flooding preparedness. *International Journal of Disaster Risk Reduction, 24:* 52–57. https://doi.org/10.1016/j.ijdrr.2017.05.013.

Khailani, D., & Perera, R. (2013). Mainstreaming disaster resilience attributes in local development plans for the adaptation to climate change induced flooding: A study based on the local plan of Shah Alam City, Malaysia. *Land Use Policy, 30*(1): 615-627. https://doi.org/10.1016/j.landusepol.2012.05.003

Khan, S., Mishra, J., Lin, K., & Doyle, E. (2017). Rethinking communication in risk interpretation and action. *Natural Hazards, 88*(3): 1709-1726. https://doi.org/10.1007/s11069-017-2942-z

King, D., Bird, D., Haynes, K., Boon, H., Cottrell, A., Millar, J., Okada, T., Box, P., Keogh, D., & Thomas, M. (2014). Voluntary relocation as an adaptation strategy to extreme weather events. *International Journal of Disaster Risk Reduction, 8*: 83-90. http://dx.doi.org/10.1016/j.ijdrr.2014.02.006

King, D., Gurtner, Y., Firdaus, A., Harwood, S., & Cottrell, A. (2016). Land use planning for disaster risk reduction and climate change adaptation: Operationalizing policy and legislation at local levels. *International Journal of Disaster Resilience in the Built Environment, 7*(2): 158-172. https://doi.org/10.1108/IJDRBE-03-2015-000

Kjartansson, G. (1967). The Steinholts Hlaup, Central-South-Iceland, on January 15th 1967. *Náttúrufræðingurinn, 37*: 120-169.

Klimeš, J., Rosario, A., Vargas, R., Raška, P., Vicuña, L., & Jurt, C. (2019). Community participation in landslide risk reduction: a case history from Central Andes, Peru. *Landslides, 16*: 1763–1777. https://doi.org/10.1007/s10346-019-01203-w

Knafou, R. (2019). Stromboli or Russian roulette tourism. *Via Tourism Review, 16*. https://doi.org/10.4000/viatourism.4829

KNR [Kalaallit Nunaata Radioa] (n.d.). *Information about KNR.* Retreived from https://knr.gl/da/om-knr/kalaallit-nunaata-radioa

Koslov, L. (2016). The case for retreat. *Public Culture, 28*: 359-387. https://doi.org/10.1215/08992363-3427487

Kousky, C. (2014). Managing shoreline retreat: A US perspective. *Climate Change, 124*: 9-20. https://doi.org/10.1007/s10584-014-1106-3

Kristinsson, S. (2013). Siðfræði rannsókna og siðanefndir. In S. Halldórsdóttir (Ed.), *Handbók í aðferðafræði rannsókna*. Akureyri, Iceland: University of Akureyri.

Kvale, S. (1996). *Interviews: An introduction to qualitative research interviewing.* Thousand Oaks, CA: Sage.

Lahsen, M. (2008). Knowledge, democracy and uneven playing fields: Insights from climate politics in – and between – the U.S. and Brazil. In N. Stehr (Ed.), *Knowledge and democracy: A 21st-century perspective*. London, UK: Transaction Publishers.

Landsbjörg (2022). *Icelandic Association for Search and Rescue.* Retrieved from https://www.landsbjorg.is/icelandic-association-for-search-and-rescue

Lateltin, O., Haemmig, C., Raetzo, H., & Bonnard, C. (2005). Landslide risk management in Switzerland. *Landslides, 2*: 313–320. https://doi.org/10.1007/s10346-005-0018-8

Lazarus, R., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York, NY: Springer.

Leonard, G., Johnston, D., Paton, D., Christianson, A., Becker, J., & Keys, H. (2008). Developing effective warning systems: Ongoing research at Ruapehu volcano, New Zealand. *Journal of Volcanology and Geothermal Research 172*(3): 199–215. https://doi.org/10.1016/j.jvolgeores.2007.12.008

Lidmo, J., Bogason, Á., & Turunen, E. (2020). The legal framework and national policies for urban greenery and green values in urban areas. *Nordregio Report, 3*. https://doi.org/10.6027/R2020:3.1403-2503.

Liebow, E. (1967). *Tally's Corner.* London, UK: Routledge and Kegan Paul.

Lin, K., Khan, S., Acosta, L., Alaniz, R., & Olanya, D. (2020). The dynamism of post disaster risk communication: A cross-country synthesis. *International Journal of Disaster Risk Reduction, 48*. https://doi.org/10.1016/j.ijdrr.2020.101556

Lindell, M., & Perry, R. (2004). *Communicating environmental risk in multiethnic communities.* Thousand Oaks, CA: Sage.

Liu, S. (2014). Crisis crowdsourcing framework: Designing strategic configurations of crowdsourcing for the emergency management domain. *Computer Supported Cooperative Work, 23*: 389–443. https://doi.org/10.1007/s10606-014-9204-3

Lofland, J. (1971). *Analyzing social settings: A guide to qualitative observation and analysis.* Belmont, CA: Wadsworth.

Loftsdóttir, K. (2012a). Colonialism at the margins: politics of difference in Europe as seen through two Icelandic crises. *Identities, 19*(5): 597-615, https://doi.org/10.1080/1070289X.2012.732543

Loftsdóttir, K. (2012b). "The white flesh of a fish": Reflections about whiteness and methodologies. *Graduate Journal of Social Science, 9*(1), 84–91.

Loftsdóttir, K. (2015). The exotic north: Gender, nation branding and postcolonialism in Iceland. *NORA - Nordic Journal of Feminist and Gender Research: 23*(4), 246–260. https://doi.org/10.1080/08038740.2015.1086814

Lundström, C. (2010). White ethnography: (Un)comfortable conveniences and shared privileges in field-work with Swedish migrant women. *NORA - Nordic Journal of Feminist and Gender Research, 18*(2): 70–87. https://doi.org/10.1080/08038741003755467

Mackenzie, S., & Kerr, J. (2012). A (mis)guided adventure tourism experience. *Journal of Sport and Tourism, 17*(2):125–144. https://doi.org/10.1080/14775085.2012.729901

Mair, J., Ritchie, B., & Walters, G. (2016). Towards a research agenda for post-disaster and post-crisis recovery strategies for tourist destinations: A narrative review. *Current Issues in Tourism, 19*(1): 1-26. https://doi.org/10.1080/13683500.2014.932758

March, S., McGregor, J., & Day, L. (2020). Relatives to sue Royal Caribbean Cruise Line over New Zealand volcano tragedy. Retrieved from https://www.abc.net.au/news/2020-04-27/new-zealand-white-island-volcano-disaster-four-corners/12150706?nw=0

Marchezini, V. (2020). "What is a sociologist doing here?" An unconventional people-centered approach to improve warning implementation in the Sendai Framework for Disaster Risk Reduction. *International Journal of Disaster Risk Science, 11*: 218–229. https://doi.org/10.1007/s13753-020-00262-1

Margreth, S., Jóhannesson, T., & Stefánsson, H. (2014). *Avalanche mitigation measures for Siglufjörður: Realisation of the largest project with snow supporting structures in Iceland. International Snow Science Workshop.* Retrieved from https://arc.lib.montana.edu/snow-science/objects/ISSW14_paper_O11.01.pdf

Marshall, T. (2020). Risk perception and safety culture: Tools for improving the implementation of disaster risk reduction strategies. *International Journal of Disaster Risk Reduction, 47*. https://doi.org/10.1016/j.ijdrr.2020.101557.

Maskrey, A. (2011) Revisiting community-based disaster risk management. *Environmental Hazards, 10*: 42-52. http://dx.doi.org/10.3763/ehaz.2011.0005

Mattea, S., Franceschinis, C., Scarpa, R., & Thiene, M. (2016). Valuing landslide risk reduction programs in the Italian Alps: The effect of visual information on preference stability. *Land Use Policy, 59*: 176-184. https://doi.org/10.1016/j.landusepol.2016.08.032

Matti (2017). Sittwe camp profiling report. *Camp Coordination and Camp Management Cluster; Danish Refugee Council; United Nations High Commissioner for Refugees.* Retrieved from https://reliefweb.int/report/myanmar/sittwe-camp-profiling-report

Matti, S. (2019). Research in humanitarian crises: Profiling internally displaced persons in Myanmar. *SAGE Research Methods Cases, 2.* https://dx.doi.org/10.4135/9781526473356

Matti, S., & Ögmundardóttir, H. (2021). Local knowledge of emerging hazards: Instability above an Icelandic glacier. *International Journal of Disaster Risk Reduction, 58*(1): 102187. https://doi.org/10.1016/j.ijdrr.2021.102187

Matti, S., Ögmundardóttir, H., Aðalgeirsdóttir, G., & Reichardt, U. (2022). Psychosocial response to a no-build zone: Managing landslide risk in Iceland. *Land Use Policy, 117.* https://doi.org/10.1016/j.landusepol.2022.106078

Matti, S., Ögmundardóttir, H., Aðalgeirsdóttir, G., & Reichardt, U. (2022). Communicating the risk of a large landslide above a glacier with foreign tourism employees in Iceland. *Mountain Research and Development. 42*(2). https://doi.org/10.1659/MRD-JOURNAL-D-21-00051.1

Mavhura, E., Manyena, S., Collins, A., & Manatsa, D. (2013). Indigenous knowledge, coping strategies and resilience to floods in Muzarabani, Zimbabwe. *Internal Journal of Disaster Risk Reduction*. *5*: 38-48. https://doi.org/10.1016/j.ijdrr.2013.07.001

Maxwell, J. (2009). Designing a qualitative study. In L. Bickman & D. Rog (Eds.), *The SAGE handbook of applied social research methods.* London, UK: Sage. https://doi.org/10.4135/9781483348858.n7

McAdam, J., & Ferris, E. (2015). Planned relocations in the context of climate change: Unpacking the legal and conceptual issues. *Cambridge Journal of International and Comparative Law, 4*(1). https://doi.org/10.7574/cjicl.04.01.137

McCool, S., & Braithwaite, A. (1992). Persuasive messages and safety hazards in dispersed and natural recreation settings. In M. Manfredo (Ed.), *Influencing human behaviour: Theory and applications in recreation, tourism, and natural resources management.* Champaign, Illinois: Sagamore Publishing Inc.

