Social dimensions of volcanic hazards, risk and emergency response procedures in southern Iceland

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Contents

Abstract

The Katla volcano in southern Iceland is one the most hazardous in the country. Frequent, destructive eruptions producing catastrophic jökulhlaup (glacial outburst floods), tephra fall and lightning hazards pose a serious risk to many local communities. Extensive geological and geophysical research details the current state of Katla and provides insights into past eruptive episodes but only one study, conducted with residents from two communities in 2004, had assessed Katla with respect to the local population. In order to develop successful risk mitigation strategies however, emergency management agencies must consider the hazard in conjunction with the varying factors affecting the society at risk.

As a result, this research explores some of the social dimensions of hazard, risk and emergency response procedures in relation to Katla. The aim of the research is to provide a social framework for disaster risk reduction by offering an in-depth social assessment to complement the physical. Using mixed methods research, the study incorporates field observations during evacuation exercises, semi-structured interviews with emergency management officials and residents, and structured questionnaire interviews with residents, tourists and tourism employees.

The research shows that each stakeholder group is inherently different and volcanic risk mitigation strategies need to be structured accordingly. Recent efforts which culminated in full-scale evacuation exercises in 2006 did not take this into consideration. On a practical level, these exercises indicated that most residents would respond positively to evacuation orders. At a conceptual level however, this research identified many contextual issues, (e.g. knowledge and perception of hazard and risk, level of trust) which affect people's ability to adopt the recommended protective action. In rural communities, emergency management agencies need to consider local knowledge, livelihood connections and attachment to place in order to develop effective mitigation strategies. Within the tourism sector, emergency management agencies must ensure that education campaigns raise awareness of hazard, risk and emergency response procedures. Significant effort is still urgently needed to address disaster risk reduction in southern Iceland as Katla is thought to be in a heightened state of activity and an eruption, without prolonged precursory signals, is expected in the near future.

Útdráttur

Katla er ein virkasta og hættulegasta eldstöð Íslands. Íbúum í nágrenni Kötlu og ferðamönnum stafar hætta af gosi í eldstöðinni vegna hamfarahlaupa, gjóskufalls og eldinga. Viðamiklar jarð- og jarðeðlisfræðilegar rannsóknir hafa verið gerðar á Kötlu, en þrátt fyrir þá hættu sem fólki stafar af henni hefur til þessa aðeins ein rannsókn verið gerð um áhrif Kötlu á íbúa.

Til þess að hægt sé að móta skilvirkar viðbragðs- og rýmingaráætlanir vegna náttúruvár er nauðsynlegt að skilja skynjun fólks og þekkingu á náttúruvá og hvernig það muni bregðast við aðsteðjandi hættu. Sú rannsókn sem hér er kynnt tekur heildstætt og ítarlega á hinum félagslega þætti og er ætlað að vera viðbót við þá þekkingu sem er til staðar á Kötlugosum og áhrifum þeirra. Markmiðið er að draga úr þeirri hættu sem fylgir gosi í Kötlu.

Beitt var fjölbreytilegum aðferðum. Í almannavarnaæfingunni Bergrisanum árið 2006 var beitt þátttökuathugun, tekin viðtöl við stjórnendur neyðar- og björgunarmála sem og íbúa og loks voru lagðar spurningar fyrir íbúa, ferðamenn og ferðaþjónustuaðila.

Niðurstöður rannsóknarinnar sýna að þekking og viðhorf íbúa á náttúruvá tengdri Kötlu og hvernig þeir myndu bregðast við hættunni er breytileg eftir hópum og þarf því að taka tilliti til þess við hönnun viðbragðsáætlana. Það var ekki gert fyrir æfinguna árið 2006. Rannsóknin bendir til þess að flestir íbúar myndu bregðast jákvætt við tilskipunum um rýmingu svæðisins en þó hafa margir samverkandi þættir áhrif á það hvort þeir sjái sér fært að fylgja ráðleggingum um varnarviðbrögð. Til að viðbragðsáætlun verði skilvirkari er því nauðsynlegt fyrir stjórnendur neyðar- og rýmingaráætlana að leita samvinnu við bændur, taka tillit til staðbundinnar þekkingar þeirra og hversu tengdir þeir eru við búskapinn og staðinn sem þeir búa á. Mikilvægt er að skipuleggjendur neyðaráætlana tryggi að miðlun upplýsinga og fræðsla til ferðamanna og ferðaþjónustuaðila skili sér í aukinni þekkingu á hættu og neyðarviðbrögðum vegna Kötlugosa. Brýn þörf er á úrbótum svo hægt verði að draga úr áföllum og hættu vegna náttúruhamfara á áhrifasvæði Kötlu því margt bendir til þess að hún gjósi í náinni framtíð og að gos geti hafist með skömmum fyrirvara.

Candidate's statement

I certify that the research in this thesis entitled 'Social dimensions of volcanic hazards, risk and emergency response procedures in southern Iceland' has not been previously submitted for a degree nor has it been submitted as part of requirements to any other university or institution other than Macquarie University and the University of Iceland.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis.

The research presented in this thesis was approved by Macquarie University Ethics Review Committee, reference number: HE26MAY2006-M04676.

This thesis is an amalgamation of five papers of which, I was the sole author on one and lead author on four. My contribution to each of the papers follows.

Chapter 2: Bird, D.K. 2009. The use of questionnaires for acquiring information on public perception of natural hazards and risk mitigation – a review of current knowledge and practice. Natural Hazards and Earth System Sciences, 9(4):1307-1325.
– Conceptual: 100%, practical: 100%, analytical: 100%, written: 100%

Chapter 3: Bird, D.K., Gisladottir, G. and 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.
– Conceptual: 100%, practical: 50%, analytical: 100%, written: 100%

Chapter 4: Bird, D.K., Gisladottir, G. and Dominey-Howes, D. 2009. Resident perception of volcanic hazards and evacuation procedures. Natural Hazards and Earth System Sciences, 9(1):251-266.
– Conceptual: 50%, practical: 65%, analytical: 100%, written: 100%

Chapter 5: Bird, D.K., Gísladóttir, G. and Dominey-Howes, D. submitted. Residents' perception of and response to volcanic risk mitigation strategies in a small rural community, southern Iceland. Bulletin of Volcanology.
– Conceptual: 25%, practical: 50%, analytical: 100%, written: 100%

Chapter 6: Bird, D.K., Gísladóttir, G. and Dominey-Howes, D. submitted. Different communities, different perspectives, different mitigation strategies? Issues affecting residents' behaviour and response in southern Iceland. Bulletin of Volcanology.
– Conceptual: 50%, practical: 50%, analytical: 100%, written: 100%

Deanne Katherine Bird
14 July 2010

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List of acronyms and definitions[1]

EC	Emergency centre
EH	Emergency headquarters
EMA	Emergency management agencies
Eyjafjallajökull	Glacier and volcano in southern Iceland
EWIS	Early warning and information system website
ICP	Icelandic Civil Protection
Jökulhlaup	'Glacier run' meaning a glacial outburst flood
Katla	Volcano in southern Iceland
Mýrdalsjökull	Glacier in southern Iceland
Rangárvallasýsla	Municipality to the west of Mýrdalsjökull
Vestur-Skaftafellssýla	Municipality to the south and east of Mýrdalsjökull
Þórsmörk	Popular tourist destination to the north of Eyjafjallajökull and west of Mýrdalsjökull

[1] The most frequently used Icelandic terms in the thesis are listed here. Others appearing in the text are explained *in situ*.

Chapter 1

This chapter consists of:

1 Introduction

Natural hazards cause extensive loss of life, damage to infrastructure and disruption of services throughout the world each year. In 2009 alone we witnessed earthquakes in Indonesia and Italy, bushfires in Australia, tsunamis in Samoa and Tonga, typhoons in the Philippines, flooding in India and landslides in Italy. It is unquestionably apparent, as evidenced by the tragic loss of life during these events that more research needs to be conducted and applied in order to successfully reduce the possibility of a natural hazard becoming a disaster.

Successful disaster risk reduction requires accurate forecasts, effective warnings and prepared officials and citizens. Since Gilbert F. White's (1945) ground-breaking work on human adjustments to floods, a great deal of research has focused on investigating hazard, risk and vulnerability in a societal context. The main aims of this research were to gain an understanding of public perception of risk and why people behave the way they do when faced with risk communication, hazard warnings and imminent threats.

One branch of risk perception research developed during the 1970's investigated people's expressed views using psychometric procedures contained within questionnaires to elicit quantitative judgements of perceived risk, acceptable risk and perceived benefit (Fischhoff et al., 1978). Termed the psychometric paradigm, this research found that perceptions of risk

and acceptability are closely related to whether the participant perceives the hazard as uncontrollable, potentially catastrophic and involuntary or, unknown (Slovic, 2000).

Another branch of research is based on the cultural theory of risk (Douglas and Wildavsky, 1982). These researchers argue that risk perception and risk-related behaviour is primarily a socio-cultural phenomenon which is affected by social organisation and values that influence behaviour and affect judgements of risk. In line with this research, Oliver-Smith (1996) considers that risk perception research addresses both problems of immediate concern to specific communities as well as theoretical questions about cultural and social constructions of reality. Adding to the discussion, Sjöberg (2000) argued that risk perception is not primarily related to socio-cultural factors, or exclusively a matter of sensory perception, but that it is also an expression of specific individual factors such as attitude, risk sensitivity and emotion.

The social context of hazards, or social vulnerability, is defined by Gaillard (2007) as the propensity of a society to suffer from damages in the event of a hazard. Some groups in society are more likely to suffer damage, loss and suffering in the context of different hazards (Wisner et al., 2004). The vulnerable state of these groups is as much a contributor to the causes of disaster as are the physical hazard with which they are associated (Lewis, 1999). As such, vulnerability stresses the condition of a society which makes it possible for a hazard to become a disaster (Cannon, 1994). Examining the concepts of vulnerability will hopefully encourage the development of more effective strategies and greater community participation in disaster risk reduction (Buckle, 1999).

Overall, what these research approaches have shown us is that emergency managers must consider the hazard in conjunction with the *wider* social context in which they occur. This includes assessing different dimensions such as stakeholders' characteristics (e.g. demographics, hazard knowledge, risk perception, attitude etc), and various social, cultural, economic and political factors (Chester et al., 2002; Dibben and Chester, 1999; Gaillard, 2007, 2008; Lavigne et al., 2008). These factors affect people's ability to adopt personal preparedness actions and take protective action in response to risk communication, hazard warnings and imminent threats.

Research on the social dimensions of volcanic hazard, risk and vulnerability has been conducted for more than half a century. Social and cultural changes in traditional societies

were documented following the evacuation of Niuafo'ou in Tonga due to volcanic unrest in 1946 (Rogers, 1981) and after the 1951 Mount Lamington eruption in Papua New Guinea (Keesing, 1952), the 1950-1951 Mt Benbow eruption in the New Hebrides (Tonkinson, 1968) and the 1961-1962 eruption of Tristan da Cunha (Blair, 1964). Other work in the 1960s focused on Hawaiian volcanoes (e.g. Lachman and Bonk, 1960) but progressed further afield to the United States mainland (e.g. Greene et al., 1981), Europe (e.g. Dibben and Chester, 1999), New Zealand (e.g. Johnston et al., 1999), Japan (e.g. Yoshii, 1992) Vanuatu (e.g. Cronin et al., 2004) and the Philippines (e.g. Gaillard et al., 2001).

The occurrence of volcanic hazards in Iceland has been documented since at least 1330 AD (Björnsson, 1992) and a multitude of literature exists on physical assessments of Icelandic volcanoes (Björnsson et al., 2000; Gudmundsson, 2005; Guðmundsson et al., 2007; Guðmundsson et al., 2008; Jónsdóttir et al., 2009; Larsen, 2000; Óladóttir et al., 2008; Russell et al., 2009; Scharrer et al., 2008; Smith and Dugmore, 2006; Soosalu et al., 2006; Sturkell et al., 2008; Sturkell et al., 2006; Sturkell et al., 2009; Sturkell et al., 2003; Thordarson and Larsen, 2007; Thorlaksson, 1967; Tómasson, 1996, among others). However, only one study consisting of 28 interviews with residents from two communities, has considered volcanic risk and vulnerability in relation to Icelandic society (Jóhannesdóttir, 2005).

In order to address this gap in research, this thesis explores some of the social dimensions of hazard, risk and vulnerability in relation to the Katla volcano in southern Iceland. The overall aim of the research is to provide a social framework for disaster risk reduction by offering an in-depth social assessment to complement the physical.

To provide context, Iceland's tectonic setting is illustrated, and the political structure and emergency management in Iceland are discussed in the next sections. This is followed by a description of the study region and details of the thesis.

1.1 Tectonics of Iceland

Iceland's exceptionally high levels of volcanism are due to the interaction of the Mid-Atlantic Ridge (MAR) with a mantle plume centred beneath Iceland (Sigmundsson, 2006). Consequently, Iceland's crust is subject to tensional stresses imposed by plate-spreading and rifting episodes (Geirsson et al., 2006). As a result, earthquakes and volcanic eruptions within the rift zone are common and have resulted in the formation of approximately 35 volcanic systems (Thordarson and Larsen, 2007).

The extent of the MAR is represented to the north of Iceland by the Kolbeinsey Ridge (KR) and to southwest by the Reykjanes Ridge (RR) (Einarsson, 1991) (Fig. 1). Terrestrially, the MAR consists of a series of interacting seismic and volcanic zones beginning with the Reykjanes Peninsula (RP) located in the southwest. It then passes through the Hengill Triple Junction (HTJ) and the South Iceland Seismic Zone (SISZ) before continuing into the Tjörnes Fracture Zone (TFZ) in the north (Einarsson, 1991).