McWilliam, A., Wasson, R., Rouwenhorst, J., & Amaral, A. (2020). Disaster risk reduction, modern science and local knowledge: Perspectives from Timor-Leste. *International Journal of Disaster Risk Reduction, 50*. https://doi.org/10.1016/j.ijdrr.2020.101641

Medby, I. (2019). State discourses of Indigenous “inclusion”: Identity and representation in the Arctic. Antipode, 51 (4): 1276–1295. https://doi.org/10.1111/anti.12542

Mercer, J., Kelman, I., Lloyd, K., & Suchet-Pearson, S. (2008). Reflections on use of participatory research for disaster risk reduction. *Area 40*(2): 172–183.

Mercer, J., Kelman, I., Taranis, L., & Suchet-Pearson, S. (2010). Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters, 34*(1): 214- 239. https://doi.org/10.1111/j.1467-7717.2009.01126.x

Merriam, S., Johnson-Bailey, J., Lee, M., Kee, Y., Ntseane, G., & Muhamad, M. (2001). Power and positionality: Negotiating insider/outsider status within and across cultures. *International Journal of Lifelong Education, 20*(5), 405–416. https://doi.org/10.1080 /02601370120490

Mileti, D., & Sorensen, J. (1990). Communication of emergency public warnings: A social science perspective and state-of-the-art assessment. United States: N.P. https://doi.org/10..2172/6137387

Miller, S. (1952). The participant observer and ‘over-rapport’. *American Sociological Review, 17*, 2: 97–9. https://doi.org/10.2307/2088368

Mirra (2019). *Immigrants in Icelandic tourism*: *Drive for growth and profit*. Retrieved from https://mirra.is/wp-content/uploads/2019/12/Executive_Summary_English-021219.pdf

Misanya, D., & Øyhus, A. (2014). How communities’ perceptions of disasters influence disaster response: Managing landslides on Mount Elgon. *Disasters, 39*(2): 389−405. https://doi.org/10.1111/disa.12099

Molinari, L., & Corsaro, W. (2012). Entering and observing in children’s worlds: A reflection on a longitudinal ethnography of early education in Italy. In Research with children: Perspectives and practice. New York, NY: Routledge. https://doi.org/10.4324/9780203024607-15

Morgan, D., & Fluker, M. (2006). Risk management for Australian commercial adventure tourism operations. In P. Christensen & A. James (Eds.), *Tourism, security and safety.* Oxford UK: Elsevier.

Mourey, J., Ravanel, L., Lambiel, C., Strecker, J., & Piccardi, M. (2019). Access routes to high mountain huts facing climate-induced environmental changes and adaptive strategies in the Western Alps since the 1990s. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography, 73*(4): 215–228. https://doi.org/10.1080/00291951.2019.1689163

Müller, D., Carson, D., de la Barre, S., Granås, B., Jóhannesson, G., Øyen, G., Rantala, O., Saarinen, J., Salmela, T., Tervo-Kankare, K., et al. (2020). *Arctic tourism in times of change: Dimensions of urban* *tourism.* Retrieved from https://www.diva-portal.org/smash/get/diva2:1471328/FULLTEXT01.pdf

Mutch, C. (2015). The role of schools in disaster settings: Learning from the 2010–2011 New Zealand earthquakes. *International Journal of Educational Development, 41*: 283-291. https://doi.org/10.1016/j.ijedudev.2014.06.008

Nadim, F., Pedersen, S., Schmidt-Thomé, P., & Sigmundsson, F. (2008). Natural hazards in Nordic countries. *Episodes.* https://doi.org/10.18814/epiiugs/2008/v31i1/

Nakashima, D., Rubis, J., & Krupnik, I. (2018). Assessment and adaptation: Introduction. In D. Nakashima, J. Rubis, & I. Krupnik (Eds.), *Indigenous knowledge for climate change assessment and adaptation.* Paris, France: Cambridge University Press and UNESCO.

Nally, D. (2013). *Flash floods and falls: Deaths and rescues in Zion National Park.* Scotts Valley, CA: CreateSpace Independent Publishing Platform.

Newsome, D., Moore, S., & Dowling, R. (2013). *Natural area tourism: Ecology, impacts and management*. Clevedon, UK: Channel View Publishing.

Nguyen, D., Imamura, F., & Iuchi, K., (2017). Public-private collaboration for disaster risk management: A case study of hotels in Matsushima, Japan. *Tourism Management, 61*(3): 129-140. https://doi.org/10.1016/j.tourman.2017.02.003

Ngwese, N., Saito, O., Sato, A., Boafo, Y., & Jasaw, G. (2018). Traditional and local knowledge practices for disaster risk reduction in northern Ghana. *Sustainability*. https://doi.org/10.3390/su10030825.

Norizan, N., Hassan, N., & Yusoff, M. (2021). Strengthening flood resilient development in Malaysia through integration of flood risk reduction measures in local plans. *Land Use Policy*, *102*(5737). https://doi.org/10.1016/j.landusepol.2020.105178

O’Brien, S., & Cadwell, P. (2021). Communicating COVID-19 in multiple languages: A maturity model assessment of Ireland’s crisis communication practice. *Journal of Language and Law*, *77*: 1-17. https://doi.org/10.2436/rld.i77.2022.3630

O’Connor, J., & Costa, J. (1993). Geologic and hydrologic hazards in glacierized basins in North America resulting from 19th and 20th century global warming. *Natural Hazards, 8*(2): 121–140. https://doi.org/10.1007/BF00605437

Oddsson, G. (2010). Class awareness in Iceland. *International Journal of Sociology and Social Policy*, *30*(5/6): 292–312. https://doi.org/10.1108 /01443331011054253

Ogilvie, A. (2007). Local knowledge and travellers' tales: A selection of climatic observations in Iceland. *Developments in Quaternary Sciences, 5*: 257-287. https://doi.org/10.1016/S1571-0866(05)80013-2

Olavius, Ó. (1780 trans. 1964-1965). *Ferðabók: landshagir í norðvestur, norður og norðaustursýslum Íslands 1775 to 1777*. S. Steindórsson (Trans.). Reykjavík, Iceland: Bókfellsútgáfan.

O'Reilly, K. (2005). *Ethnographic methods.* London, UK: Routledge.

O'Reilly, K. (2009*). Key concepts in ethnography*. Online: SAGE.

Orlove, B., Roncoli, C., Kabugo, M., & Majugu, A. (2010). Indigenous climate knowledge in southern Uganda: The multiple components of a dynamic regional system. *Climatic Change*, *100*(2): 243–65. https://doi.org/10.1007/ s10584-009-9586-2

Ögmundardóttir, H. (2011). *The shepherds of Þjórsárver.* Uppsala, Sweden: Uppsala University.

Okada, T., Howitt, R., Haynes, K., Bird, D., & McAneney, J. (2018). Recovering local sociality: Learnings from post-disaster community-scale recoveries. *International Journal of Disaster Risk Reduction, 31*: 1030-1042. https://doi.org/10.1016/j.ijdrr.2018.08.010.

Okada, T., Haynes, K., Bird, van den Honert, R., & King, D. (2014). Recovery and resettlement following the 2011 flash flooding in the Lockyer Valley. *International Journal of Disaster Risk Reduction, 8*: 20-31. https://doi.org/10.1016/j.ijdrr.2014.01.001.