Earthquakes occur frequently in the HTJ, the SISZ, and the TFZ. Typically, earthquake swarms occur with the accumulation of magma at shallow depths which sometimes leads to volcanic eruptions (Sigmundsson et al., 1997; Sturkell et al., 2006). Earthquake and volcanic activity is monitored by the Icelandic Meteorological Office (IMO) through the South Iceland Lowland (SIL) national seismic network. The Katla volcano, renowned for frequent, destructive eruptions, parallels the SISZ.

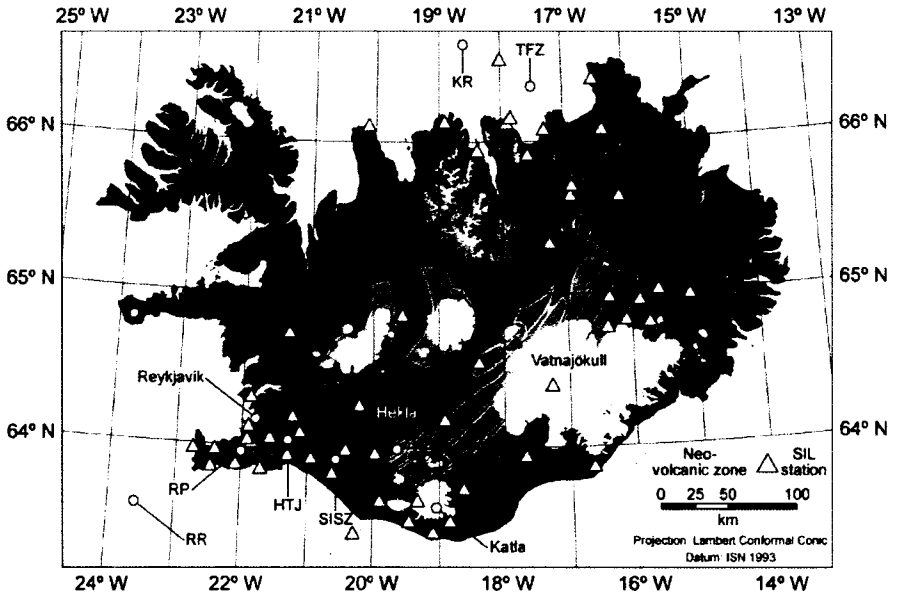

Figure 1. The tectonic setting of Iceland, highlighting the neo-volcanic and seismic zones, the volcanoes Hekla and Katla and the Vatnajökull ice-cap. Please note: the abbreviated labels denote the location of each seismic zone but not its extent (from Bird et al., 2008; map produced by Matthew J. Roberts).

1.2 Political structure and emergency management in Iceland

Iceland's local authorities, the municipality, function under the Local Government Act, No. 45/1998 and although they are very different in nature, size and population, they perform the same duties (Samband, 2010). The municipalities have legal authority of self-government

regarding their own affairs and no matter involving their special interest can be determined without their consultation (Samband, 2010). The number of municipalities in Iceland has been decreasing as those with small populations have merged to form larger administrative units. According to Almannavarnir (2009) there are 78 municipalities in Iceland.

The Icelandic Civil Protection Department (ICP) is responsible for preparing, organising and implementing strategies to protect the safety and wellbeing of the public and prevent them from harm caused by natural hazards (Almannavarnir, 2009). Positioned within the Ministry of Justice, the ICP's responsibilities are delegated at the national level by the National Commissioner of the Icelandic Police (NCIP). At the local level however, regional Chiefs of Police are in charge of all Civil Protection operations in their respective jurisdiction. In general, the municipalities are not directly involved in the operations of the Chiefs of Police (Samband, 2010).

There are 15 Police Districts and 27 Civil Protection Districts in Iceland and as such, there are one or more Civil Protection Districts within each of the police jurisdictions (Almannavarnir, 2009). Volunteer organisations such as the Icelandic Association for Search and Rescue and the Icelandic Red Cross provide integral support to the ICP and Chiefs of Police.

In the event of an impending disaster, the ICP works collaboratively with scientists in order to determine the most appropriate actions (Stefánsson, 2003). According to Section III Article 5 of the Civil Protection Act (Althingi, 2008) the NCIP manages civil protection issues on behalf of the Minister of Justice. The NCIP will make decisions regarding civil protection alert levels in consultation with the relevant Chief of Police, whenever possible (Althingi, 2008). A state of emergency will be declared if an extreme event such as a volcanic eruption is likely to occur, is imminent, or has already begun.

1.3 Regional setting

1.3.1 Katla

Katla, located under the Mýrdalsjökull icecap (Fig. 2), is one of the most hazardous volcanoes in Iceland due to catastrophic jökulhlaup (glacial outburst flood) (Table 1) and its proximity to inhabited regions on the south coast (Guðmundsson et al., 2007). Sturkell et al. (2003) suggest that Katla has a 5 km wide magma chamber sitting at a shallow depth of 1.5 km beneath sea level or 3 km below the topographical surface of Mýrdalsjökull. The elliptical

caldera is 14 km long, 600–750 m deep (Björnsson et al., 2000) and is overlain by 590 km^2 of ice which constitutes the Mýrdalsjökull icecap (Björnsson and Pálsson, 2008).

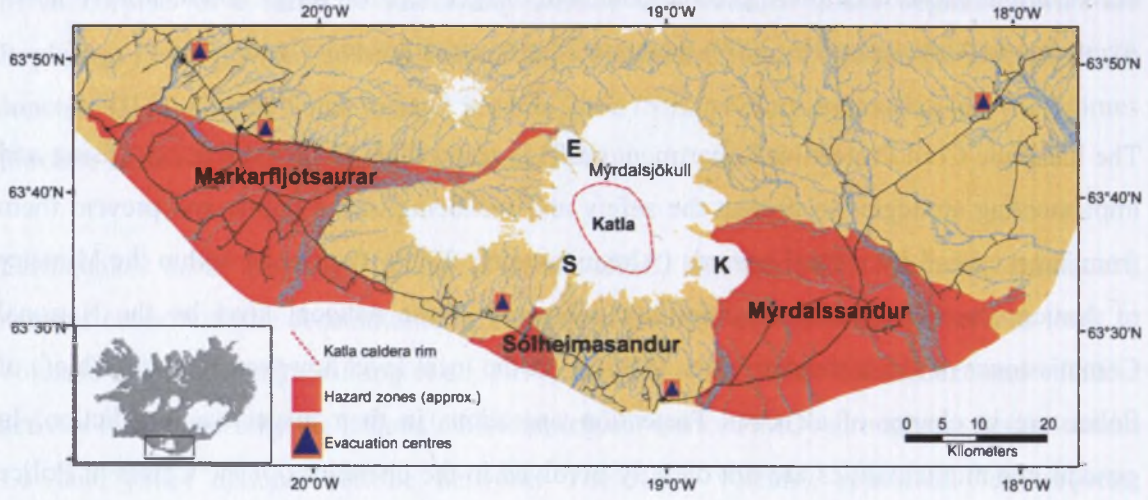

Figure 2. The Mýrdalsjökull icecap overlaying the Katla volcano and the catchment areas (and outlet glaciers) Kötlujökull (K), Sólheimajökull (S) and Entujökull (E) which contribute sediment and water to the outwash plains Mýrdalssandur, Sólheimasandur and Markarfljótsaurar respectively. These outwash plains constitute the eastern, southern and western jökulhlaup hazards zones.

Table 1. Categorisation of Icelandic jökulhlaup (from Guðmundsson et al., 2005).

Category	Peak Discharge ($m^3 s^{-1}$)
1 – Very small	<3,000
2 – Small	3,000 – 10,000
3 – Medium	10,000 – 30,000
4 – Big	30,000 – 100,000
5 - Catastrophic	>100,000

The well documented post-1500 AD historic record of Katla (Table 2) indicates eruptions twice a century, with the last confirmed eruption in 1918. Minor eruptions however, which did not break the glacier surface, are thought to be responsible for small, sudden jökulhlaup in 1955 and 1999 and the formation of ice-cauldrons above the caldera rim (Gudmundsson, 2005). Rist (1983) reported that the 1955 jökulhlaup destroyed bridges on the national highway that crosses Mýrdalssandur.

Katla eruptions are able to penetrate the 400 m of ice cover and produce catastrophic jökulhlaup that can reach a peak discharge of 100,000–300,000 m^3s^{-1} within a few hours (Björnsson, 2002). It is estimated that the Katla jökulhlaup, produced during the eruption that began on 12 October 1918, reached a peak discharge of over 300,000 m^3s^{-1} and transported

vast amounts of sediment and ice (Fig. 3) (Tómasson, 1996). The jökulhlaup carved its way through the glacier creating a glacier gorge 1,460–1,830 m in length, 366–550 m in width and more than 145 m in height (Tómasson, 1996). As a result, a segment of the glacier was detached from the glacier margin and transported in blocks, which were estimated to be 40–60 m high (Fig. 4a), onto Mýrdalssandur (Tómasson, 1996).

Table 2. Katla eruptions, known (verified) and possible floods since the 8th Century (from Guðmundsson et al., 2005). Katla – S and Katla – K depict eruption sites within catchment areas of Mýrdalsjökull (see Fig. 2 for catchment locations). Please note: there were insufficient data pre-1500 AD for a complete and accurate record.

Location of Eruption	Eruption Year	Flood (days)	Jökulhlaup Route	Size of Eruption	Size of Jökulhlaup
(Katla - S)	1999?	-	Sólheimasandur	Very Small	1
(Katla - K)	1955?	<1	Mýrdalssandur	Very Small	1
Katla – K	1918	24	Mýrdalssandur	Big	5
Katla - K (S)	1860	20	Mýrdalss/Sólheimas	Small	4/1?
Katla – K	1823	28	Mýrdalssandur	Small	4
Katla – K	1755	~120	Mýrdalssandur	Big	5
Katla – K	1721	>100	Mýrdalssandur	Medium	5
Katla – K	1660	>60	Mýrdalssandur	Medium	5
Katla – K	1625	13	Mýrdalssandur	Big	5?
Katla – K	1612		Mýrdalssandur	Small	4?
Katla – K	1580		Mýrdalssandur	Small	4?
Katla – K	1500		Mýrdalssandur	Big	5?
Katla – K	14??		Mýrdalssandur	Small	?
Katla – K	1440		Mýrdalssandur	Small	?
Katla – K	1416		Mýrdalssandur	Medium	?
Katla – K	1357		Mýrdalssandur	Medium	?
Katla – K	1262		Mýrdalssandur	Big	?
Katla – K	1245		Mýrdalssandur	Small	?
Katla – K	1179		Mýrdalssandur	Small	?
Katla – K	11??		Mýrdalssandur	Small	?
Katla - K,S	934		Mýrdalss/Sólheimas	Big	5?
Katla – K	920		Mýrdalssandur?	Medium	?
Katla – K	8??		Mýrdalssandur?	Small	?
Katla – S	8??		Sólheimasandur	Small	?
Katla – S	7??		Sólheimasandur	Medium	?

O'Connor and Costa (2004) reported that the 1918 Katla jökulhlaup was the world's largest known historic flood caused by volcanism. However, based on resident's descriptions recorded in annals, the jökulhlaup produced during the 1755 Katla eruption was probably larger (Guðmundsson and Högnadóttir, 2006).

In comparison, the 1996 jökulhlaup on Skeiðarársandur, south of Vatnajökull (see Fig. 1), attained a peak discharge of ~53,000 m^3s^{-1} (Magilligan et al., 2002). It demolished one bridge (Fig. 4b) and partially another, destroyed many kilometres of road and cut electrical services and phone lines. Fortunately, no one was injured.

Figure 3. A boulder that was transported over 15 km on Mýrdalssandur during the 1918 Katla eruption. The Mýrdalsjökull icecap can be seen in the background on the left-hand side of the image. Photo taken by Guðrún Gísladóttir.

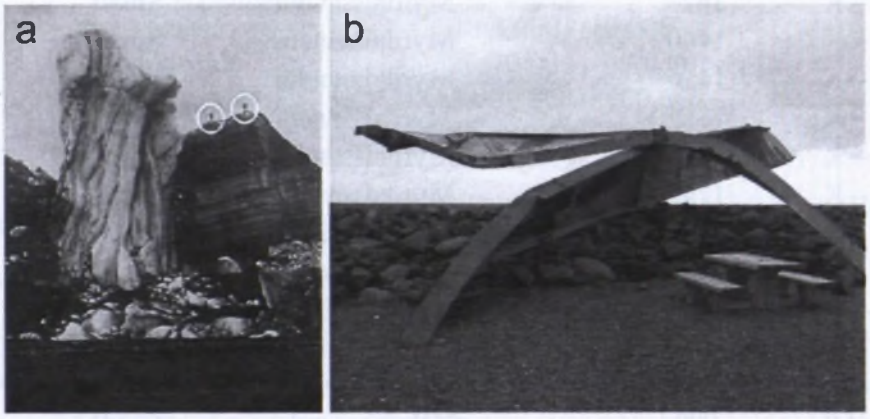

Figure 4. a) Blocks of ice that were broken off the glacier margin and transported onto Mýrdalssandur during the 1918 Katla eruption. The circled areas show men standing on top of the ice blocks. Original photo taken by Ljósm K. Guðmundsson on 17/11/1918 (Thorarinsson, 1977). b) Twisted metal debris from a bridge destroyed during the 1996 jökulhlaup on Skeiðarársandur, south of Vatnajökull (Wikipedia, 2009).

In addition to jökulhlaup, Katla eruptions have produced heavy tephra fall approximately 20 cm thick to distances of 30 km (Guðmundsson et al., 2008). Larsen (2000) however, considers lightning as the greatest hazard to people and livestock in areas within 30–40 km of the eruption site.

High levels of seismicity and crustal deformation suggest that Katla is in a heightened state of activity and an eruption, without prolonged precursory signals, is expected in the near future (Sturkell et al., 2008; Sturkell et al., 2009).