Pagneux, E. (2016). *Öræfajökull: Evacuation time modelling of areas prone to volcanogenic floods*. Reykjavik, Iceland: Icelandic Meteorological Office. Retrieved from https://www.researchgate.net/profile/Emmanuel_Pagneux/publication/291346554_Oraefajokull_Evacuation_time_modelling_of_areas_prone_to_volcanogenic_floods/links/56a1497008ae24f62701fc74.pdf

Pagneux, E., Gísladóttir, R., & Jónsdóttir, S. (2011). Public perception of flood hazard and flood risk in Iceland: A case study in a watershed prone to ice-jam floods. *Natural Hazards, (58)*. https://doi.org/10.1007/s11069-010-9665-8

Parliament of Greenland [Inatsisar] (1992). *Pigisanik aalaakkaasunik arsaarinnissuteqartarneq pillugu Inatsisartut inatsisaat nr. 25 [Act 25 on expropriation]*. Retrieved from https://inatsisit-gl.translate.goog/Lov?rid=%7BFFFF90B1-0AC2-48D1-B206-24BBC2A1D60F%7D&sc_lang=kl-GL&_x_tr_sl=da&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=wapp

Parliament of Greenland [Inatsisar] (2010). *Kalaallit Nunaanni annaassiniarnissamut upalungaarsimaneq aamma ikuallattoornissamik qaartoornissamillu pitsaaliuinermi iliuusissat* *pillugit Inatsisartut inatsisaat nr. 14 [Act 14 on rescue preparedness in Greenland and on fire and explosion prevention measures: Amended, repealed, principal law, compiles, replaces information]*. Retrieved from https://lovgivning.gl/lov?rid=%7BE60E9911-120D-4325-8472-2D16F9F419C4%7D

Parliament of Iceland (1997). *Lög nr. 49/1997 um varnir gegn snjóflóðum og skriðuföllum [Act 49/1997 on Protective Measures Against Avalanches and Landslides]*. Retrieved from https://www.althingi.is/lagas/nuna/1997049.html

Parliament of Iceland (2000). *Reglugerð nr. 505/2000 um hættumat vegna ofanflóða, flokkun og nýtingu hættusvæða og gerð bráðabirgðahættumats. [Regulation 505/2000 on hazard zoning due to snow- and landslides, classification and utilisation of hazard zones, and preparation of provisional hazard zoning]*. Retrieved from https://www.reglugerd.is/reglugerdir/allar/nr/505-2000

Parliament of Iceland (2007). *Lög nr. 60/2007 um Vatnajökulsþjóðgarð [Act 60/2007 on Vatnajökull National Park]*. Retrieved from https://www.althingi.is/lagas/nuna/2007060.html

Parliament of Iceland (2008). *Lög nr. 82/2008 µm almannavarnir [Act 82/2008 on Civil Protection]*. Retrieved from https://www.althingi.is/lagas/150c/2008082.html

Parliament of Iceland (2018). Parliamentary resolution on a strategic regional plan for the period 2018-2024. Retrieved from https://www.stjornarradid.is/lisalib/getfile.aspx?itemid=3b970dc2-f19a-11e8-942f-005056bc4d74

Patel, S., Webster, R., Greenberg, N., Weston, D., & Brooks, S. (2020). Research fatigue in COVID-19 pandemic and post-disaster research: Causes, consequences and recommendations. *Disaster prevention and management, 29*(4): 445-455. https://doi.org/10.1108/dpm-05-2020-0164

Paton, D. (2003). Stress in disaster response: A risk management approach. *Disaster Prevention and Management, 12* (3): 203-9. https://doi.org/10.1108/09653560310480677

Paton, D. (2006). Promoting household and community preparedness for bushfires: A review of issues that inform the development and delivery of risk communication strategies. *Bushfire Cooperative Research Centre.* Retrieved from https://www.bushfirecrc.com/sites/default/files/managed/resource/risk-communication-summary_w-cover_1.pdf

Pálsson, G. (1994). Enskilment at sea. *Man*, *29*(4): 901-927. https://doi.org/10.2307/3033974

Pelling, M. (2007). Learning from others: The scope and challenges for participatory disaster risk assessment. *Disasters*, *31*(4):373–385. doi: 10.1111/j.1467-7717.2007.01014.x.

Peräkylä, A., & Ruusuvuori, J. (2011). Analyzing talk and text. In N. Denzin & Y. Lincoln (Eds.), *The SAGE handbook of qualitative research* (4th ed.). Thousand Oaks, CA: Sage.

Perry, R., & Lindell, M. (2003). Preparedness for emergency response: Guidelines for the emergency planning process. *Disasters 27*(4): 336-350. https://doi.org/10.1111/j.0361-3666.2003.00237.x

Pfister, C. (2009). The "disaster gap" of the 20(th) century and the loss of traditional disaster memory. *GAIA, 18*: 239-246. https://doi.org/10.14512/gaia.18.3.10

Plough, A., & Krimsky, S. (1987). The emergence of risk communication studies: Social and political context. *Science, Technology, and Human Values, 12*(3/4): 4-10.

Plummer, K. (2001). *Documents of life 2: An invitation to a critical humanism.* Thousand Oaks, CA: Sage.

Poliwoda, G. (2007). Learning from disasters: Saxony fights the floods of the river Elbe 1784-1845. *Historical Social Research*, *32*(3): 169-199. https://doi.org/10.12759/hsr.32.2007.3.169-199

Prideaux, B., Laws, E., & Faulkner, B. (2003). Events in Indonesia: Exploring the limits to formal tourism trends forecasting methods in complex crisis situations. *Tourism Management*, *24*: 475-487. https://doi.org/10.1016/S0261-5177(02)00115-2

Priest, H., Roberts, P., & Woods, L. (2002). An overview of three different approaches to the interpretations of qualitative data. Part 1: Theoretical Issues. *Nurse Researcher, 10*(1): https://doi.org/30-42. nr2002.10.10.1.30.c5877.

Purdie, H., Gomez, C., & Espiner, S. (2015). Glacier recession and the changing rockfall hazard: Implications for glacier tourism. *New Zealand Geographer*, *71*: 189–202. https://doi.org/10.1111/nzg.12091

Radonic, L. (2019). Becoming with rainwater: A study of hydrosocial relations and subjectivity in a desert city. *Economic Anthropology*, *6*: 291–303. https://doi.org/10.1002/sea2.12146

Rahman, A., & Munadi, K. (2019). *Communicating risk in nhancing disaster preparedness: A pragmatic example of disaster risk communication approach from the case of Smong story*. Paper presented at IOP Conference Series: Earth and Environmental Science. 273: 01204010.1088/1755-1315/273/1/012040

Raymond, C., Fazey, I., Reed, M., Stringer, L., Robinson, G., & Evely, A. (2010). Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management, 91*(8): 1766–77. https://doi.org/10.1016/j.jenvman.2010.03.023

Resnik, D. (1998). *The ethics of science: An introduction*. New York, NY: Routledge.

Rice, J., Burke, B., & Heynen, N. (2015). Knowing climate change, embodying climate praxis: Experiential knowledge in Southern Appalachia. *Annals of the Association of American Geographers, 105*(2): 253–62. https://doi.org/10.1080/00045608.2014.985628

Richardson, L., & St. Pierre, E. A. (2005). Writing: A method of inquiry. In N. Denzin & Y. Lincoln (Eds.), *The SAGE Handbook of Qualitative Research* (3rd ed.). Thousand Oaks, CA: Sage.

Rink, E., & Reimer, G. (2019). A toolkit for community based participatory research in Greenland. Retrieved from https://da.uni.gl/media/5467066/greeland_cbpr_toolkit_november2019.pdf

Roberts, M., & Guðmundsson, T. (2010). Öræfajökull volcano: Geology and historical floods. In E. Pagneux, M. Gudmundsson, S. Karlsdóttir & M. Roberts (Eds.), *Volcanogenic floods in Iceland: An assessment of hazards and risks at Öræfajökull and on the Markarfljót outwash plain.* Reykjavík, Iceland: Icelandic Meteorological Office.

Roncoli, C., Crane, T., & Orlove, B. (2009). Fielding climate change in cultural anthropology. In S. Crate & M. Nuttall (Eds.), *Anthropology and climate change: From encounters to actions.* New York, NY: Routledge.

Rosenzweig, C., & Neofotis, P. (2013). Detection and attribution of anthropogenic climate change impacts: Anthropogenic climate change impacts. *Wiley Interdisciplinary Reviews: Climate Change, 4*(2): 121–150. https://doi.org/10.1002/wcc.209

Rygaard, J. (2008). The City Life of Youths in Greenland. *Études/Inuit/Studies, 32(*1) : 33–54. http://www.jstor.org/stable/42870704

Sakurai, M., & Adu-Gyamfi, B. (2020). Disaster-resilient communication ecosystem in an inclusive society: A case of foreigners in Japan. *International Journal of Disaster Risk Reduction, 51*(1). https://doi.org/10.1016/j.ijdrr.2020.101804

Salim, E., Ravanel, L., Bourdeau, P., & Deline, P. (2021). Glacier tourism and climate changes. *Regional Environmental Change, 21*(120). https://doi.org/10.1007/s10113-021-01849-0

Salim, E., Ravanel, L., Deline, P., & Gauchon, C. (2021). A review of melting ice adaptation strategies in the glacier tourism context. *Scandinavian Journal of Hospitality and Tourism, 21*(2): 229-246. https://doi.org/10.1080/15022250.2021.1879670

Santos, C., Toda, L., Orduña, J., Santos, F., & Ferrão, J. (2015). The impacts of Typhoon Haiyan in the Philippines: Implications to land use planning. *Climate, Disaster and Development Journal, 1*(1): 57-66. https://doi.org/10.18783/cddj.v001.i01.a06

Scaffa, M., Gerardi, S., Herzberg, G., & McColl, M. (2006). The role of occupational therapy in disaster preparedness, response, and recovery. *The American Journal of Occupational Therapy, 60*(6): 642-9. https://doi.org/10.5014/ajot.60.6.642

Scheper-Hughes, N. (1995). The primacy of the ethical: Propositions for a militant anthropology. *Current Anthropology*, *36*(3): 409–20.