1.3.2 Emergency management

Regional Civil Protection committees and Chiefs of Police are responsible for developing and implementing local emergency preparedness and response strategies in conjunction with the municipal authorities and ICP. Because all historic jökulhlaup flooded Mýrdalssandur and Sólheimasandur, specific evacuation and response plans were developed and exercised for the communities situated in these southern and eastern regions since at least 1973 (Jóhannesdóttir, 2005). However, no plan existed for communities located in the western zone, Markarfljótsaurar.

In light of the recent activity relating to Katla, the regional Chief of Police and ICP committee requested a volcanic hazard assessment to investigate the possible threat to local communities to the west. This request was made on 23 December 2002 and a steering committee was appointed on 4 February 2003 to manage the hazard assessment (Guðmundsson and Gylfason, 2005). The committee requested 19.5 million Icelandic krona (ISK) in funding to complete the investigation and on 8 July 2003 approval was given by the Minister of Justice (Guðmundsson and Gylfason, 2005).

The hazard assessment included a flood simulation model based on geomorphological and sedimentological investigations. The results of the model indicate that the entire outwash plain of Markarfljótsaurar would be inundated for over 24 hours with a peak flood depth reaching 45 m in the gorge close to the outlet glacier Entujökull and 1-2 m in the inhabited areas (Guðmundsson and Gylfason, 2005). The model was also used to assess jökulhlaup hazard for communities in the southern and eastern zones.

Overall, the western, southern and eastern jökulhlaup hazard zones encompass approximately 1,000 km^2, 40 km^2 and 350 km^2 and contain approximately 1,900, 53 and 500 residents

respectively (Guðmundsdóttir et al., 2010). In order to facilitate the evacuation of these residents, an engineering consultancy company was contracted to investigate travel times and traffic delays (Sigthorsson et al., 2006). This was done for a number of scenarios based on different reaction and preparation times, summer and winter conditions and number of travellers in the area.

Based on the information from the flood and traffic simulation models, evacuation strategies were developed for the communities located in the western hazard zone and updated for communities in the southern and eastern hazard zones. To test the newly developed strategies, full-scale evacuation exercises were conducted in March 2006.

1.3.3 The surrounding communities

As of December 2008, Iceland's population stood at 319,756 with 2,716 people living in the municipalities around Mýrdalsjökull (Statistics Iceland, 2009a). This includes 619 children under the age of 18 years, 504 people aged 18 to 30 years, 682 people aged 31 to 50 years, and 911 people aged 51 years and over. However, it is difficult to ascertain if these figures are correct because people who are registered in this region might reside elsewhere. It is not uncommon for younger Icelandic residents to be registered at the family home but live in the capital city of Reykjavik or internationally for education and work.

Since the last major eruption of Katla in 1918, local communities surrounding Mýrdalsjökull are considered to be more vulnerable as they have become reliant on critical lifelines such as water and electricity and, transport and communication infrastructure (Jóhannesdóttir, 2005). Many families are also reliant on agriculture, which further exacerbates their vulnerability. This region encompasses important agricultural communities that collectively include 37% of the country's cattle, 36% of the country's horses and 17% of the country's sheep (Statistics Iceland, 2009b).

Adding to the population at risk is the tourism sector. During 2008 a total of 491,135 overnight bookings were recorded by registered accommodation establishments in this region (Statistics Iceland, 2009c). This record does not include unregistered campers, campervans or visitors staying with friends and colleagues and it is therefore likely to be far greater.

The short warning time of a Katla eruption will place tremendous stress on emergency management agencies. It is estimated that they will have only 1–1.5 hours to execute

evacuations and road closures (Fig. 6) (Guðmundsson et al., 2008). As the possibility of a major subglacial eruption increases with time, Katla represents a significant hazard to the surrounding population (Russell et al., 2009), international flight paths which cross southern Iceland (Sturkell et al., 2009) and the increasing number of tourists who frequent the adjacent areas (Guðmundsson et al., 2008).

Figure 5. Agriculture is an important industry in southern Iceland. This photo shows sheep grazing in Álftaver with the Mýrdalsjökull ice cap and the underlying Katla volcano in the background. Photo taken by Guðrún Gísldóttir.

Figure 6. Gate on the main highway which will be closed during a Katla eruption to prevent vehicles travelling across the jökulhlaup flood path on Mýrdalssandur. Mýrdalsjökull can be seen in the background. Photo taken by Deanne K. Bird.

1.4 The thesis

1.4.1 My journey

The ideas behind this research began during my candidature in 2003 as a Macquarie University exchange student at the University of Iceland. Shortly after my arrival, I worked in a part-time job providing tourist information, sales and guiding, and was introduced to the drama and beauty of the south coast of Iceland. While fording the many rivers in Þórsmörk (Fig. 7), a valley to the west of Mýrdalsjökull which is described in Chapter 6, and ice hiking, climbing and snowmobiling on the outlet glacier Sólheimajökull (see Fig. 2), I learnt about Katla and its devastating hazards.

During an ice hiking trip on Sólheimajökull I witnessed one of the rescue teams, which are so prevalent in Iceland (see www.icesar.com), conducting field-based search and rescue training. This provoked many thoughts about safety, particularly that of the tourists. I realised that I had no idea what to do or how to react if Katla erupted. I had been living in Iceland for 6 months and I had not seen any emergency response information for tourists despite having worked in the industry all that time.

Figure 7. A mountain hut area in Þórsmörk with Mýrdalsjökull in the background. During 2007, a total of 21,505 overnight bookings were recorded in Þórsmörk. This included 12,179 local and 9,326 international tourists (Statistics Iceland, 2007, personal communication). Please note: the record for overnight bookings includes registered accommodation only; it does not include unregistered campers or campervans, or visitors staying with friends and colleagues. Photo taken by Deanne K. Bird.

After formulating some ideas I contacted my past professors at the University of Iceland. I met with Professor Magnús Tumi Guðmudsson who was incredibly helpful. Magnús gave me a copy of the freshly printed report entitled 'Hættumat vegan eldgosa og hlaupa frá vestanverðum Mýrdalsjökli og Eyjafjallajökli' ('Volcanic eruptions and Jökulhlaup from the Western part of Mýrdalsjökull and from Eyjafjallajökull') (Guðmundsson and Gylfason, 2005). Magnús also referred me to Professor Guðrún Gísladóttir, with whom I had never met, as he believed that she would be interested in this research proposal.

I met with Guðrún in July 2005 and we discussed my ideas about emergency response in the tourist region of Þórsmörk. I was delighted to discover that Guðrún shared my excitement for the research and agreed to supervise my project. Considering that this was the first hazard assessment and emergency response plans for the western region, we decided to include residents living in the western jökulhlaup hazard zone in the survey. Consequently, I began my Master of Philosophy (MPhil) degree at Macquarie University, and embarked on the journey of interviewing tourists and residents in regards to Katla, volcanic hazards and emergency response procedures in Iceland.

However, previous work conducted by Johannesdottir (2005) showed that despite the development of evacuation strategies since 1973 for the southern and eastern hazard zones, there have been few exercises to test these plans. This study also found that collaboration and trust was limited between local residents and civil authorities and that residents did not consider that the evacuation plan and communication strategies were appropriate. These plans had been developed by regional and national officials from ICP without proper consideration of the social context (Jóhannesdóttir, 2005) and based on the report edited by Guðmundsson and Gylfason (2005) it appeared that the 2006 plans were developed similarly.

I therefore considered it necessary to undertake a more in-depth and rigorous approach that encompassed all communities in the hazard zones. As a result, I upgraded to a Doctor of Philosophy (PhD) through a Co-tutelle agreement between the University of Iceland and Macquarie University. This joint agreement was the first of its kind between these two institutions.

The threat that Katla poses to the adjacent regions, the lack of information available to tourists and the apparent insufficient use of data from a social context in developing the new and revised emergency response plans, provide the conceptual basis for this research.

1.4.2 Theoretical background and research approach

The proposed evacuation exercises for the western, southern and eastern jökulhlaup hazard zones in March 2006 were considered as an ideal platform to examine residents' knowledge and perceptions and how issues such as trust influence behavioural response. In order to encapsulate the diversity of stakeholders that might be involved during a Katla emergency, the research includes interviews with residents, tourists, tourism employees and emergency management agencies (ICP, regional Chief of Police, the president of the Icelandic Association for Search and Rescue and the Director for Communication for the Red Cross, among others).

To facilitate a successful response to the evacuation exercises with respect to public participation, emergency management agencies communicated information about the hazard, risk and proposed response strategies through town information meetings and news media (e.g. newspaper, radio and television) (K. Þorkelsson and R. Ólafsson, personal communication, 2006). Such communication programs aim to promote appropriate behavioural response to imminent or long-term hazards.

Many communication programs however, are based on the assumption that people do not adopt personal preparedness measures and protective action recommendations because they lack knowledge of the hazard or misperceive the risk (Lindell and Perry, 2004). Therefore emergency management agencies assume that by communicating information about hazard and risk people will be motivated to adopt the recommended procedures (Smith, 1992). This approach to emergency management is naïve in that it does not take into account people's social and cultural perspectives and existing beliefs (Gudykunst, 1998; Lindell and Perry, 2004; McGuire et al., 2003; Mileti et al., 1975; Mileti and Sorensen, 1990; Sorensen and Gersmehl, 1980).

To gain an understanding of the complexities of human behaviour during emergency situations, Lindell and Perry (2004) reviewed various theoretical perspectives and conceptual models dealing with social influence, behavioural evaluation and choice, attitude-behaviour relationships and information seeking behaviour that influence people's actions. The information derived from this analysis was then integrated into the Protective Action Decision Model (PADM). This model attempts to characterise the way people typically make decisions about adopting preparedness measures or protective action in response to environmental cues (such as earthquakes preceding a volcanic eruption) or risk communication messages.

The PADM describes a sequential process of decision making, starting with the pre-decisional stage and followed by cognitive processing of risk identification, risk assessment, protective action search, protective action assessment and protective action implementation. This process is influenced by the interpretation of environmental and social context variables in addition to the characteristics of the information sources and channels, message content and receiver characteristics.

By examining these components of the PADM, emergency management agencies can gain a better understanding of how different groups (e.g. tourists, tourism employees and residents) of the population at risk will respond to an environmental cue or risk communication messages. As such, the research presented within this thesis investigates hazard knowledge, risk perception, adoption of preparedness measures, behavioural response to hazard and warnings, and education. This is done in an attempt to identify some of the social and cultural variables that influence people's decision making process and behavioural response to environmental cues and risk communication relating to Katla. To achieve this, the research adopts a pragmatic approach, which is defined as a deconstructive paradigm that focuses on 'what works' as the truth regarding the research problem under investigation (Teddlie and Tashakkori, 2009).

Pragmatism is not committed to any one system of philosophy. Instead it allows the researcher to focus attention on the research problem and apply all approaches available to investigate the issues at hand (Creswell, 2009). This freedom of using the best methods to address the research problem enables the researcher to apply qualitative and quantitative methods of data collection and analysis. Labelled as mixed methods research, both qualitative and quantitative data are used to provide the best understanding of a research problem.

Although the psychometric paradigm increased understanding of people's response in relation to risk and provided a new language for analysing risk perceptions (Gregory and Satterfield, 2002; Slovic, 2000), the restrictiveness of the questionnaire and the researcher defined rating scales do not provide deep and meaningful responses (Bickerstaff, 2004). As such, they do not capture the true complexity of risk perception and methods more sensitive to the context are required (Horlick-Jones et al., 2003). Consequently, an increasing number of researchers have been incorporating qualitative methods such as participant observations and interviews (e.g. Haynes et al., 2007, 2008; Johnston et al., 2005).

In light of the recent developments in risk perception and behavioural response research, this thesis uses mixed methods research to explore the varying factors that might influence the decision making process to warnings associated with Katla. The initial phases of field work presented in this thesis were conducted in 2006 prior to, during and after the evacuation exercises. This field work incorporated qualitative methods of observation and semi-structured interviews in an attempt to understand the complex behavioural response to communication and emergency response procedures. The subsequent phases of field work conducted in 2006, 2007 and 2008 involved a more quantitative style assessment, using face-to-face questionnaire-based interviewing techniques.

Personal experience in conducting face-to-face, structured questionnaire-based interviews also contributed to the development of this research approach. Presented in the paper by Bird and Dominey-Howes (2008), I had previous experience as a researcher in developing and testing the use of a questionnaire for assessing people's knowledge and perception of tsunami hazards and risk in Australia. This experiential knowledge provided a basis from which I developed the methods in this thesis.

Although it is considered important to productively incorporate this experience (Maxwell, 2005) it is also essential that it does not limit the research design. In this respect, the exploratory approach used during the initial phases of the research in 2006 provided greater understanding to the research problem and as such, contributed to the development of the methods used in 2006, 2007 and 2008.

Using this approach, the research aims to generate information that is valuable to emergency management agencies for the ongoing development of risk communication, hazard warnings and emergency response plans for southern Iceland.

1.4.3 Outline

This thesis is the culmination of a series of papers (three published and two submitted for publication) which are presented in chapters 2 to 6 and are outlined in Table 3. Chapter 2 further explores the theoretical background to the research, describes methods used to construct questionnaires for exploring the social dimensions of hazard and risk, and highlights the benefits of mixed methods research. Chapter 2 also describes a pilot study where the

questionnaire is tested for its usefulness in generating valuable information. Chapter 3 investigates volcanic hazard and risk in relation to tourism in Þórsmörk. Chapter 4, 5 and 6 focus on residents' knowledge and perceptions in the case study regions Rangárvallasýsla, Álftaver and Vestur-Skaftafellssýsla respectively (Fig. 8). Chapters 3 to 6 address the overall aim of the research and based on the findings in each of these chapters, recommendations are made to facilitate improvements in risk communication and emergency response in southern Iceland.

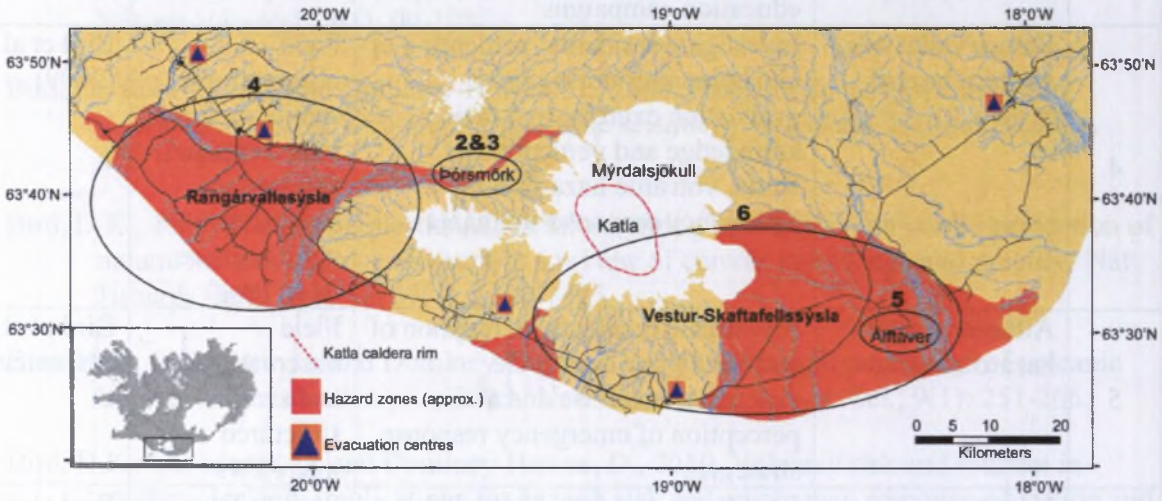

Figure 8. Jökulhlaup hazard zones around the Mýrdalsjökull icecap. The encircled regions identify each case study. This includes Þórsmörk (2&3) and Rangárvallasýsla (4) in the western hazard zone and Álftaver (5) and Vestur-Skaftafellssýsla (6) in the eastern and southern hazard zones. Numbers correspond to each chapter listed in Table 3.

In order to demonstrate how this thesis represents a coherent body of work, Chapter 7 summarises the research as a whole, including the key findings, limitations and suggestions for future work. The contents and formatting of each paper have not been modified from the published or submitted versions. Each paper is therefore formatted according to journal requirements and includes its own reference list. For consistency, reference lists are also provided at the end of this chapter and chapter 7.

Chapters 2 to 6 begin with an overview of the corresponding paper, an account of how the ideas evolved and an outline of my contribution to the research and photographs from the case study.

Table 3. Thesis outline and aims

Ch.	Case study	Broad Aim	Methods	Reference
2	Þórsmörk, western hazard zone	Review techniques available for developing and implementing questionnaire surveys	Literature review and pilot investigation	Bird (2009)
3	Þórsmörk, western hazard zone	Investigate tourists' and tourism employees' knowledge and perception of Katla, volcanic hazards and emergency response strategies prior to rigorous education campaigns	Face-to-face structured questionnaire interviews	Bird et al. (2010)
4	Rangárvallasýsla, western hazard zone	Investigate residents' perception of and behaviour during the evacuation exercise and their knowledge and perception of Katla, volcanic hazards and emergency response strategies	Field observations, semi-structured interviews and face-to-face structured questionnaire interviews	Bird et al. (2009)
5	Álftaver, eastern hazard zone	Investigate residents' perception of and behaviour during the evacuation exercise and their perception of emergency response strategies	Field observations and semi-structured interviews	Bird et al., (in review-a)
6	Vestur-Skaftafellssýsla, southern and eastern hazard zones	Investigate residents' knowledge and perception of Katla, volcanic hazards and emergency response strategies	Face-to-face structured questionnaire interviews	Bird et al., (in review-b)

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Chapter 2

The use of questionnaires for acquiring information on public perception of natural hazards and risk mitigation – a review of current knowledge and practice

The following chapter consists of:

- Overview
- Motivations and contributions
- Images from the case study
- The paper -

Overview

The paper presented in this chapter has been published in the journal *Natural Hazards and Earth System Sciences*[1]. Drawing from the social and behavioural sciences literature, this research reviews current knowledge and practice for developing and implementing questionnaires. After highlighting methodological details, which should be included in research articles to allow comparison and reproduction, a questionnaire is developed and tested in a pilot investigation during August and September 2006. The questionnaire is designed to assess tourists' knowledge and perception of Katla, jökulhlaup hazards and evacuation strategies in the case study region of Þórsmörk in the western hazard zone. Twenty four tourists and 16 tourism employees were interviewed in this case study.

[1] Erratum to the published paper is as follows:

The word 'participants' has been misplaced in Table 7 page 1313. In the 'Telephone' row and 'Advantages' column the point should read 'Less threatening than face-to-face' while the 'Disadvantages' column should read 'May create class or gender bias amongst participants'.

Motivations and contributions

Based on my experiences discussed in Chapter 1, I developed the idea of conducting this investigation within the tourism sector. I developed the questionnaire, in consultation with Guðrún Gísladóttir and Dale Dominey-Howes, and set about testing its usefulness by interviewing tourists and tourism employees in Þórsmörk in 2006.

During this period I felt that the process of learning how to develop and implement a questionnaire had been an invaluable experience and one which was not addressed in the literature pertaining to natural hazards research. As a result, this paper evolved.

All interviews, data entry and analysis were conducted by me and I wrote the manuscript. In addition to my supervisors' critical reviews, Thomas Glade (editor) and two anonymous reviewers provided insightful comments which significantly improved the manuscript from the original. I addressed all suggested amendments and responded to each reviewer's comments.

The introductory cover letter and, the tourism employees and tourist questionnaires are provided in Appendix B, C and D respectively.

The paper was accepted for publication in the journal of *Natural Hazards and Earth System Sciences* on 6 July 2009 and is available electronically via the journal's website.

The following selection of photographs is included in order to set the scene for the study presented in this chapter. The first photograph shows one of the many hiking paths located around Þórsmörk. The second photograph highlights the view of Eyjafjallajökull from one of the mountain hut areas in Þórsmörk. In the third photograph the researcher is using a footbridge that provides access from one mountain hut area to the next. Finally, the fourth photograph depicts a gorge carved out by Fremri Emstruá. As detailed in the previous chapter in section 1.3.2, it is estimated that a catastrophic jökulhlaup will reach a maximum depth of 45m within this gorge.

Photographs from the case study

Hiking paths leading up to the Entujökull outlet glacier (photo taken by Deanne K. Bird)

Mountain hut in Þórsmörk with Eyjafjallajökull in the background
(photo taken by Deanne K. Bird)

Crossing one of the braided glacial rivers in Þórsmörk (photo taken by Guðrún Gísladóttir)

The Fremri Emstruá river transports meltwater and sediment from Entujökull to the Markarfljót river (photo taken by Deanne K. Bird)

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Natural Hazards and Earth System Sciences

The use of questionnaires for acquiring information on public perception of natural hazards and risk mitigation – a review of current knowledge and practice

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Abstract. Questionnaires are popular and fundamental tools for acquiring information on public knowledge and perception of natural hazards. Questionnaires can provide valuable information to emergency management agencies for developing risk management procedures. Although many natural hazards researchers describe results generated from questionnaires, few explain the techniques used for their development and implementation. Methodological detail should include, as a minimum, response format (open/closed questions), mode of delivery, sampling technique, response rate and access to the questionnaire to allow reproduction of or comparison with similar studies. This article reviews current knowledge and practice for developing and implementing questionnaires. Key features include questionnaire design, delivery mode, sampling techniques and data analysis. In order to illustrate these aspects, a case study examines methods chosen for the development and implementation of questionnaires used to obtain information on knowledge and perception of volcanic hazards in a tourist region in southern Iceland. Face-to-face interviews highlighted certain issues with respect to question structure and sequence. Recommendations are made to overcome these problems before the questionnaires are applied in future research projects. In conclusion, basic steps that should be disclosed in the literature are provided as a checklist to ensure that reliable, replicable and valid results are produced from questionnaire based hazard knowledge and risk perception research.

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1 Introduction

The questionnaire is a well established tool within social science research for acquiring information on participant social characteristics, present and past behaviour, standards of behaviour or attitudes and their beliefs and reasons for action with respect to the topic under investigation (Bulmer, 2004). Within natural hazards research, the questionnaire is a popular and fundamental tool for acquiring information on knowledge and perception (Table 1). However, the questionnaire has been relatively neglected in descriptions of social research methods (Bulmer, p. ix, 2004) – and natural hazard studies are no exception.

Research articles should contain sufficient methodological detail to allow reproduction of or comparison with similar studies. This is impossible to achieve if basic criteria are not disclosed in the article. In a review of methodological issues in research articles on risk perception, Hawkes and Rowe (2008) found that most studies using semi-structured questionnaires lacked specific information on question wording and phrasing. Hawkes and Rowe (p. 637, 2008) questioned: "Can we therefore be sure that differences identified in risk perceptions are due to the differences between the people being questioned, or differences in the framing of the questions posed?" In order to overcome this problem, researchers should provide enough detail on important methodological features such as response format (i.e. open or closed questioning), mode of delivery, sampling technique and response rate in peer reviewed research articles.

If the data generated from a questionnaire are to form baseline indicators, then the method has to be comparable over time with identical wording of questions (Enders, 2001). As Cecić and Musson (p. 41, 2004) highlighted "The point of

Table 1. Examples of the use of the questionnaire survey instrument as a fundamental tool within natural hazard research projects.

Hazard	Location	Purpose of questionnaire	Reference
Volcanic eruption	Montserrat, Caribbean	Explore volcanogenic knowledge and generate perception data on risk communication, management of volcanic crisis, and public behaviour.	Haynes et al. (2008a)
Tsunami	Washington State, USA	Quantify tsunami hazard understanding, knowledge of the warning system and preparedness.	Johnston et al. (2005)
Earthquake	Los Angeles, USA	Assess perception of seismic risk, knowledge, protection responsibilities, adoption of hazard adjustments and adoption intentions.	Lindell and Whitney (2000)
Flood	Celje, Slovenia	Investigate perception of flood frequency and characteristics, concerns, opinions about countermeasures and responsibility, and warning characteristics.	Brilly and Polic (2005)
Landslide	Gran Canaria, Spain	Obtain data on knowledge of what landslides are and where they occur and, perception of future threat and how to respond during an emergency situation.	Solana and Kilburn (2003)
Cyclone	Cairns, Australia	Examine cyclone experience, knowledge, attitudes, the degree and state of cyclone awareness and preparedness.	Anderson-Berry (2003)

having a questionnaire is primarily to have all the data in more or less the same format, which means that all the questions are asked of the whole population of observers in precisely the same way. It makes the collected data comparable within the data set..... as well as between different events (for which the same type of form was used)". Furthermore, international scientific journals request that authors provide enough methodological detail to allow the work to be reproduced (see Elsevier, 2009). Therefore, a copy of the questionnaire should be provided within the text, as an appendix or available electronically (i.e. referenced in the article as available online or via email from the author).

An extensive review of 46 articles which describe results generated from questionnaires related specifically to natural hazards revealed that very few explained the basic techniques employed for their development and implementation (Table 2). The majority of these articles were sourced from keyword (i.e. questionnaire/survey and natural hazards) searches in relevant scientific literature databases (e.g. Elsevier, Science Direct) in addition to journal specific databases (e.g. Disasters, Natural Hazards and Earth System Sciences, Natural Hazards). References in these articles then provided access to additional sources. Articles that had not undergone peer review were excluded (Drabek, 1986). This included articles that referenced an empirical study (e.g. a working paper or project report) for a more comprehensive description of the methods applied. Other articles were excluded due to ambiguity within their description of methods.

Each article was assessed on the basis of whether or not it included methodological detail on response format, mode of delivery, sampling technique and response rate. These techniques were selected because they are described in many social and behavioural sciences texts (see references in Sect. 3 of this article) as some of the basic methods employed during the development and implementation of a simple questionnaire. Access to the questionnaire (whether it is provided within the article or available electronically) was also noted.

The oldest of these articles was published in 1996 and more than half were published within the last two years. All articles were sourced from international, peer reviewed scientific journals. From these articles 65% reported response format, 57% reported mode of delivery, 37% reported sampling technique, 50% reported response rate and 33% provided access to the questionnaire. Overall, only 9% provided all five of these criteria. One article in a leading natural hazards journal simply stated "a questionnaire regarding... was sent to ..." before presenting the results. If the work has been published elsewhere it is common practice to simply

Table 2. A review of 46 questionnaire based natural hazard research articles and the number of articles that provided: response format, delivery mode, sampling technique, response rate, the questionnaire and the total number of articles that include all 5 of these criteria (Akason et al., 2006; Anderson-Berry, 2003; Badri et al., 2006; Barberi et al., 2008; Bird and Dominey-Howes, 2006, 2008; Bruen et al., 2008; Carlino et al., 2008; Davis et al., 2005; Dolce and Ricciardi, 2007; Dominey-Howes and Minos-Minopoulos, 2004; Gaillard, 2008; Gaillard et al., 2008; Glatron and Beck, 2008; Gregg et al., 2004a, b, 2006, 2007; Grímsdóttir and McClung, 2006; Haynes et al., 2007, 2008a, b; Johnston and Benton, 1998; King et al., 2006; Kozak et al., 2007; Kreibich et al., 2005; Kurita et al., 2006; Lam et al., 2007; Leonard et al., 2008; Lindell and Whitney, 2000; Martin et al., 2007; McIvor and Paton, 2007; Meheux and Parker, 2006; Paton et al., 2001a, b, 2008a; Perry and Lindell, 2008; Raaijmakers et al., 2008; Rasid et al., 1996; Solana and Kilburn, 2003; Solana et al., 2008; Thieken et al., 2005, 2007; Tran et al., 2008; Xie et al., 2007; Zhai and Ikeda, 2008).