Schmidt, L., Ađalgeirsdóttir, G., Pálsson, F., Langen, P., Guđmundsson, S., & Björnsson, H. (2020). Dynamic simulations of Vatnajökull ice cap from 1980 to 2300. *Journal of Glaciology, 66*(255): 97–112. https://doi.org/ https://doi.org/10.1017/jog.2019.90

Schuster, R., & Highland, L. (2007). Urban landslides: Socioeconomic impacts and overview of mitigative strategies. *Bulletin of Engineering Geology and the Environment, 66*(1): 1-27. https://doi.org/10.1007/s10064-006-0080-z

Scolobig, A., Prior, T., Schröter, D., Jörin, J., & Patt, A. (2015). Towards people-centred approaches for effective disaster risk management: Balancing rhetoric with reality. *International Journal of Disaster Risk Reduction, 12*: 202-212. https://doi.org/10.1016/j.ijdrr.2015.01.006

Seeger, M. (2006). Best practices in crisis communication: An expert panel process. *Journal of Applied Communication Research, 34*(3):232-244. https://doi.org/10.1080/00909880600769944

Seneviratne, S., Nicholls, N., Easterling, D., Goodess, C., Kanae, S., Kossin, J., Luo, Y., Marengo, J., McInnes, K., Rahimi, M., Reichstein, M., Sorteberg, A., Vera, C., & Zhang, X. (2012). Changes in climate extremes and their impacts on the natural physical environment. In C. Field, V. Barros, T. Stocker, D. Qin, D. Dokken, K. Ebi, M. Mastrandrea, K. Mach, G. Plattner, S. Allen, M. Tignor, & P. Midgley (Eds.). A special report of working groups I and II of the IPCC. Cambridge, UK: Cambridge University Press, pp. 109-230.

Sermitsiaq (2020a). *Buildings in crisis.* Retrieved from https://sermitsiaq.ag/bygder-i-krise

Sermitsiaq. (2020b). *Aaja i kontroversiel udmelding: Luk bygder naturligt [Aaja in controversial announcement: Close settlements naturally]*. Retrieved from https://sermitsiaq.ag/node/224741

Sermitsiaq (2021). *Citizen of Niaqornat: We remain calm.* Retrieved from https://sermitsiaq.ag/node/229274

Sermitsiaq (2022). *Risk of tsunami: 22 households want to move away*. Retrieved from https://sermitsiaq.ag/risiko-tsunami22-husstande-oensker-flytte-vaek

Shamoo, A., & Resnik, D. (2009). *Responsible conduct of research*. Oxford, UK: Oxford University Press.

Siders, A. (2013). Managed coastal retreat: A legal handbook on shifting development away from vulnerable areas. *Center for Climate Change Law*. Retrieved from https://scholarship.law.columbia.edu/sabin_climate_change/147

Siders, A., Hino, M., & Mach, K. (2019). The case for strategic and managed climate retreat. *Science, 365*: 761-763. https://doi.org/10.1126/science.aax8346

Sigurmundsson, F., Gísladóttir, G., & Erlendsson, E. (2013*). The impacts of the Öræfajökull eruption in AD 1362 and climate change on cultural landscape dynamics in the province of Öræfi south of Vatnajökull glacier*. Paper presented at Fall Meeting, Abstract Id. NH43B-1748, American Geophysical Union, Iceland. Retrieved from https://ui.adsabs.harvard.edu/abs/2013AGUFMNH43B1748S/abstract

Sigurðsson, J. (1392). *Annals of Skálholt Bisophric. Vol 1*. Cited in Björnsson, H. (2016). *The glaciers of Iceland: A historical, cultural and scientific overview*. Barcelona, Spain: Springer.

Sigurðsson, J. (Ed.) (1857-1876). *Íslenskt Fornbréfasafn (1-16)*. Copenhagen, Denmark and Reykjavik, Iceland: Moller and Félagsprentsmiðjan.

Sigurðsson, O., Sigurðsson, G., Björnsson, B., Pagneux, E., Zóphóníasson, S., Einarsson, B., Þórarinsson, O., & Jóhannesson, T. (2011). *Flood warning system and jökulhlaups – Eyjafjallajökull*. Reykjavik, Iceland: Icelandic Meteorological Office. Retrieved from https://en.vedur.is/hydrology/articles/nr/2097

Simms, J., Waller, H., Brunet, C. & Jenkins, P. (2021). The long goodbye on a disappearing, ancestral island: A just retreat from Isle de Jean Charles. *Journal of Environment Studies and Science, 11*: 316–328. https://doi.org/10.1007/s13412-021-00682-5

Skaptadóttir, U., & Wojtynska, A. (2019). Sveigjanlegur vinnumarkaður og harkvinna innflytjenda á Íslandi. *Íslensk þjóðfélagið, 10*(2):14-28.

Skinner, J. (2012). A four-part introduction to the interview: Introducing the interview; society, sociology and the interview; anthropology and the interview; anthropology and the interview. In J. Skinner (Ed.), *The interview: An ethnographic approach*. London, UK: Berg.

Stancu, A., Ariccio, S., Dominicis, S., Cancellieri, U., Petruccelli, I., Ilin, C., & Bonaiuto, M. (2020). The better the bond, the better we cope: The effects of place attachment intensity and place attachment styles on the link between perception of risk and emotional and behavioural coping. *International Journal of Disaster Risk Reduction, 51*(101771). https://doi.org/10.1016/j.ijdrr.2020.101771

StatBank Greenland (2019). Population by residence in urban or rural areas 1979–2019. Retrieved from http://bank.stat.gl/BEEST3

StatBank Greenland (2022). *Greenland, gender and age structure by area, sex, place of birth, content and time.* Retrieved from https://bank.stat.gl/

Statistics Iceland (2020). *Population by postcodes, sex and age 1998-2020.* Retrieved from https://px.hagstofa.is/pxen/pxweb/en/Ibuar/Ibuar__mannfjoldi__2_byggdir__Byggdakjarnarhverfi/MAN03200.px

Statistics Iceland (2019). *Population by postcodes, sex and age 1998-2020.* Retrieved from https://px.hagstofa.is/pxen/pxweb/en/Ibuar/Ibuar__mannfjoldi__2_byggdir__Byggdakjarnarhverfi/MAN03200.px

Stewart, E., Welling, J., Espiner, S., & Wilson, J. (2017). Comparing motives of glacier tourists to Westland Tai Poutini National Park, New Zealand and Vatnajokull National Park, Iceland. In C. Lee, S. Filep, J. Albrecht, and W. Coetzee (Eds.), *Time for big ideas? Re-thinking the field for tomorrow.* Dunedin, New Zealand: Department of Tourism, University of Otago.

Stewart, E., Wilson, J., Espiner, S., Purdie, H., Lemieux, C., & Dawson, J. (2016). Implications of climate change for glacier tourism. *Tourism Geographies, 18*(4): 377–398. https://doi.org/10.1080/14616688.2016.1198416

Strauss, A. (1987). *Qualitative analysis for social scientists.* New York, NY: Cambridge University Press

Strzelecki, M. (2018). Extreme processes shaping Arctic coasts in a period of rapid paraglacial landscape transformation. Paper presented at Students in Polar and Alpine Research Conference 2018, held in Brno, Czechia 16-18 April 2018. Retrieved from https://www.researchgate.net/profile/Michaela-Knazkova/publication/325147009_Proceedings_Students_in_Polar_and_Alpine_Research_Conference_2018/links/5afabf93aca272e7302a17bd/Proceedings-Students-in-Polar-and-Alpine-Research-Conference-2018.pdf#page=9

Strzelecki, M., & Jaskólski, M. (2020). Arctic tsunamis threaten coastal landscapes and communities: Survey of Karrat Isfjord 2017 tsunami effects in Nuugaatsiaq, western Greenland. *Natural Hazards and Earth Systems Science, 20*: 2521–2534. https://doi.org/10.5194/nhess-20-2521-2020

Strzelecki, M., Long, A., Lloyd, J., Małecki, J., Zagórski, P., Pawłowski, Ł., & Jaskólski, M. (2018). The role of rapid glacier retreat and landscape transformation in controlling the post-Little Ice Age evolution of paraglacial coasts in central Spitsbergen (Billefjorden, Svalbard). *Land Degradation and Development, 29*: 1962–1978, https://doi.org/10.1002/ldr.2923

Sultana, N., & Tan, S. (2021). Landslide mitigation strategies in southeast Bangladesh: Lessons learned from the institutional responses. *International Journal of Disaster Risk Reduction, 62*. https://doi.org/10.1016/j.ijdrr.2021.102402

Suzuki, T. (2020). Disaster information provision for international tourists using an interpreter application. *Sustainable Tourism. 248*: 103-116. https://doi.org/10.2495/ST200091

Svennevig, K., Dahl-Jensen, T., Keiding, M., Boncori, J., Larsen, T., Salehi, S., Solgaard, A., and Voss, P. (2020). Evolution of events before and after the 17 June 2017 rock avalanche at Karrat Fjord, West Greenland: A multidisciplinary approach to detecting and locating unstable rock slopes in a remote Arctic area. *Earth Surface Dynamics*, 8: 1021–1038 10.5194/esurf-8-1021-2020

Sword-Daniels, V., Eriksen, C., Hudson-Doyle, E., Alaniz, R., Adler, C., Schenk, T., & Vallance, S. (2018). Embodied uncertainty: Living with complexity and natural hazards. *Journal of Risk Research, 21*(3): 290-307. https://doi.org/10.1080/13669877.2016.1200659

Sylvain, R. (2005). Loyalty and treachery in the Kalahari. In A. Meneley & D. Young (Eds.), *Auto-ethnographies: The anthropology of academic practices*. Peterborough, Canada: Broadview Press.