Year	No. of papers	Response format	Delivery mode	Sampling technique	Response rate	Questionnaire provided	All 5
1996	1	1	1	1	0	0	0
1998	1	1	0	0	0	0	0
2000	1	1	0	1	0	0	0
2001	2	1	0	0	2	1	0
2003	2	1	1	0	2	1	0
2004	3	1	0	0	2	1	0
2005	4	3	3	2	1	2	0
2006	7	5	5	2	1	2	0
2007	9	6	4	4	6	2	1
2008	16	10	12	7	9	6	3
TOTAL	46	30	26	17	23	15	4
%		65	57	37	50	33	9

reference the original source by stating "a more detailed description of the whole questionnaire can be found in . . . ". But frustratingly some of the original articles did not provide this "detailed description". Instead, they refer the reader back to the other article thus creating a circular form of referencing lacking in valuable detail.

With growing concern about climate change and its potential effect on increasing natural hazard frequency and magnitude (IPCC, p. 110–111, 2007) the time has come to provide a clear template for questionnaire development and implementation for researchers investigating public knowledge and perception of, and response to, natural hazards. This is because the development of appropriate mitigation and adaptation strategies will not evolve from the physical sciences alone but rather in combination with an understanding of public knowledge and perception of hazard and risk (Anderson-Berry, 2003; Barberi et al., 2008; Bird and Dominey-Howes, 2006, 2008; Brilly and Polic, 2005; Dominey-Howes and Minos-Minopoulos, 2004; Gregg et al., 2007; Johnston et al., 2005; Lindell and Whitney, 2000; Solana and Kilburn, 2003) and behaviour when faced with hazards (Chester et al., 2008; Gaillard, 2008; Gaillard et al., 2008; Gregg et al., 2004b; Haynes et al., 2008a; Lavigne et al., 2008; McIvor and Paton, 2007; Paton et al., 2008b).

This article reviews current knowledge and practice for developing and implementing questionnaires. Following a brief discussion on approaches to social science research, consideration is given to the key features in developing questionnaires, choice of the most appropriate mode of delivery, employment of sampling techniques, data analysis and piloting the questionnaire. To illustrate these aspects, a case study examines methods chosen for the development and implementation of questionnaires for obtaining information on knowledge and perception of volcanic hazards in a tourist region in southern Iceland. Key findings from this pilot investigation are presented, followed by a review of the questionnaire's design and interview process, and concludes with recommendations for future studies. Finally, a review of survey research on the human dimension of risk and related methodological issues is presented.

2 Approaches to social science research

Approaches to social research can be qualitative or quantitative. Philosophical assumptions, strategies of enquiry and specific research methods define the variations between the two (Creswell, 2003). Hanson (2008), however, argues that these sociological approaches have converged. Certainly, one can be integrated within the other (e.g. Haynes et al., 2007) in order to strengthen research design (Patton, 1990). This mixed methods approach (Creswell, 2003) may include sequential procedures (Table 3) whereby a qualitative method is used for exploratory research, followed by a broader quantitative study to produce statistically reliable data that are

Table 3. A summary of quantitative, qualitative and mixed method approaches (after Creswell, p. 3–26, 2003).

	Quantitative	Qualitative	Mixed Methods
Philosophical Assumptions	• Postpositive knowledge claims	• Constructivist, advocacy or participatory knowledge claims	• Pragmatic knowledge claims
Strategies of Enquiry	• Experimental designs • Non-experimental designs e.g. surveys	• Narratives • Phenomenology • Ethnographies • Grounded Theory • Case Studies	• Sequential • Concurrent • Transformative
Specific Research Methods	• Predetermined • Closed, instrument based questions • Performance, attitude, observational and census data • Statistical analysis	• Emerging methods • Open questions • Interview, observation, document, audiovisual data • Text and image analysis	• Both predetermined and emerging methods • Both open and closed questions • Multiple forms of data drawing on all possibilities • Statistical and text analysis
Motivations for selection	• Test a theory or explanation • Identify factors that influence an outcome • Understand the best predictors of an outcome	• Understand a concept or phenomenon due to insufficient or new research • Identify unknown variables	• Generalise findings to a population whilst developing a detailed explanation of the concept or phenomenon

more representative of the population. Alternatively, concurrent procedures combine qualitative and quantitative data collection in order to allow comprehensive analysis of the research question.

Regardless of whether researchers adopt a qualitative or quantitative approach, some aspects of each will be incorporated into research design (Sarantakos, 2005). With respect to questionnaires, qualitative comments (e.g. generated from open-ended questions) can be used to corroborate, illustrate or elaborate on the meaning of quantitative responses (Bazeley, 2006). The following section provides an overview of key features for the development and implementation of a questionnaire with reference to both qualitative and quantitative approaches.

3 Key features for developing and implementing a questionnaire

3.1 Developing a questionnaire

Good questionnaire design is crucial (Bulmer, 2004; Creswell, 2003; de Vaus, 2002; McGuirk and O'Neill, 2005; Oppenheim, 1992; Parfitt, 2005; Patton, 1990; Sarantakos, 2005) in order to generate data conducive to the goals of the research. Questionnaire format, sequence and wording, the inclusion of classification, behavioural, knowledge and perception questions, and questionnaire length and output, need to be considered to ensure reliability, validity and sustained engagement of the participant.

The principal requirement of questionnaire format is that questions are sequenced in a logical order, allowing a smooth transition from one topic to the next (Sarantakos, 2005). This will ensure that participants understand the purpose of the research and they will carefully answer questions to the end of the survey (McGuirk and O'Neill, 2005). This can be accomplished by grouping related questions under a short heading describing the section's theme.

Researchers must decide on question response format. That is, whether to include closed questions, open questions or both. There is debate on the use of open and closed questions within social research (Bulmer, 2004; Vol. 1, Sect. 2). Closed questions are typically difficult to construct but easy to analyse whereas open questions are easy to construct but difficult to analyse (Sarantakos, 2005). Closed questions are often used within quantitative research while open questions are used within qualitative research (Table 3).

Table 4. Examples of various methods used to measure degrees of difference in closed questions (after Sarantakos, 2005; p. 78).

Measurement	Properties	Nature	Nature of underlying construct	Examples	Typical Answers
Nominal	Naming	Categorical	Discrete	Marital status, gender, race, residency	Male, female, single, married
Ordinal	Naming and ranking	Ranking	Discrete or continuous	Income status, achievement, social class, size	Very high, high, moderate, low, very low
Interval	Naming, ranking and equal intervals	Scoring	Continuous	Temperature, calendar time, IQ scores, attitude scales	Scores, Likert scales, degrees
Ratio	Naming, ranking, equal intervals and zero points	Scoring	Continuous	Length, weight, distance, age, number of children	Years, kilograms, kilometres

Closed questions are easy to administer, easily coded and analysed, allow comparisons and quantification, and they are more likely to produce fully completed questionnaires while avoiding irrelevant responses (Sarantakos, 2005). Nominal, ordinal, interval and ratio levels are used to measure degrees of difference in closed questions (Table 4). However, researchers must have a comprehensive understanding of the possible range of participant responses which makes the design of closed questions demanding (de Vaus, 2002). To minimise the effect of limiting participants to predefined answers the options "other, please specify" (McGuirk and O'Neill, 2005), "don't know" or "not applicable" should be included where appropriate (Oppenheim, 1992). Clear instructions should be given which describe how participants are expected to answer closed questions e.g. *please choose only one response from the list provided.*

Advantages for open-ended questioning include freedom and spontaneity of answers, opportunity to probe and usefulness for testing hypotheses about ideas or awareness (Oppenheim, 1992). Open questions allow time and space for free-form responses which invite participants to share their understandings, experiences, opinions and interpretations of, as well as their reactions to, social processes and situations (McGuirk and O'Neill, 2005). However, given that a large variety of answers may be provided for any one question, analysis of the results can be challenging. With this in mind, open questions can be asked in a style that directs participants into definite channels without actually suggesting responses (Payne, 1951) e.g. *how many people are there in your family living at this address?*

Overall, a combination of closed and open questions provides the survey write-up with quantifiable and in-depth results. Closed questions produce results that are easily summarised and clearly presented in quick-look summaries while open questions produce verbatim comments adding depth and meaning.

Next to consider is the type of questions to include. Five basic types of questions are classification, behavioural, knowledge, perception and feelings (Table 5). Classification questions related to age, education, occupation and place of residence help place participants in relation to others (Patton, 1990) as well as providing information that may predict the main effects (Parfitt, 2005) revealed from behavioural, knowledge, perception or feeling questions.

To produce reliable and valid results, the wording of each question should be precise and unambiguous to ensure that each participant can interpret its meaning easily and accurately (Payne, 1951). Reliability refers to the consistency of a question; that is, the probability of obtaining the same results if the question is duplicated. Validity refers to whether or not the question measures what it was intended to (Oppenheim, 1992). To achieve reliability and validity, questions should be short, simple and in line with the targeted population's vernacular and avoid problems such as double-barrelled questions (Table 6).

Once the questionnaire has been designed and formatted researchers should reconsider length. The key rule is that the questionnaire should contain as many questions as necessary and as few as possible (Sarantakos, 2005). Every question should have a clear role and purpose (McGuirk and O'Neill,

Table 5. Five basic types of questions that can be asked of a participant (after Patton, p. 290–293, 1990).

Question type	Description	Example
Classification	• Aims to identify the characteristics of the person being interviewed	What is your occupation?
Behavioural	• Aims to discover what a person does or has done	What would you do if an evacuation warning is issued?
Knowledge	• Aims to determine what factual information a person has about a certain subject	Have you heard of the Katla volcano?
Perception	• Aims to understand the cognitive and interpretive processes of people	Do you think this region could be affected by a volcanic eruption?
Feeling	•Aims to explore the emotional responses of people to their experiences and thoughts	How did you feel about leaving your animals during an evacuation?

Table 6. Common problems associated with question wording (de Vaus, 2002, p. 97-99, Payne, 1951).

Problem question	Description	Example
Double-barrelled	• Whereby two questions are incorporated in one	Have you accessed hazard information from newspapers and the internet?
Loaded or leading	• Pushing people to give different answers than they would give if the question had been worded in a more neutral way	You do agree that evacuation exercises should be conducted in this region, don't you?
Negative	• Using "not" in a question making it difficult to understand	Are you not travelling with a guide?
Unnecessarily detailed	• Asking about precise age or income-categories can be used instead such as age groups: 18<30; 30<50 or 50+	What is your exact age?
Dead giveaway	• Questions that contain absolute, all-inclusive or exclusive words or phrases	Could the civil protection do a better job of protecting residents from volcanic hazards?

2005). Questionnaires should take no longer to complete than participants are willing to spend time answering and the interviewer is able to commit (including the time commitment of data entry and analysis).

3.2 Choosing the most appropriate mode of delivery

Each questionnaire mode of delivery has advantages and disadvantages (Table 7) and selection will depend on each mode's suitability to the study and available resources (Oppenheim, 1992). Factors that should be taken into account when selecting delivery mode include sample size and distribution, types of questions, nature of the population, survey topic, availability of resources (e.g. skilled interviewers, equipment, funding) and time constraints (de Vaus, 2002).

Table 7. Advantages and disadvantages of the more common modes of questionnaire distribution within a quantitative framework (after Bird and Dominey-Howes, 2008 and references therein).

Mode of Distribution	Advantages	Disadvantages
Self-administered Mail:	• Cost effective • Greater coverage area • Anonymity • Time to consider responses • Interviewer cannot shape questions	• Limited length • Limited complexity i.e. questions must be brief and self-explanatory • No control who completes the survey • Interviewer cannot shape questions • Response rates can be poor • Difficult to check non-response biases
Email:	• Cost effective especially for the use of colour graphics • Time to consider responses • More complex questions therefore more complex qualitative data • Strong response rate	• Distribution shaped by age, class and gender biases that shape computer use and email patronage • Interviewer cannot shape questions
Administered Telephone:	• Cost effective when compared to face-to-face • More anonymity than face-to-face interviews • Encourage participation • Less threatening than face-to-face participants • Can motivate participants • Questions can be clarified • Question sequenced controlled • Longer verbal responses compared to written • Vague responses can be probed	• Time consuming therefore questionnaire length may be constrained • Question format must be kept simple • Number of response categories in closed questions limited • May create class or gender bias amongst • Telephone surveys are becoming very unpopular in society
Face-to-face:	• Complex questions can be asked • Can motivate participants • Longer verbal responses compared to written • Questions can be clarified • Question sequenced controlled • Vague responses can be probed • Visual prompts can be used • Long questionnaires sustained • High response rates	• Costly • Time consuming • Spatially restricted • Answers may be filtered or censored • Interviewer's presence may affect responses

Initial contact in the form of a cover letter, telephone call or direct approach is the first step to building rapport and motivating participation for any mode of distribution. During first contact, researchers should introduce themselves and their credentials, explain the study and why it is being conducted, reveal why the person was selected for the study, indicate how long the questionnaire will take to complete and the intended use of the results (Dunn, 2005). Due to ethical considerations, participants should be assured that no harm will come to them as a result of their participation and they have the right to anonymity, the right to refuse to answer certain questions and the right to refuse to be interviewed (Oppenheim, 1992).

Table 8. A brief summary of probability and non-probability sampling methods available to the natural hazards researcher (after Sarantakos, 2005: p. 154–166).

	Sampling technique	Description
Probability:	• Simple random	Gives all people within a target population an equal chance of being selected. Methods used to generate this random sample are by lottery, computer etc
	• Cluster	The first groups of clusters are selected and then individual participants are selected from these groups
	• Longitudinal	The same participants from an original sample are studied on more than one occasion
	• Spatial	Sampling people who have temporarily congregated in a specific space
Non-probability:	• Accidental	All people that the researcher accidentally meets during a certain period are considered for the investigation
	• Purposive	Participants who are thought to be relevant to the research are purposively chosen
	• Quota	A "quota" of participants to be chosen from a specific population group is predetermined
	• Snowball	The first participant recommends other people who meet the research criteria

Self-administered questionnaires may contain a further introductory paragraph to help set the scene and guide participants towards answering instructions and definitions (Oppenheim, 1992). Not only do these directions clarify questions and procedures but they also serve to maintain motivation. Questionnaire format and graphic layout is especially significant with self-administered modes as it helps promote response rates (Sarantakos, 2005). Eliciting reliable and valid data relies on developing an attractive and professional design. Self-administered questionnaires may also be delivered to participants by someone in an official position. The questionnaire is then left for the participant to complete at their own leisure.

Questionnaires developed for telephone or face-to-face delivery should contain instructions for participants as well as researchers administering the survey (Oppenheim, 1992). Interviewers should be trained to conduct and deliver the questionnaire to ensure that differences between participant responses is a reflection of their knowledge or perception and not on how the data were collected (Collins, 2003). The interviewer should not be in a position to make judgements, include subjective views or personal bias and convictions (Sarantakos, 2005).

To ensure a high rate of participation with an administered questionnaire researchers should consider approach, explanation, respect, trust and friendliness. Sarantakos (p. 288, 2005) provides a list of issues that may be employed to improve interview response rates. More insightful and valid data will generally be gained from telephone and face-to-face interviews when both the interviewer and participant feel at ease and when the interviewer adopts an active role rather than just asking a list of predetermined questions (Dunn, 2005). Administered questionnaires may also be delivered to groups of participants assembled together (e.g. focus groups).

3.3 Employing sampling techniques

The sampling technique will determine how representative the sample is of the population of interest. In addition to reflecting the population's characteristics such as age, socioeconomic status, education, gender and marital status, a representative sample is one where every member of a population has a statistically equal chance of being selected (Oppenheim, 1992). Probability sampling (Table 8) is best for obtaining a representative sample which allows researchers to make statistical generalisations about a wider population

(de Vaus, 2002). However, not all samples are representative. Some studies need to be conducted on populations whose demographic characteristics are unknown. Non-probability sampling does not allow researchers to make statistical generalisations but it is commonly used when the selection of participants is based on a known common characteristic (McGuirk and O'Neill, 2005; Patton, 1990) but population demographics are unknown. Probability sampling is typically associated with quantitative research while non-probability sampling is associated with qualitative research. However, both forms of sampling can be either quantitative or qualitative and the use of both is common in mixed methods research (Kemper et al., 2003).

The main factors to consider when determining sample size are:

- degree of accuracy (in relation to sampling error and confidence interval) and
- the extent of variation in the population in regard to the key characteristic of the study (de Vaus, 2002).

Sampling error reflects the extent to which the sample differs from the population while confidence level indicates the likelihood of the population parameter lying within the specified range. Statistical tables are used to determine sampling error associated with various sample sizes (e.g. de Vaus, p. 81, 2002). However, these assume that an up-to-date and accurate sampling frame (a list containing all members of the target population) was used, the sampling was faultless, biases have been compensated for, field work was precise and that there is no non-response error (Oppenheim, 1992). In summary, the size of a sample will depend upon theoretical requirements (e.g. sampling error, cluster size, required accuracy of population estimates), precision of the sampling operation, number of sub-group comparisons, nature of the dependent variable and temporal and financial constraints. Statistical assumptions about sampling errors do not apply to non-probability sampling (Oppenheim, 1992).

3.4 Analysing data

Before data analysis, researchers should address non-response error and missing data. Low response rates can be overcome by sending out more questionnaires, careful training of interviewers, use of interpreters and conducting call backs at different times of the day and week. However, these do not overcome the problem of non-response bias. Often non-respondents are characteristically different from responders. To reduce the effect of non-response bias on the analysis, statistical techniques such as statistical weighting and multivariate analysis can be applied (see Oppenheim, p. 106–107, 1992). Alternatively, de Vaus (p. 84, 2002) suggests obtaining information about the non-respondents, using available observational data, gathering information from the sampling frame or exploring known characteristics of the population, in order to neutralise the effect of non-response bias during the analysis.

Missing data may be enclosed within an otherwise complete individual record. Techniques such as listwise (deletion of all data for an entire case that has missing entries) and pairwise deletion (partial deletion of a case for only the missing entries) can be employed to deal with missing data (Oppenheim, 1992). However, before undertaking such methods, researchers should consider missing data bias (i.e. if participant characteristics are different between complete datasets and incomplete ones (de Vaus, 2002)).

Raw data from open and closed questions should be converted into numbers for data entry. Questionnaires may be pre-coded, field coded (coded on the spot by the interviewer) or office coded after the questionnaire has been completed. Coding complex open questions for quantitative analysis involves developing categories and assigning corresponding labels and values to each question (Sarantakos, 2005). A code book with coding instructions should be compiled regardless of whether data entry rests with one or several persons. General principles to incorporate within the instructions include how to deal with queries, a description of the case numbering system and the method for coding multiple-response questions, to ensure that the data are entered accurately by all researchers (Oppenheim, 1992). Continuous checks and cross-checks are a critical part of data preparation and quality assurance protocols, in order to certify that "interesting" findings are not simply due to mistakes in data entry. Common practices such as running frequency distributions on the main variables, range checks for each variable and internal consistency checks help identify inconsistencies within datasets (Oppenheim, 1992).

Once the data have been checked, edited, coded and entered, analysis can begin. Data analysis can be undertaken manually or electronically. The latter, known as computer assisted data analysis (CADA) is most commonly used. The most popular program, offering a powerful, fast and reliable statistical analysis for quantitative data, is *SPSS*® (Statistical Package for the Social Sciences) (Sarantakos, 2007). *SPSS*® can provide a general and descriptive overview of data through "frequency tables" and "crosstabs" while correlation tests assess associations between variables and tests of significance assess whether or not results from the sample can be applied to the population.

Coding verbatim for qualitative analysis may entail one of many methods depending on the approach (e.g. Sarantakos, p. 349–350, 2005). The purpose of coding in qualitative research is to classify and tag text with codes in order to facilitate later retrieval. It is a way of linking data to ideas and from ideas back to supporting data (Bazeley, 2007). Word processing programs such as *Microsoft Word*® are adequate for low-level CADA of qualitative data. However, for more complex qualitative analysis, a range of other software allows researchers to process data similarly to that employed

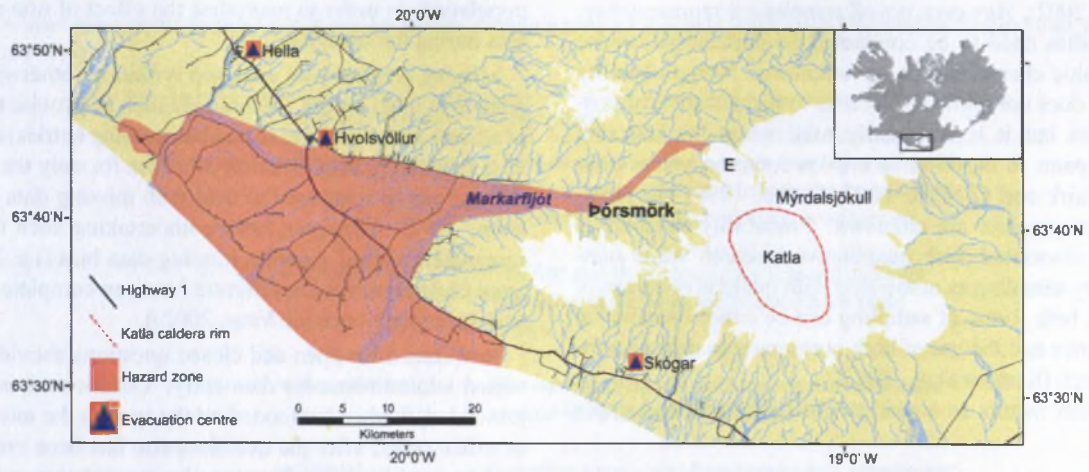

Fig. 1. The tourist destination of Þórsmörk to the west of Mýrdalsjökull in southern Iceland. Highlighted on the map are the western jökulhlaup hazard zone, an outline of the Katla caldera and the three regional evacuation centres in the towns of Hella, Hvolsvöllur and Skógar. One four-wheel-drive road, crossing 10 glacial rivers and tributaries, gives tourists' access to Þórsmörk. Rather than crossing these fast flowing channels, tourists will be instructed to stay in Þórsmörk during a volcanic crisis. They will not be advised to evacuate to the designated centres.

in quantitative analyses (Sarantakos, 2005). For example, the program *NVivo*® allows researchers to undertake projects ranging from fine, deeply reflective analysis to analytical processing of large volumes of data (Bazeley, 2007). Within *NVivo*® researchers can manage data and ideas, perform simple or complex queries and model ideas or concepts graphically.

Analysing datasets from a mixed methods approach to identify apparent themes is referred to as triangulation. This encompasses integrating qualitative and quantitative datasets, comparing multiple qualitative datasets and, multiple perspectives from multiple observers. Triangulation helps overcome the intrinsic bias that is inherent within single-method, single-observer and single-theory studies and as such, offers greater validity (Denzin, 2006). Bryman (2006) advocated the combination of quantitative and qualitative research with the argument that despite the apparent problems and concerns of triangulation the advantages are overwhelming. However, Blaikie (2006) concludes that the use of methods drawn from different methodological perspectives is not legitimate within the same study unless they are used sequentially. Similarly, Hemming (2008) prefers to combine qualitative datasets through "crystallisation" in order to build a more holistic picture of the issue under investigation rather than simply duplicating results to improve validity.

3.5 Piloting the questionnaire

Before embarking on the main study, the questionnaire should be piloted to test its usefulness in providing valuable information that might be relevant to emergency management personnel for the development of risk mitigation and adaptation strategies (Bird and Dominey-Howes, 2008). The pilot phase is also practical for detecting major defects in questionnaire design. Pilot work can be costly but it will avoid a great deal of wasted effort on unintelligible questions producing unquantifiable responses and uninterpretable results (Oppenheim, 1992).

The next section describes a case study whereby questionnaires were developed and piloted in southern Iceland – with specific reference to volcanic hazards.

4 Case Study: Hazard perception in Þórsmörk, a popular tourist destination in southern Iceland

4.1 Rationale

A future eruption of Katla volcano could cause a jökulhlaup (glacial outburst flood) from the western region of the Mýrdalsjökull ice cap and down the river Markarfljót in southern Iceland (Fig. 1). If this were to occur the tourist destination of Þórsmörk would be the first affected. A catastrophic jökulhlaup (with a discharge $> 100\,000\,m^3\,s^{-1}$) on the Markarfljót, triggered by a Katla eruption, would produce a flood height across the floodplain in excess of 20 m, reaching Þórsmörk no more than two hours after the start of the eruption (Guðmundsson et al., 2005). Þórsmörk consists of several valleys and ridges, small mountain hut communities and several hundred kilometres of walking tracks. More than 14 000 overnight stays were recorded during 2006 summer season (Statistics Iceland, 2007, personal communication).

While there is abundant literature on the physical attributes of Icelandic jökulhlaup (e.g. Björnsson et al., 2000; Carrivick, 2007; Eliasson et al., 2006; Guðmundsson et al., 2005; Larsen, 2000, 2002; Roberts, 2005; Rushmer, 2007; Russell et al., 2006; Smith, 2004; Smith and Haraldsson, 2005) little research exists on the social aspects of jökulhlaup hazards and none exists for the tourist region of Þórsmörk. To bridge this gap in understanding, questionnaires were developed and piloted with tourists and tourism employees in Þórsmörk. The aims of this pilot investigation are to: (1) report on the methods chosen for the development and implementation of the questionnaires, (2) briefly summarise the key findings, and (3) review the questionnaire design and interview process making recommendations to improve these in future studies.

4.2 Methods chosen for the development and implementation of the questionnaires

Survey design and format was based on a questionnaire developed and tested by Bird and Dominey-Howes (2008). However, some questions were added while others were adjusted or removed from the original questionnaire in order to suit the regional setting and hazards. The purpose of developing and implementing the questionnaire was to generate data that may be useful to emergency management agencies (particularly the Icelandic Civil Protection (ICP)) for developing risk mitigation strategies around Katla. To identify insights and differences in perceptions between stakeholder groups, distinct questionnaires were drafted for tourists and tourism employees. The proposed contents were discussed with key emergency management personnel from the ICP, Iceland Search and Rescue (ICE-SAR) and local police prior to this pilot investigation and minor adjustments were made according to their comments and views.

To produce quantifiable and in-depth results that will be meaningful to emergency management agencies, open and closed questions were incorporated in the design. Check-box answers were provided for certain closed questions with the option "other, please specify" so as not to limit participant responses to pre-defined answers. To gain an in-depth understanding of knowledge and motivations participants were asked "why", or "if yes/no, can you tell me/can you describe..." following certain closed questions. Where applicable, open questions were used to avoid leading participants into pre-defined answers and to gather more detailed responses. A large variety of nationalities were expected in this region, so where possible diction was kept simple without the use of academic jargon or complicated expressions.

Demographic data such as participant age and level of education were gathered in the first section of each questionnaire. Country of residency was included since the survey was aimed at both local and international tourists and tourism employees. A series of questions were integrated for both groups to assess participant's self protective behaviour, their knowledge and awareness of Katla and jökulhlaup hazards, perception of jökulhlaup hazards in the Markarfljót region and knowledge and perception of evacuation procedures. To be counted as correct, responses had to include the approximate recurrence interval of Katla eruptions and the year of the last eruption. Their definition of jökulhlaup was counted as correct if participants mentioned something about flood water from a glacier. Additional questions were incorporated for the tourist group to gather information on their length of stay and purpose for visiting Þórsmörk. Extra questions in the tourism employee's group collected data on company training, group characteristics and guiding techniques. Electronic copies of both questionnaires are available from the author.

Due to the length of the questionnaire and the nature of the open/closed questioning face-to-face delivery was considered most appropriate. Administering the questionnaires face-to-face prevented participants from taking time to research "correct" answers (since information on how participants would respond in a sudden emergency situation should be generated from this type of survey) and it allowed the interviewer to be more actively involved in data collection.