Sæmundsson, Þ. (2018). *Risk of major rock slope failure at the Svínafellsheiði mountain, SE Iceland mapping and monitoring.* Paper presented at Landslides onto Glaciers: Research, Monitoring and Hazard Assessment. 13 November 2018. Haskoli Islands, Nordic House. Iceland.

Sæmundsson, Þ., Helgason, J., Ben-Yehoshua, D., Bergsson, B., Ófeigsson, B., Magnússon, E., Hjartardóttir, Á., Drouin, V., Belart, J., Grímsdóttir, H., Pedersen, G., Birkefeldt M., Pálsson, F., Guðmundsson, S., & Geirsson, H. (2019*). Risk of major rock slope failure at the Svínafellsheiði mountain, SE Iceland.* Paper presented at 21st EGU General Assembly, held 17-22 April 2019. Vienna, Austria. Retrieved from https://ui.adsabs.harvard.edu/abs/2019EGUGA..21.9650S/abstract

Sæmundsson, Þ., & Margeirsson, G. (2016). Frequency, triggering factors and possible consequences of mass movements on outlet glaciers in Iceland. Paper presented at 18th EGU General Assembly, *held 17-22*

April 2016. Vienna, Austria. Retrieved from https://ui.adsabs.harvard.edu/abs/2016EGUGA..18.4704S/abstract

Sæmundsson, Þ., Petursson, H., & Decaulne, A. (2003). Triggering factors for rapid mass movements in Iceland. In C. Chen & J. Major (Eds.), *Debris-flow hazards mitigation: Mechanics, prediction, and assessment.* Rotterdam, Netherlands: Millpress.

Sæmundsson, Þ., Pétursson, H., & Decaulne, A. (2003). Triggering factors for rapid mass movements in Iceland. In D. Rickenmann, & C. Chen (Eds.), *Debris-Flow Hazards Mitigation: Mechanics, Prediction, and Assessment.* Rotterdam, Netherlands: Millpress.

Sæþórsdóttir, A. (2010). Planning nature tourism in Iceland based on tourist attitudes. *Tourism Geographies, 12*(1): 25-52. https://doi.org/10.1080/14616680903493639

Taylor, S. J., & Bogdan, R. (1998). *Introduction to qualitative research methods: A guidebook and resource.* New York, NY: John Wiley and Sons.

Taylor, S., Bogdan, R., & DeVault, M. (2015). *Introduction to qualitative research methods : A guidebook and resource.* Hoboken, NJ: John Wiley and Sons.

Thompson, R., Garfin, D., & Silver, R. (2017). Evacuation from natural disasters: a systematic review of the literature. *Risk Analysis, 37*(4): 812-839. https://doi.org/10.1111/risa.12654

Toubes-Rodrigo, M. (2017). Geomicrobiology of the basal ice layer at Svínafellsjökull glacier, SE Iceland. *Doctoral thesis*. Manchester, UK: Manchester Metropolitan University. Retrieved from https://e-space.mmu.ac.uk/620102/

Toubes-Rodrigo, M., Cook, S., Elliott, D., & Sen, R. (2016). Bacterial 16S diversity of basal ice, sediment, and the forefront of Svínafellsjökull glacier via isolation chips and classical culturing techniques. Paper presented at EGU General Assembly 2016, held 17-22 April, 2016. Vienna Austria. https://meetingorganizer.copernicus.org/EGU2016/EGU2016-9805.pdf

Toyoda, Y., & Kanegae, H. (2014). A community evacuation planning model against urban earthquakes. *Regional Science Policy and Practice, 6*(3): 231-249. https://doi.org/10.1111/rsp3.12036

Tropeano, D., & Turconi, L. (2004). Using historical documents for landslide, debris flow and stream flood prevention: Applications in northern Italy. *Natural Hazards, 31*: 663–679. https://doi.org/10.1023/B:NHAZ.0000024897.71471.f2

Tryggvason, E. (2000). Ground deformation at Katla: results of precision levelling 1967–1995. *Jökull, 48*: 1–16.

Tsai, C., & Chen, C. (2011). The establishment of a rapid natural disaster risk assessment model for the tourism industry. *Tourism Management, 32*(1):158-171. https://doi.org/10.1016/j.tourman.2010.05.015

UNDRR [United Nations Office for Disaster Risk Reduction, formerly UNISDR] (2005). *Hyogo Framework for Action 2005-2015*. Geneva, Switzerland: UNDRR.

UNDRR [United Nations Office for Disaster Risk Reduction, formerly UNISDR] (2009). *Terminology on disaster risk reduction*. Geneva, Switzerland: UNDRR.

UNDRR [United Nations Office for Disaster Risk Reduction, formerly UNISDR] (2015). *Sendai framework for disaster risk reduction 2015-2030*. Geneva, Switzerland: UNDRR.

UNDRR [United Nations Office for Disaster Risk Reduction, formerly UNISDR] (2022). *Terminology.* Retrieved from https://www.undrr.org/terminology/disaster-risk-management

UNESCO [United Nations Educational, Scientific and Cultural Organization] (2020). *Local and indigenous knowledge systems (LINKS).* Retrieved from https://en.unesco.org/

United States Government Accountability Office (2020). *Climate change: A climate migration pilot program could enhance the nation's resilience and reduce federal fiscal exposure*. Retrieved from https://www.gao.gov/products/gao-20-488

UNPFII [United Nations Permanent Forum on Indigenous Issues] (2015). *Study on the treatment of traditional knowledge in the framework of the United Nations Declaration on the Rights of Indigenous Peoples and the post-2015 development agenda*. E/C.19/2015/4. Retrieved from https://digitallibrary.un.org/record/788550?ln=en

UNPFII [United Nations Permanent Forum on Indigenous Issues] (n.d.). *Indigenous people, Indigenous voices: Factsheet.* Retrieved from https://www.un.org/esa/socdev/unpfii/documents/5session_factsheet1.pdf

Van Well, L., van der Keur, P., Harjanne, A., Pagneux, A., Perrels, A., & Henriksen, H. (2018). Resilience to natural hazards: An analysis of territorial governance in the Nordic countries. *International Journal of Disaster Risk Reduction*, *31*: 1283-1294. https://doi.org/10.1016/j.ijdrr.2018.01.005

Vice (2021*). Residents displaced by a mega-tsunami can never go home*. Retrieved from https://www.vice.com/en/article/93wzzd/residents-displaced-by-a-mega-tsunami-can-never-go-home

Victor, D. (2015). Climate change: Embed the social sciences in climate policy. *Nature*, *520:* 27-29. https://doi.org/10.1038/520027a

Vilímek, V., Klimeš, J., Vlčko, J., & Carreño, R. (2006). Catastrophic debris flows near Machu Picchu village (Aguas Calientes), Peru. *Environmental Geology, 50*(7): 1041–1052. https://doi.org/10.1007/s00254-006-0276-3

Vísir (2020). *Talsvert eignatjón en engin alvarleg slys á fólki eftir þrjú „mjög stór“ snjóflóð á Vestfjörðum*. Retrieved from https://www.visir.is/g/2020200119500/talsvert-eignatjon-en-engin-alvarleg-slys-a-folki-eftir-thrju-mjog-stor-snjoflod-a-vestfjordum

Voight, B. (1990). The 1985 Nevado del Ruiz volcano catastrophe: Anatomy and retrospection. *Journal of Volcanology and Geothermal Research,* 44(3): 349–386. https://doi.org/10.1016/0377-0273(90)90075-Q

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox: Implications for governance and communication of natural hazards. *Risk Analysis, 33*(6). https://doi.org/10.1111/j.1539-6924.2012.01942.x

Wamsler, C. (2004). Managing urban risk: Perceptions of housing and planning as a tool for reducing disaster risk. *Global Built Environment Review, 4*(2): 11–28.

Wang, S., & Zhou, L. (2019). Integrated impacts of climate change on glacier tourism. *Advances in Climate Change Research, 10*(2): 71-79. https://doi.org/10.1016/j.accre.2019.06.006.

Ward, S., & Day, S. (2011). The 1963 landslide and flood at Vajont Reservoir Italy: A tsunami ball simulation. *Italian Journal of Geosciences, 130*(1), 16–26. https://doi.org/10.3301/IJG.2010.21

Watson, C., & King, O. (2018). Everest’s thinning glaciers. *Geology Today, 34*(1):18–25. https://doi.org/10.1111/gto.12215

Weber, E. (2006). Experience-based and description-based perceptions of long-term risk: Why global warming does not scare us (yet). *Climatic Change, 77*(1–2): 103–120. https://doi.org/10.1007/s10584-006-9060-3

Weerasinghe, S. (2014). *Planned relocation, disasters and climate change: Consolidating good practices and preparing for the future.* Geneva, Switzerland: United Nations High Commissioner for Refugees. Retrieved from https://www.unhcr.org/54082cc69.pdf

Welling, J. (2020). Glacier tourism and climate change adaptation in Iceland. *Doctoral thesis.* Reykjavik, Iceland: University of Iceland. Retrieved from https://opinvisindi.is/handle/20.500.11815/2133

Welling, J., & Abegg B. (2019). Following the ice: Adaptation processes of glacier tour operators in Southeast Iceland. *International Journal of Biometeorology, 65*(12). https://doi.org/10.1007/s00484-019-01779-x

Welling, J., & Árnason, T. (2016). External and internal challenges of glacier tourism development in Iceland. In H. Richins & J. Hull (Eds.), *Mountain tourism: Experiences, communities, environments and sustainable futures*. Reykjavik, Iceland: CABI.