All participants were selected through a non-probability purposive sampling technique where potential participants working or staying in the Þórsmörk region were approached directly. These people were selected as it was expected that they had an interest in the region or hazard. Within the context of this investigation people located within the remote region of Þórsmörk who could possibly be one of first groups affected by a Katla eruption were targeted.

Due to the lack of demographic data on Þórsmörk tourists it is impossible to determine whether or not this small sample size is representative of the broader population. All hut wardens located in Þórsmörk were approached during this investigation and a response rate of 89% was achieved. An 80% response rate was recorded for the tourist group. Both these figures are high and may be due to the nature of this pilot investigation and the purposive sampling technique.

To determine a questionnaire's usefulness and suitability a pilot investigation should be conducted with approximately 20 participants (Parfitt, 2005). Twenty-four participants in the tourist group and 16 participants in the tourism employees group were recruited for this investigation. Before conducting the questionnaire, participants were required to read a letter which explained the questionnaire's purpose and content, that they could withdraw from the survey at any time without consequence and that no participant would be identifiable through publication of the results. Their approval of these conditions and consent to conduct the interview was indicated by their signature on this letter.

Each question was read aloud by the interviewer and participants were instructed to respond verbally. The interviewer recorded all answers on the questionnaire with any other relevant information communicated by the participant. All interviews were conducted in English during August and

Table 9. A summary of key characteristics and specific survey questions for the tourist group. All data are given as a percentage. Some sections do not equal 100% due to rounding.

Age		
18–30 years old	31–50 years old	51+ years old
42	42	17
What is the highest level of education you have completed?		
Up to high school	University degree	Other
25	63	13
Question		Response=Yes
Are you travelling with a guide while in this region?		25
Are friends/family (or anyone else) aware of your exact location while you are travelling in this region?		83
Do you have your GSM (mobile phone) with you while travelling in this region?		75
Do you carry a satellite phone or another form of communication device with you when travelling in this		4
Have you followed discussions in the media about natural hazards connected to a Katla eruption?		25
Do you know that Iceland is a volcanically active island?		100
Have you heard of Katla?		42
Have you heard of the Icelandic term jökulhlaup?		50
Do you know whether a jökulhlaup warning system exists for the Markarfljót region?		21

September 2006. This time period was chosen as it falls within the tourist high season and therefore, a broad cross-section of nationalities could be sampled.

4.3 Key findings from the questionnaires

Data entry and analysis was carried out using *SPSS*® 15.0. Due to the nature of this pilot study only a brief summary of key findings will be given. It is unclear whether or not these results represent the broader tourist sector. However, they provide baseline data against which future research can be assessed. Questions listed in each result table are written exactly as in their corresponding questionnaire. Results from tourist questionnaires are in Table 9. This includes participant responses to two classification questions in addition to various behavioural, knowledge and perception questions. Results from tourism employee questionnaires are in Table 10. This includes participant responses to two classification questions in addition to company information and various behavioural, knowledge and perception questions.

4.4 Review of questionnaire design and the interview process and recommendations for improvement

Administering the questionnaires via face-to-face delivery, researchers could determine whether or not participants were comfortable with the sequence and structure of questions, questionnaire length and determine if there were any other defects with its design. In general, questions were sequenced in a logical order. However, in the tourist group questionnaire, questions relating to media discussions on Katla should be placed after the question "have you heard of Katla". If the participant answers "yes", then it is appropriate to ask them if they have followed media discussions about Katla. If they state "no", then these questions can be skipped.

A few problems arose with respect to question wording. The first question was inadequately worded although this was overcome by the interviewer. The question simply read "Age?" instead of writing the full question "Within which age group were you on your last birthday?" If the questionnaire was self-administered, then participants would have to

Table 10. A summary of key characteristics and specific survey questions for the tourism employees group. All data are given as a percentage.

Age		
18–30 years old 56	31–50 years old 38	51+ years old 6
What is the highest level of education you have completed?		
Up to high school 37	University degree 44	Other 19
Question		Response= Yes/Correct
Does your company hold regular emergency training in relation to natural hazards associated with the regions where you work?		6
Do you inform your tourists that Iceland is volcanically active?		44
Do you inform your tourists about natural hazards associated with Katla and Mýrdalsjökull?		44
How would you describe a brief eruptive history of Katla?		50
How would you define jökulhlaup?		94
Do you think the Markarfljót could be affected by a jökulhlaup?		100
Do you know whether a jökulhlaup warning system exists for the Markarfljót region?		63
Are you aware of the emergency procedures you need to follow if a jökulhlaup warning is issued?		13
Do you have your GSM (mobile phone) with you while travelling in this region?		81
Do you carry a satellite phone or another form of communication device with you when travelling in this region?		88

add words in order to make an answerable question and this is not desirable since the object is to have all participants answering the same questions (Fowler, 2002). Problems arose with the structuring of one particular question. The question "Do you know whether a jökulhlaup warning system exists for the Markarfljót region?" was confusing for participants. This question should be rewritten as "Does a jökulhlaup warning system exist for the Markarfljót region?" so participants have the opportunity to state "yes" one does exist or "no" one does not exist or simply "do not know".

Overall, the questionnaire took approximately 30 min to complete which was acceptable to the participants. However, some participants took the opportunity to spend more or less time as required. No major defects in questionnaire design were apparent during this pilot investigation.

Some natural hazards researchers preferentially use self-administered questionnaires to prevent participants feeling uncomfortable in front of the interviewer, or natural pressure in giving a "correct" response. However, it is possible that participants may not fully comprehend certain questions (Solana and Kilburn, 2003). If an interviewer is present they may offer assistance if they perceive, through body language or an irrelevant response, that participants do not understand a question. Furthermore, the interviewer will be able to determine whether or not participants comprehend all questions the same way (Collins, 2003). This is a critical factor during the pilot phase as researchers can assess if certain aspects of the questionnaire need to be changed before the main survey is conducted.

Considering that participants within the tourist group came from such varied cultural, ethnical, educational and generational backgrounds it is recommended that future surveys use face-to-face delivery. If the questionnaire is administered only in English then future research should consider non-response bias of non-English speakers. Furthermore, the interviewer needs to ensure that all participants whose first language is not English understand each question as it is intended. It is suggested that future studies consider providing the questionnaire in various languages in order to ensure reliability and validity. However, if a multilingual questionnaire is administered then recruitment of qualified interviewers is essential with appropriate training to reduce bias and error-producing factors, and to encourage accuracy, clarity and inter-interviewer consistency (Sarantakos, 2005).

The purposive sampling technique was considered appropriate for this type of research. However, when considering the temporal distribution of Icelandic tourists in Þórsmörk it would be more representative to conduct interviews throughout the whole year as many visit Þórsmörk during winter. Due to the vast and rugged landscape, targeting potential participants when they were located within the mountain huts was deemed the most logical method for recruitment. If future studies adopt this technique it is advisable to increase the sample size to reduce the effect of over-relying on accessible participants and thereby ensuring a reasonably representative sample (Sarantakos, 2005).

Questionnaires were office coded and data entry and analysis was carried out using *SPSS*® and *Microsoft Word*®. Categories were developed for various open answer questions to enable analysis in *SPSS*®. Due to the small sample size the analysis of the verbatim record was sufficient in *Microsoft Word*®. However, if a larger sample size is obtained and qualitative analysis is required then the use of a program such as *NVivo*® is suggested.

A simple questionnaire, involving a small sample size purposively selected from the population was used in this pilot investigation. This simple questionnaire was used for two main reasons: (1) to provide a working example of the basic techniques employed for developing and implementing a questionnaire and (2) to create a benchmark for future studies on knowledge and perception of Katla in Þórsmörk since this research is the first of its kind to assess volcanic risk and tourism in southern Iceland. Future studies, which incorporate the suggested improvements to the questionnaire, should encapsulate a more rigorous quantitative design with a larger sample size to produce statistically reliable results that are representative of the tourist sector.

While a simple questionnaire was used in this pilot investigation due to the abovementioned reasons, more comprehensive instruments have been designed based on various theoretical frameworks developed in relation to risk perception and disaster research. The following section provides a brief review of the prominent research in the realm of risk perception and discusses related methodological issues with emphasis on the use of the questionnaire.

5 Research on the human dimension of risk and methodological issues

G. F. White's (1945) ground-breaking work on human adjustments to floods pioneered the way for research on the human dimension of risk in multi-hazard environments. Nearly three decades later, Kates (1971) described human behaviour as a key component of the present state of natural hazards research within the international community. Kates (1971) illustrated that the choices made by individuals who occupy hazardous areas are related to their perception, awareness and evaluation of the hazard.

Douglas and Wildavsky's (1982) view that risk perception and risk-related behaviour is primarily a socio-cultural phenomenon has influenced the way in which questions are asked of participants in survey research. Other researchers (e.g. Slovic, 2000b) have employed the psychometric paradigm. This approach to risk perception research applies "psychophysical scaling and multivariate analysis techniques to produce quantitative representations or "cognitive maps" of risk attitudes and perceptions" (Slovic, p. 222, 2000a). However, the disparity between the public's over-reaction to officially designated minimal risks and their under-reaction to adopt preparedness measures despite government warnings, led to the development of the social amplification of risk framework (SARF) (Horlick-Jones et al., 2003).

Introduced in 1988, SARF was developed in an attempt to overcome the fragmented nature of risk perception and risk communication research (Kasperson et al., 2003). To achieve this, an integrative theoretical framework was established to deal with results produced from media research, from the psychometric and cultural schools of risk perception research and, from studies of organisational response to risk. In essence, within the SARF framework, risk experience not only relates to the physical experience of harm but also to the result of processes by which groups and individuals learn to acquire or create interpretations of risk, whether they be attenuated or amplified (Kasperson et al., 2003).

A holistic framework for assessing an individual's awareness of and preparedness for a natural hazard event, and a list of possible data items for inclusion in a tool for data collection, is provided by Enders (2001). This framework, on which questionnaires can be modelled, contains hazard knowledge, attitudes to risk, previous experience of emergencies, exposure to awareness raising, ability to mitigate/prepare/respond and demographic details. In order to provide a more holistic analysis of the emergency awareness and preparedness issue, all of the aforementioned factors must be considered (Enders, 2001).

Regardless of framework, methodological issues in relation to questionnaire development and implementation will occur. After reviewing a multitude of published research on the human dimension of disasters, Drabek (1986) stressed that methodological issues in relation to survey research (e.g. design flaws, inadequate sampling and poor measurement) must be overcome.

Practical, well developed methods of attitude measurement and psychological scaling should be applied in risk perception studies (Sjöberg, 2000). Asserting that it is not difficult to measure beliefs and attitudes about risk perception, Sjöberg (p. 409, 2000) stated: "People can be asked to make ratings of size of perceived risk on a scale, say from 0 (no risk) through a number of defined categories to a maximum risk, perhaps defined as "an extremely large risk". Such ratings have been found to be quite useful."

With respect to design flaws, the careful refinement of questions is an essential part of the research journey when moving from a set of hypotheses to a theory of hazard behaviour (Kates, 1971). This is because different results are generated when question wording differs from one instrument to the next, and often in interpretation (Drabek, 1986).

The conceptual clarification of highly significant independent variables is also essential for homogenous interpretation of questions. For example, Mileti et al. (1975) questioned if "hazard experience" included false warnings or, direct observation and in-depth discussion of a hazardous event that occurred in a neighbouring community.

Broadening the scope of research on hazard experience, both Bourque et al. (1997) and King (2002) discussed the range of issues encountered in post-disaster research. While King's disaster research was based on rapid response studies (i.e. producing results a maximum of a few months after the event), Bourque et al.'s research was conducted between 217 and 712 days following various natural hazard events. Standardised questions are prominent within each study (e.g. questions concerning warnings), but additional, location specific questions are include to generate information on severity, timing, location of the event and regional issues (King, 2002).

Based on a review of 130 post-disaster studies, King (2002) concluded that longitudinal community surveys were the most constructive as they were able to produce a measurement of change in hazard awareness and preparedness over time, and in response to subsequent hazard experience. In order to record this change, the same questionnaire must be used, with only minor modifications.

Bourque et al. (1997) used the replication of common questions, asked in identical or highly comparable ways, in six different questionnaires to examine how residents do or do not differ between geographic areas, time and hazard events. Furthering this analysis, they were able to ascertain the extent to which memory decay or enhancement occurs across time following an event.

When individuals are asked to self-report or self-assess their level of actual hazard awareness, experience and preparedness problems can occur. This is due to the facts that individuals may lack the ability to quantify their actual knowledge or may not be at ease in providing a truthful response (Enders, 2001). Further, participants may instinctively respond yes/no without consideration or may assess their own knowledge or behaviour on a level different to that perceived by emergency management agencies (Enders, 2001). In order to measure actual awareness, experience and preparedness, participants should be asked to describe what they know or what actual preparedness strategies they have adopted.

King (2002) revealed that most post-disaster surveys consist of relatively short questionnaires administered either face-to-face or by telephone. Bourque et al. (1997) advocated the use of telephone interviewing. Although Sjöberg (2000) addressed the problem of interviewer bias, he highlighted that it is predominantly related to unstructured interviews and that interviewers conducting face-to-face or telephone interviews using a structured questionnaire have a relatively minor impact.

Despite the benefits of using structured questionnaires as a tool for generating information on the social aspects of natural hazards, research (e.g. Haynes et al., 2008a; Johnston et al., 2005) has shown that in order to capture the true complexity of a hazard in a societal context mixed methodologies which employ both qualitative and quantitative techniques should be applied. In relation to hazards research, Rohrmann (1998) notes that quantitative and qualitative approaches generate different results and as such are complementary. King (2002) reports that the questionnaire is often supported by other forms of data collection such as interviews, observations and secondary data sources (government reports, emergency management records, census databases etc).