Welling, J., Ólafsdóttír, R., & Árnason, Þ. (2020). Implications of climate change on nature-based tourism demand: A segmentation analysis of glacier site visitors in southeast Iceland. *Sustainability, 12*(13), 5338. https://doi.org/10.3390/su12135338

Wendt, M. (2019). "A good first job"? Migrant workers in Icelandic hotels. *Masters thesis.* Reykjavik, Iceland: University of Iceland. https://skemman.is/bitstream/1946/34487/3/A%20good%20first%20job%3F%20Migrant%20workers%20in%20Icelandic%20hotels.pdf

Whitington, J. (2016). Carbon as a metric of the human. *Political and Legal Anthropology Review*, *39*(1): 46-63. https://doi.org/10.1111/plar.12130

Whittlesey, L. (2014). *Death in Yellowstone: Accidents and foolhardiness in the First National Park*. Boulder, CO: Roberts Rinehart Publishers.

Wisner, B. (2020). Five years beyond Sendai: Can we get beyond frameworks?' *International Journal of Disaster Risk Science, 11*: 239–249 https://doi.org/10.1007/s13753-020-00263-0

Wisner, B., Piers, B., Cannon, T., & Davis, I. (2004). *At risk: Natural hazards, people's vulnerability and disasters* (2nd ed.). New York, NY: Routledge.

World Bank (2022). *Urban population – Greenland*. Retrieved from https://data.worldbank.org/indicator/SP.URB.TOTL?locations=GL

Ziegler, A., Wasson, R., Sundriyal, Y., Srivastava, P., Sasges, G., Ramchunder, S., Ong, C., Nepal, S., McAdoo, B., Gillen, J., Bishwokarma, D., Bhardwaj, A., & Apollo, M. (2021). A call for reducing tourism risk to environmental hazards in the Himalaya. *Environmental Hazards*. https://doi.org/10.1080/17477891.2021.1984196

Þórarinsson, S. (1958). The Öræfajökull eruption of 1362. *Islandica, Acta Nat. II.*

Þórarinsson, S. (1974). *Vötnin stríð. saga skeiðarárhlaupa og Grímsvatnagosa.* Reykjavik, Iceland: Bókaútgáfa Menningarsjóðs.Þórarinsson

Þórðardóttir, E., Guðmundsdóttir, B., Pétursdóttir, G., Valdimarsdóttir, U., & Hauksdóttir, A. (2018). Psychosocial support after natural disasters in Iceland-implementation and utilization. *International Journal of Disaster Risk Reduction,* 27: 642-648. https://doi.org/10.1016/j.ijdrr.2017.11.006

Annex 1 Interviews about Svínafellsheiði risk

Table 5: Semi-structured interviews about Svínafellsheiði risk

Code	Type	Role	Location	Date
RM/GO.1	Interview	Risk manager	Reykjavík	06-Oct-18
RM/GO.2	Interview	Risk manager	Reykjavík	22-Oct-18
RM/GO.3	Interview	Risk manager	Reykjavík	14-Dec-18
RM/GO.4*	Interview	Risk manager	Öræfi	24-Oct-18
MG.1	Interview	Municipal government staff	Online	13-Jan-21
MG.2	Interview	Municipal government staff	Online	9-Feb-21
GG.1	Interview	Glacier guide	Öræfi	18-Oct-18
GG.2	Interview	Glacier guide	Reykjavík	19-Oct-18
GG.3	Interview	Glacier guide	Reykjavík	30-Oct-18
GG.4	Interview	Glacier guide	Reykjavík	23-Nov-19
GG.5	Interview	Glacier guide	Reykjavík	25-Nov-19
GG.6	Interview	Glacier guide	Öræfi	26-Nov-19
GG.7	Interview	Glacier guide	Öræfi	27-Nov-19
GG.8	Interview	Glacier guide	Öræfi	28-Nov-19
GG.9	Interview	Glacier guide	Öræfi	28-Nov-19
FI.1	Interview	Foreign inhabitant	Reykjavík	24-Nov-19
FI.2	Interview	Foreign inhabitant	Öræfi	26-Nov-19
FI.3	Interview	Foreign inhabitant	Öræfi	27-Nov-19
FI.4	Interview	Foreign inhabitant	Öræfi	27-Nov-19
FI.5	Interview	Foreign inhabitant	Öræfi	27-Nov-19
FI.6	Interview	Foreign inhabitant	Öræfi	27-Nov-19
FI.7	Interview	Foreign inhabitant	Öræfi	27-Nov-19
LI.1	Interview	Local inhabitant	Öræfi	16-Jul-19
LI.2	Interview	Local inhabitant	Öræfi	17-Jul-19
LI.3	Interview	Local inhabitant	Öræfi	27-Nov-19
LI.4	Interview	Local inhabitants (2 people)	Öræfi	27-Nov-19
LI.5	Interview	Local inhabitant	Öræfi	27-Nov-19
LI.6	Interview	Local inhabitant	Öræfi	27-Nov-19
LI.7	Interview	Local inhabitant	Öræfi	24-Oct-20
LI.8	Interview	Local inhabitant	Öræfi	24-Oct-20
LI.9	Interview	Local inhabitant	Öræfi	25-Oct-20
LI.10	Interview	Local inhabitants (4 people)	Öræfi	27-Oct-20
LI.11	Interview	Local inhabitants (2 people)	Öræfi	28-Jun-20
LI.12	Interview	Local inhabitants (2 people)	Öræfi	28-Jun-20
LI.13	Interview	Local inhabitant	Öræfi	28-Jun-20

LI.14*	Interview	Local inhabitant	Öræfi	29-Jun-20
LI.15	Interview	Local inhabitant (in Icelandic)	Öræfi	29-Jun-20
LI.16	Written	Local inhabitant	Online	7-July-19
S.1	Interview	Scientist	Reykjavík	27-Sep-18
S.2	Interview	Scientist	Reykjavík	04-Oct-18
S.3*	Interview	Scientist	Reykjavík	01-May-
S.4*	Interview	Scientist	Reykjavík	13-Nov-20
S.5	Interview	Scientist	Online	30-Mar-21
T.1	Interview	Tourist	Öræfi	28-Nov-19
T.2	Interview	Tourist	Öræfi	28-Nov-19
T.3	Interview	Tourist	Öræfi	28-Nov-19
T.4	Interview	Tourist	Öræfi	28-Nov-19
T.5	Interview	Tourist	Öræfi	28-Nov-19
T.6	Interview	Tourist	Öræfi	28-Nov-19
T.7	Interview	Tourist	Öræfi	28-Nov-19
T.8	Interview	Tourist	Öræfi	28-Nov-19
TE.1	Interview	Tourism expert	Höfn	17-Oct-18
TE.2	Interview	Tourism expert	Öræfi	26-Nov-19
NP.1	Interview	National parks	Reykjavik	14-Dec-18
SAR.1	Interview	Search and Rescue (2 people)	Reykjavik	29-Jan-19
PB.1	Observation	Public risk briefing	Öræfi	24-Oct-18
PB.2	Observation	Public risk briefing	Öræfi	24-Oct-18
PB.3	Observation	Public risk briefing	Öræfi	24-Oct-18

Interviews conducted with: risk managers/government officials (RM/GO); glacier guides (GG); foreign inhabitants (FI); local inhabitants (LI); scientists (S); tourists (T); national parks rangers (NP); search and rescue coordinators (SAR); tourism experts (TE); and observation of the public briefing (PB).

*The interviews LI.14 and RM.4 were follow-ups on interviews LI.10 and RM.2 respectively. They involved the interviewee clarifying or expanding on what they had mentioned in the earlier interview. Similarly S.3 and S.4 involved updates or follow-on questions from the interview S.2. While included in this table, these interviews are not included in the official interview count under the methodology sections as they were typically more informal, less structured and shorter.

** Note there are several reasons for the discrepancy between Section 5 and the rest of the PhD in terms of the number of interviews referenced. The article presented in Section 5 was published first, as a result several interviews had not yet been conducted (S.5, MG.1, MG.2). At this stage, the follow-up interviews cited above were still included in the overall tally (LI.14, RM.4, S.3, S.4). Finally, on reflection, the interview with a foreign inhabitant as FI.8 (Matti and Ögmundardóttir, 2021) and the contribution of an additional local inhabitant were more akin to informal interaction than an official semi-structured interview. In the later sections of this PhD thesis the they were included as such.

Annex 2 Examples of interview questions

Foreign inhabitants and glacier guides

- What country are you from?
- What is your job?
- How long have you been in this position for?
- Have you ever lived or spent time in similar landscape?
- What are the main environmental hazards in this area?
- Have you heard about the fracture on Svínafellsheiði?
- What do you know about it?
- How did you receive information about the fracture?
- Have you discussed the fracture with people from the local area?
- What do you feel when you think about the fracture?
- How often do you think about the fracture?
- If there was an immediate threat of collapse, how would you receive that information?
- What action would you take?
- Do you feel that you are engaged in risk management processes?
- Describe your experiences in or around Svínafellsjökull?
- What are the main outstanding questions you have about the risk?

Local inhabitants

- How long have you lived in Öræfi?
- How long has your family lived in Öræfi?
- When did you first hear about the instability in Svínafellsheiði?
- How did you first learn about Öræfajökull?
- Are there any stories passed down about eruptions?
- Was there talk about landslides in the area when you were growing up? What was discussed?
- Are there any stories passed down about landslides or rockslides?
- How did you receive information about the fracture?
- Do you feel that you are engaged in risk management processes
- Do you feel that everyone living here has the same understanding of how to respond to a large landslide from the fracture as you do?
- Is there anything that will give you an indication if a landslide is about to happen?
- What do you think will happen if a landslide occurs?
- What are the main outstanding questions you have about the risk?

Tourists

- What country are you from?
- How long have you been in Iceland?
- Have you ever been in landscapes similar to this?
- How did you hear about Svínafellsjökull?
- What are the main environmental hazards in this area?
- Did you see the big signs on the road in?
- Did you read them? What were they about?
- What was your response?
- Do you think that they were a good way to communicate information?
- Are you concerned for your personal safety in this area?
- If there was an immediate threat of collapse, how would you receive that information?
- What action would you take?
- Do you want to receive more information about potential hazards?
- How would you like to receive this information?

Risk managers

- What is the process for managing the risk of the Svínafellsheiði fracture?
- What challenges have been experienced?
- What are the thresholds for making different decisions including evacuation?
- How has information about the risk stemming from the fracture been communicated with different audiences?
- What has been the response of different audiences to the risk?
- What lessons have been learnt from other disasters in Iceland or elsewhere?

Annex 3 Articles about Karrat and Uummannaq Fjord risk

Table 6: KNR articles used for Greenland case

Date	Title (English)	Website
23-Jun-17	Experts advise against blasting rocks	https://knr.gl/da/nyheder/eksperter-frar%C3%A5der-spr%C3%A6nge-fjeld
30-Jun-17a	Kielsen: Too dangerous to open Nuugaatsiaq and Illorsuit	https://knr.gl/da/nyheder/farligt-%C3%A5bne-nuugaatsiaq-og-illorsuit
10-Jul-17b	Experts secure houses in tsunami-affected settlements	https://knr.gl/da/nyheder/eksperter-sikrer-huse-i-flodb%C3%B8lgeramte-bygder
11-Jul-17	Nuugaatsiaq Arctic Command hopes to retrieve property today	https://knr.gl/da/nyheder/arktisk-kommando-h%C3%A5ber-hente-ting-i-dag
15-Jul-17	Property retrieved from Illorsuit	https://knr.gl/da/nyheder/ejendele-hentet-i-illorsuit
17-Jul-17	Citizens affected by tsunamis are advised not to move home	https://knr.gl/da/nyheder/borgere-frar%C3%A5des-flytte-hjem
4-Aug-17	Illorsuit and Nuugaatsiaq must be cleared of environmentally hazardous materials	https://knr.gl/da/nyheder/illorsuit-og-nuugaatsiaq-skal-ryddes-milj%C3%B8farlige-materialer
15-Aug-17	Dorph and Kielsen thank Danish for support for tsunami victims	https://knr.gl/da/nyheder/dorph-og-kielsen-takker-dansk-st%C3%B8tte-til-tsunami-ofre
16-Aug-17	Illorsuit without power and water	https://knr.gl/da/nyheder/illorsuit-uden-str%C3%B8m-og-vand
1-Sept-17	The Folketing's finance committee approves a grant for tidal wave victims	https://knr.gl/da/nyheder/folketingets-finansudvalg-godkender-bevilling-til-flodb%C3%B8lgeofre
1-Dec-17	Uummannaq evacuation creates greater revenue in Pilersuisoq	https://knr.gl/da/nyheder/evakuerede-skaber-st%C3%B8rre-oms%C3%A6tning-i-pilersuisoq
7-Dec-17	The area around Nuugaatsiaq is temporarily closed to raw material activities	https://knr.gl/da/nyheder/omr%C3%A5det-ved-nuugaatsiaq-lukkes-midlertidigt-r%C3%A5stofaktiviteter

17-Jun-18	Moving memorial service in Uummannaq	https://knr.gl/da/nyheder/bev%C3%A6gende-mindeh%C3%B8jtidlighed-i-uummannaq
22-Jun-18a	Alcohol has replaced Nuugaatsiaq and Illorsuit	https://knr.gl/da/nyheder/alkohol-har-erstattet-nuugaatsiaq-og-illorsuit
21-Aug-18b	Contingency: Continued high risk of landslides in the Karratfjord	https://knr.gl/da/nyheder/fortsat-h%C3%B8j-fare-fjeldskred-i-karratfjorden
22-Aug-18	Evacuated people get paperwork for new homes	https://knr.gl/da/nyheder/evakuerede-f%C3%A5r-papir-p%C3%A5-nye-boliger
4-Sept-18	Illorsuarmiut demonstrates to be allowed to return home	https://knr.gl/da/nyheder/illorsuarmiut-demonstrerer-f%C3%A5-lov-vende-hjem
5-Jan-19	Saqqaq Landslide risk - but no need to panic	https://knr.gl/da/nyheder/fjeldskredsrisiko-men-ingen-grund-til-panik
12-Feb-19	Replacement homes for tsunami victims will not be ready on time	https://knr.gl/da/nyheder/erstatningsboliger-til-tsunamiofre-bliver-ikke-klar-til-tiden
30-Jun-19	Illorsuit citizens have formed an association	https://knr.gl/da/nyheder/borgerne-har-dannet-forening
19-Jul-19	The first tsunami victims are moving into new homes	https://knr.gl/da/nyheder/de-f%C3%B8rste-tsunamiofre-flytter-ind-i-nye-boliger
20-Jul-19	New home gives peace of mind to tsunami victims	https://knr.gl/da/nyheder/nyt-hjem-giver-ro-i-sj%C3%A6len-til-tsunamiofre
15-Jul-20	After the tsunami: The last replacement homes are ready	https://knr.gl/da/nyheder/efter-tsunami-de-sidste-erstatningsboliger-st%C3%A5r-klar
19-Oct-20	Mining research: The emergency services are not ready for a disaster	https://knr.gl/da/nyheder/forsker-i-minedrift-beredskabet-er-ikke-klar-til-en-katastrofe
11-Feb-21	Despite the risk of nine meter high waves, people will move home to Illorsuit	https://knr.gl/da/nyheder/trods-risiko-ni-meter-h%C3%B8je-b%C3%B8lger-vil-folk-flytte-hjem-til-illorsuit
11-May-21a	Tsunami danger in Karrat Fjord: 176 residents are offered relocation	https://knr.gl/da/nyheder/tsunamifare-i-karrat-fjorden-176-beboere-f%C3%A5r-tilbudt-flytning

11-May-21b	Katrine Kruse Hansen from Niaqornat: I will be living here	https://knr.gl/da/nyheder/katrine-kruse-hansen-fra-niaqornat-jeg-bliver-boende-her
11-May-21c	New tsunami assessment: Waves risk reaching houses, power plants and health center	https://knr.gl/da/nyheder/ny-tsunamivurdering-b%C3%B8lger-risikerer-n%C3%A5-huse-elv%C3%A6rker-og-sundhedscenter
12-May-21a	Upcoming Mayor on tsunami warning: It's a tough ride for anyone to hear about	https://knr.gl/da/nyheder/kommende-borgmester-om-tsunamivarsel-det-er-en-tung-omgang-nogen-h%C3%B8re-om
12-May-21b	Mikkel was evacuated after a tsunami in 2017: Doubts whether people will move	https://knr.gl/da/nyheder/mikkel-blev-evakueret-efter-tsunami-i-2017-tvivler-p%C3%A5-om-folk-vil-flytte
12-May-21c	Múte B. Egede on tsunami danger: We will cooperate with our neighboring countries	https://knr.gl/da/nyheder/m%C3%BAte-b-egede-om-tsunamifare-vi-vil-samarbejde-med-vores-nabolande
13-May-21a	Replacement housing and lost gear filled civic meetings in Uummannaq	https://knr.gl/da/nyheder/erstatningsboliger-og-tabte-redskaber-fyldte-borgerm%C3%B8der-i-uummannaq
13-May-21b	State geologist about the Karrat Fjord: It could be much worse than 2017	https://knr.gl/da/nyheder/statsgeolog-om-karrat-fjorden-det-kan-blive-meget-v%C3%A6rre-end-2017
14-May-21	GEUS: Large unstable mountain area may have been active for 1000 years	https://knr.gl/da/nyheder/geus-stort-ustabilt-fjeldomr%C3%A5de-kan-have-v%C3%A6ret-aktivt-1000-%C3%A5r
16-May-21	Doctor about health center in Uummannaq: We have a plan	https://knr.gl/da/nyheder/l%C3%A6ge-om-sundhedscenter-i-uummannaq-vi-har-en-plan
17-May-21	Tsunami alert: The siren cannot be heard by everyone	https://knr.gl/da/nyheder/tsunamivarsel-sirenen-kan-ikke-h%C3%B8res-af-alle

23-May-21	Mother of traumatized son from Nuugaatsiaq: He still fears the waves are coming	https://knr.gl/da/nyheder/mor-til-traumatiseret-s%C3%B8n-fra-nuugaatsiaq-han-frygter-stadig-b%C3%B8lgerne-kommer
24-May-21	Kristian was evacuated from Illorsuit - and he still misses his village	https://knr.gl/da/nyheder/kristian-blev-evakueret-fra-illorsuit-og-han-savner-stadig-sin-bygd
26-May-21	Naalakkersuisoq: It’s not forbidden to stay in Illorsuit	https://knr.gl/da/nyheder/naalakkersuisoq-det-er-ikke-forbudt-opholde-sig-i-illorsuit
30-May-21	Tsunami stairs are being built in Niaqornat	https://knr.gl/da/nyheder/tsunamitrappe-bliver-bygget-i-niaqornat
17-Jun-21a	Karrat tsunami danger: People are still waiting for relocation assistance	https://knr.gl/da/nyheder/tsunamifare-i-karrat-folk-venter-stadig-på-flyttehjælp
17-Jun-21b	Eyewitness to the tsunami: I will never experience it again	https://knr.gl/da/nyheder/%C3%B8jenvidne-til-tsunami-jeg-vil-aldrig-opleve-det-igen
18-Jun-21	Mayor’s response to the anxious at Karrat: You can move next week	https://knr.gl/da/nyheder/borgmesters-svar-til-de-ængstelige-ved-karrat-i-kan-flytte-i-næste-uge
24-Jun-21	Coke in communication: Villagers can still keep their houses	https://knr.gl/da/nyheder/koks-i-kommunikationen-bygdeboere-kan-alligevel-beholde-deres-huse
25-Jun-21	Residents demand apology after confusion about house demolitions	https://knr.gl/da/nyheder/bygdeboer-kr%C3%A6ver-undskyldning-efter-forvirring-om-husnedrivninger
26-Jun-21	Naalakkersuisoq to villagers: Sorry	https://knr.gl/da/nyheder/naalakkersuisoq-til-bygdeborgere-undskyld
29-Jun-21	Maline Kruse after moving fad: Now I’m staying in Niaqornat	https://knr.gl/da/nyheder/maline-kruse-efter-flyttefad%C3%A6se-nu-bliver-jeg-i-niaqornat
1-Jul-21	Oops: Municipality planned emergency accommodation in tsunami risk zone	https://knr.gl/da/nyheder/ups-kommune-planlagde-n%C3%B8dindkvartering-i-tsunami-risikozone

14-Jul-21	Inatsisartut cancels residence requirement in Karrat Fjord	https://knr.gl/da/nyheder/inatsisartut-oph%C3%A6ver-bop%C3%A6lskrav-i-karrat-fjorden%C2%A0
14-Dec-21	Association misses millions due to misunderstanding	https://knr.gl/da/nyheder/forening-misser-millioner-p%C3%A5-grund-af-misforst%C3%A5else
15-Dec-21	Association on missed millions: It is very disappointing that such a big misunderstanding can happen	https://knr.gl/da/nyheder/forening-om-missede-millioner-det-er-meget-skuffende-en-s%C3%A5-stor-misforst%C3%A5else-kan-ske
12-Apr-22	New unstable mountain area found in Uummannaq's fjord system	https://knr.gl/da/nyheder/nyt-ustabilt-fjeldomr%C3%A5de-fundet-i-uummannaqs-fjordsystem
13-Apr-22a	Mayor of Avannaata Kommunia: We pay extra attention to the unstable mountain	https://knr.gl/da/nyheder/borgmester-i-avannaata-kommunia-vi-er-ekstra-opm%C3%A6rksomme-p%C3%A5-det-ustabile-fjeld
13-Apr-22b	Enok Skade lives in a new unstable mountain area: I will be living here	https://knr.gl/da/nyheder/enok-skade-bor-i-nyt-ustabilt-fjeldomr%C3%A5de-jeg-bliver-boende-her
20-May-22	Tsunami alert: 10 have agreed to move from Niaqornat and Qaarsut	https://knr.gl/da/nyheder/tsunamivarsel-10-har-sagt-ja-til-flytte-fra-niaqornat-og-qaarsut

Annex 4 Interview consent form

Adapting to Emerging Hazards:
Instability above an Icelandic glacier
Stephanie Matti PhD candidate, University of Iceland
sam33@hi.is +354 855 5520

I…………………………………… voluntarily agree to participate in this PhD research study.

- I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.
- I understand that I can withdraw permission to use data from my interview within two weeks after the interview, in which case the material will be deleted.
- I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.
- I understand that participation involves an interview and potential follow-up questions.
- I understand that I will not benefit directly from participating in this research.
- I agree to my interview being audio-recorded.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report on the results of this research my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.
- I understand that disguised extracts from my interview may be quoted in published papers, PhD dissertation, conference presentations, and other research outputs.
- I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

Signature of research participant

----

believe the participant is giving informed consent to participate in this study.
Signature of researcher

Annex 5 Reflections on Svínafellsjökull

The
icefall
drops
steeply,
dominating the landscape.

Icebergs calve from the glacial tongue, drifting across the lake.

*Steel crampons **engage** the glacier surface with a **crunch**.*

Rough-hewn seracs
contrast with
serpentine
meltwater
channels
that carve
their way
through the
frozen landscape.

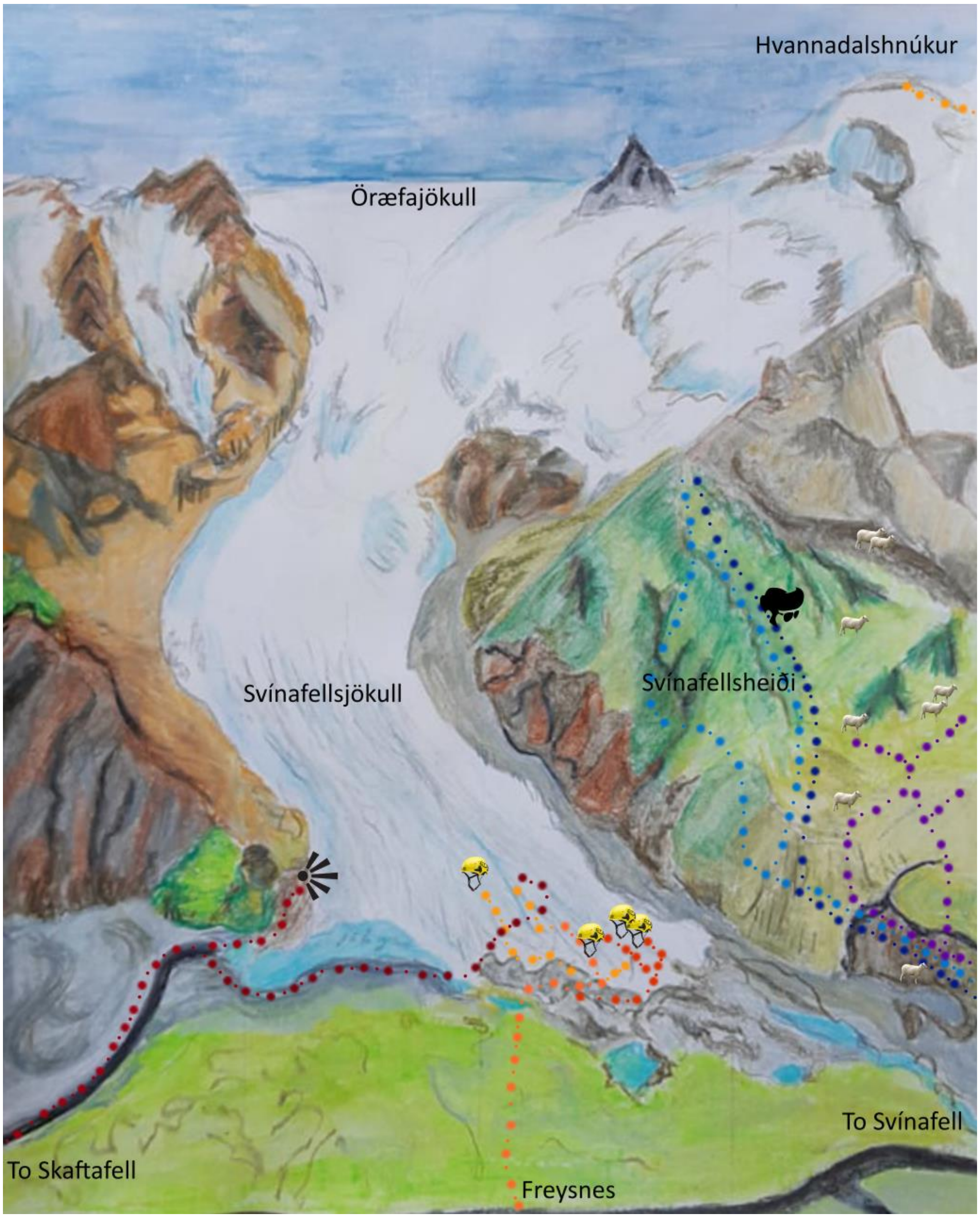
Moulins

p
l
u
n
g
e

into the depths of the glacier, while turquoise ice [traps air] from centuries past.

A surreal labyrinth of ice,
constantly changing,
performing new contortions,
before melting away…

Annex 6 Sites visited during research



Glacier guiding training activities
Scientific monitoring missions
Sheep gathering
Tourist hike on Svínafellsjökull

Faldur = rock that looks like Elvis
Some places sheep were sited
Glacier viewing area
Ice climbing sites

Source: Stephanie Matti with hand-drawn base map illustration by Marian Matti