Considering the multitude of studies conducted since 1945, it is obvious that there are many well-designed survey instruments available for generating social data in relation to natural hazards. For example, Rohrmann (2004) provides a list of questionnaires which contain risk propensity and/or risk aversion scales and presents several new questionnaire instruments for examining risk attitudes, behaviour and motivation. Consequently new structures for collecting data are not necessary. However, some form of standardised procedure is required for gathering information, assembling the data and guaranteeing worldwide accessibility to them (Alexander, 1993). It is essential that the research methodology is legitimate and replicable (King, 2002). In order to achieve this, research articles must provide a detailed account of the research methods in addition to providing access to the questionnaire.

6 Conclusions

Despite popular use of questionnaires for acquiring social data in relation to natural hazards, the techniques employed for their development and implementation have been a relatively neglected topic within published research articles dealing with hazards, risk and disaster. In line with Hawkes and Rowe's (p. 630, 2008) findings, "future studies ought to be more comprehensive in the descriptions of their methods". In order to rectify this situation, this article offers a template for researchers responsible for conducting social investigations in natural hazards research. It is not the purpose of this article to provide another best practice questionnaire or review previous instruments in terms of whether or not they can be classed as best practice. However, this article highlights the basic techniques used in developing and implementing questionnaires and it emphasises the need for researchers to provide enough detail on these important methodological features. To achieve this, a review of the social science literature on questionnaires has been provided. Based on this review, it is concluded that research articles, as a minimum, should include:

- Response format (Were open or closed questions incorporated in the design? If closed, what levels were used to measure the degrees of difference? Were participant responses limited by predefined answers?)
- Delivery mode (Was the questionnaire administered or self-administered? If administered, how was interviewer bias minimised?)
- Sampling techniques (Which probability or non-probability technique was used to select the sample? If a probability technique was employed, how representative is the sample of the population of interest?)
- Response rate (How was non-response bias dealt with?)
- The questionnaire as an appendix or available electronically.

In doing so, this will not only allow the work to be compared and/or reproduced but it will also allow us to build on our current understanding, knowledge and practice. As a result, the natural hazards research community will benefit from reliable, replicable and valid results.

Questionnaires can be used to reveal information on public knowledge, attitude, perception, experience and preparedness levels in relation to natural hazards. When this information is combined through a mixed methods approach, robust results can be obtained, which are both comprehensive and quantifiable, adding an invaluable perspective to the development of appropriate risk mitigation and adaptation strategies.

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Chapter 3

Volcanic risk and tourism in southern Iceland: Implications for hazard, risk and emergency response education and training

The following chapter consists of:

- Overview
- Motivations and contribution
- Images from the case study
- The paper -

Overview

The paper presented in this chapter has been published online in the *Journal of Volcanology and Geothermal Research*. This research expands on the pilot investigation conducted in chapter 2 by investigating tourists' and tourism employees' hazard knowledge, risk perception, adoption of personal preparedness measures, predicted behaviour if faced with a Katla eruption and views on education. It incorporates face-to-face structured questionnaire interviews with 116 tourists and 23 tourism employees in Þórsmörk during the period from July to September 2007.

Motivations and contributions

The motivation behind this research was to expand the Þórsmörk case study in chapter 2 so as to provide a more thorough assessment within the tourism sector. The questionnaire used in this

study was slightly modified by me based on the findings highlighted during the pilot investigation. Both Guðrún and I conducted the interviews and I performed all data entry, analysis and compilation. Insightful advice was provided by Pat Bazeley regarding the application of the qualitative data analysis program *QSR NVivo 8®*.

I wrote the paper with advice from both co-authors. Damian Gore and Benjamin Gillespie provided invaluable comments and suggestions which helped improve the research. The paper was critically reviewed by Ilan Kelman and Graham S. Leonard before being accepted for publication. Both reviewers provided thorough and insightful comments. I addressed all suggested amendments and responded to each reviewer's comments as per the journal's specifications. As a consequence, the final paper was greatly improved from the original.

The English and Icelandic introductory cover letters in Appendix E and F and the questionnaires in Appendix G and H were used in this survey.

This paper was accepted for publication in the *Journal of Volcanology and Geothermal Research* on 29 September 2009 and is available electronically via the journal's website.

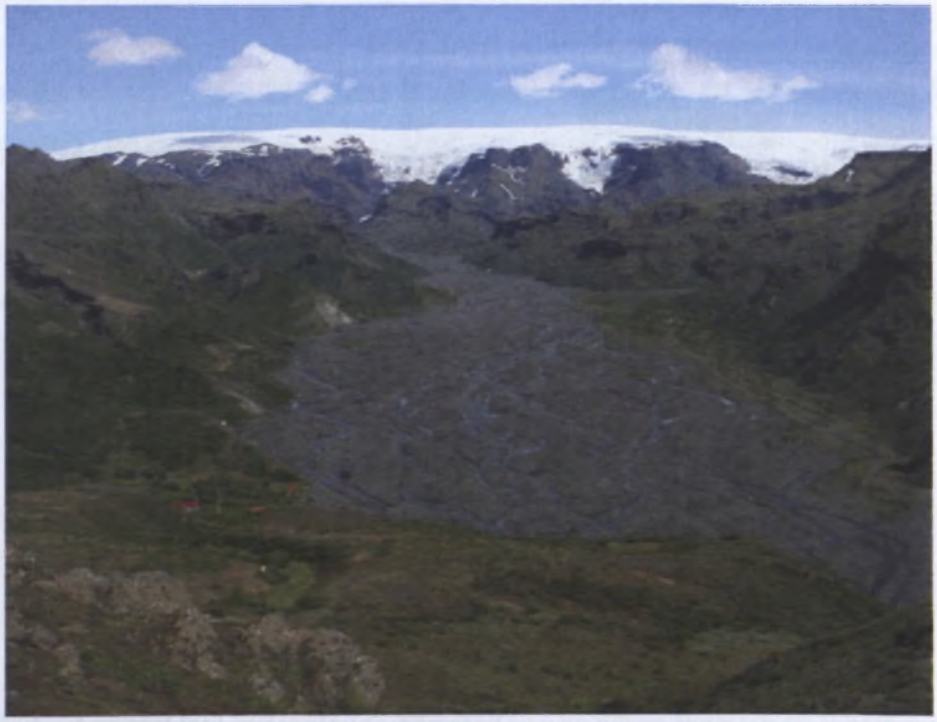
The following selection of photographs is included in order to set the scene for the study presented in this chapter. In the first photograph I am interviewing one of the tourism employees in Þórsmörk. The second, third and fourth photographs are included in order to illustrate the mountain landscape which is characteristic of this region. Two hikers are attempting to cross a glacial river in the second and a rescue vehicle is crossing a glacial river in the third photograph. Finally, the fourth photograph highlights the Mýrdalsjökull icecap in proximity to Þórsmörk.

Photographs from the case study

Interviewing a mountain hut warden in Þórsmörk (photo taken by Guðrún Gísladóttir)

Fording a glacial river on the way to Þórsmörk (photo taken by Deanne K. Bird)

Rescue vehicle crossing one of the glacial rivers in Þórsmörk
(photo taken by Deanne K. Bird)



Þórsmörk and the Mýrdalsjökull icecap (photo taken by Deanne K. Bird)

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Volcanic risk and tourism in southern Iceland: Implications for hazard, risk and emergency response education and training

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ABSTRACT

This paper examines the relationship between volcanic risk and the tourism sector in southern Iceland and the complex challenge emergency management officials face in developing effective volcanic risk mitigation strategies. An early warning system and emergency response procedures were developed for communities surrounding Katla, the volcano underlying the Mýrdalsjökull ice cap. However, prior to and during the 2007 tourist season these mitigation efforts were not effectively communicated to stakeholders located in the tourist destination of Þórsmörk despite its location within the hazard zone of Katla. The hazard zone represents the potential extent of a catastrophic jökulhlaup (glacial outburst flood). Furthermore, volcanic risk mitigation efforts in Þórsmörk were based solely on information derived from physical investigations of volcanic hazards. They did not consider the human dimension of risk. In order to address this gap and provide support to current risk mitigation efforts, questionnaire surveys were used to investigate tourists' and tourism employees' hazard knowledge, risk perception, adoption of personal preparedness measures, predicted behaviour if faced with a Katla eruption and views on education.

Results indicate that tourists lack hazard knowledge and they do not adopt preparedness measures to deal with the consequences of an eruption. Despite a high level of risk perception, tourism employees lack knowledge about the early warning system and emergency response procedures. Results show that tourists are positive about receiving information concerning Katla and its hazards and therefore, the reticence of tourism employees with respect to disseminating hazard information is unjustified.

In order to improve the tourism sector's collective capacity to positively respond during a future eruption, recommendations are made to ensure adequate dissemination of hazard, risk and emergency response information. Most importantly education campaigns should focus on: (a) increasing tourists' knowledge of Katla, jökulhlaup and other volcanic hazards and (b) increasing tourist and employee awareness of the early warning and information system and appropriate behavioural response if a warning is issued. Further, tourism employees should be required to participate in emergency training and evacuation exercises annually. These efforts are timely given that Katla is expected to erupt in the near future and international tourism is an expanding industry in Þórsmörk.

1. Introduction

Tourist destinations have a predilection for locating in scenically spectacular, relatively high-risk areas in order to offer clients access to adventure activities and outstanding views (Murphy and Bayley, 1989). Compared to residents, tourists can be more vulnerable to hazards because they lack hazard knowledge and are unaware of the resources available to protect them (Murphy and Bayley, 1989; Drabek, 1995; Burby and Wagner, 1996). Consequently, during a hazard event, tourism employees play a critical role in ensuring that tourists comply with warnings and emergency response procedures (Burby and Wagner, 1996; Leonard et al., 2005; Johnston et al., 2007; Leonard et al., 2008).

Iceland is becoming an increasingly popular and accessible tourist destination. International passenger numbers (including transit, business as well as pleasure related travel) increased by 49% between 2003 and 2007 (Statistics Iceland, 2009). Due to Iceland's recent "economic meltdown" the tourism industry is expected to thrive because "tourists who saw this remote North Atlantic island as prohibitively expensive are now flocking to its dramatic volcanic scenery" (The Age, 2009). Given that Iceland experiences a volcanic

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eruption every 3–4 years (Guðmundsson et al., 2008), it is essential that risk mitigation strategies incorporate the tourism sector, not only to protect its clients, operators and staff, but also to protect economic interests. Tourism operators should not alarm clients with unjustifiably dire warnings but they do have a moral obligation to apprise visitors of potential hazards and appropriate preparedness measures (Murphy and Bayley, 1989).

Underlying the Mýrdalsjökull ice cap, and located within the heart of a major tourist region, is the Katla volcano (Fig. 1). The last confirmed Katla eruption occurred in 1918 and the volcano has erupted, on average, twice per century during the last 1100 years (Larsen, 2000). Despite two smaller, unconfirmed eruptions in 1955 and 1999 (Björnsson et al., 2000; Russell et al., 2000; Gudmundsson, 2005), Katla is in an agitated state and "an eruption in the near future should not be ruled out" (Sturkell et al., 2008; p. 15).

All recorded Katla eruptions have produced jökulhlaup (glacial outburst floods) that have emanated from the eastern or southern catchments of Mýrdalsjökull. Recent investigations have however identified a threat of jökulhlaup from the western catchment, Entujökull (Guðmundsson and Gylfason, 2005). Consequently, 'town-hall' information meetings were held in 2005/06 and a full-scale evacuation exercise was conducted in March 2006 to help improve the community's collective capacity to positively respond during an event (see Bird et al., 2009 for details). Although an integral part of the region's economy, the tourism sector was *not* considered in these activities.

Due to Þórsmörk's location within the jökulhlaup hazard zone and its proximity to Katla, major concerns exist for tourists and tourism employees (K. Þorkelsson, personal communication, 2006). Consequently, efforts are underway to mitigate the effects of volcanic hazards on the tourism sector. Information brochures entitled "Eruption Emergency Guidelines" (Fig. 2), published in six languages, were posted on the Icelandic Civil Protection Department (ICP) website (www.almannavarnir.is) prior to the main tourist season in 2007 and warning and emergency response strategies were developed. These mitigation efforts however, were based solely on information derived from physical investigations of volcanic hazards. Despite increased interest in the relationship between volcanic risk and human societies (see the Special Edition of the Journal of Volcanology and Geothermal Research, volume 172 edited by Gaillard and Dibben, 2008), volcanic hazard mitigation efforts in Þórsmörk have not considered the human dimension of risk.

In order to address this gap and provide support to current risk mitigation efforts, this paper investigates the relationship between volcanic risk and the tourism sector in southern Iceland. To achieve this, questionnaires were used to assess tourists' and tourism employees' hazard knowledge, risk perception, adoption of personal preparedness measures, expected behaviour if faced with a Katla eruption and views on education. The following section reviews each of these issues and their relevance to the development of effective risk mitigation strategies.

2. The human dimension of risk mitigation

Volcanic eruptions and their associated hazards can be complex and extreme. In order to reduce their impact, it is essential to understand the many factors that influence people's ability to effectively respond to warnings and evacuation orders. A review of literature indicates that the following five issues are particularly important.

2.1. Hazard knowledge

A natural hazard is defined as a "natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage" (UNISDR, 2009; p. 9). Knowledge of a natural hazard does not just include information about the phenomenon and its hazardous processes but also an understanding of the characteristics and behaviour of those processes (Paton, 2006). For example, volcanic hazards include jökulhlaup, tephra, lightning and so forth, while behaviour includes frequency, intensity, duration, precursory period, spatial distribution etc.

When an individual possesses hazard knowledge they are better equipped to decide if and how, they should engage in personal preparedness measures (Siegrist and Cvetkovich, 2000; Paton et al., 2008) and as such, reduce their vulnerability (Blaikie et al., 1994). Research shows people can overestimate their actual knowledge of hazards and therefore overestimate their level of safety (e.g. Johnston et al., 1999). This 'unrealistic optimistic bias' has been identified in volcanic hazard studies where individuals perceive themselves as knowledgeable in relation to volcanic information. Consequently, they believe they are less vulnerable than others, which in turn

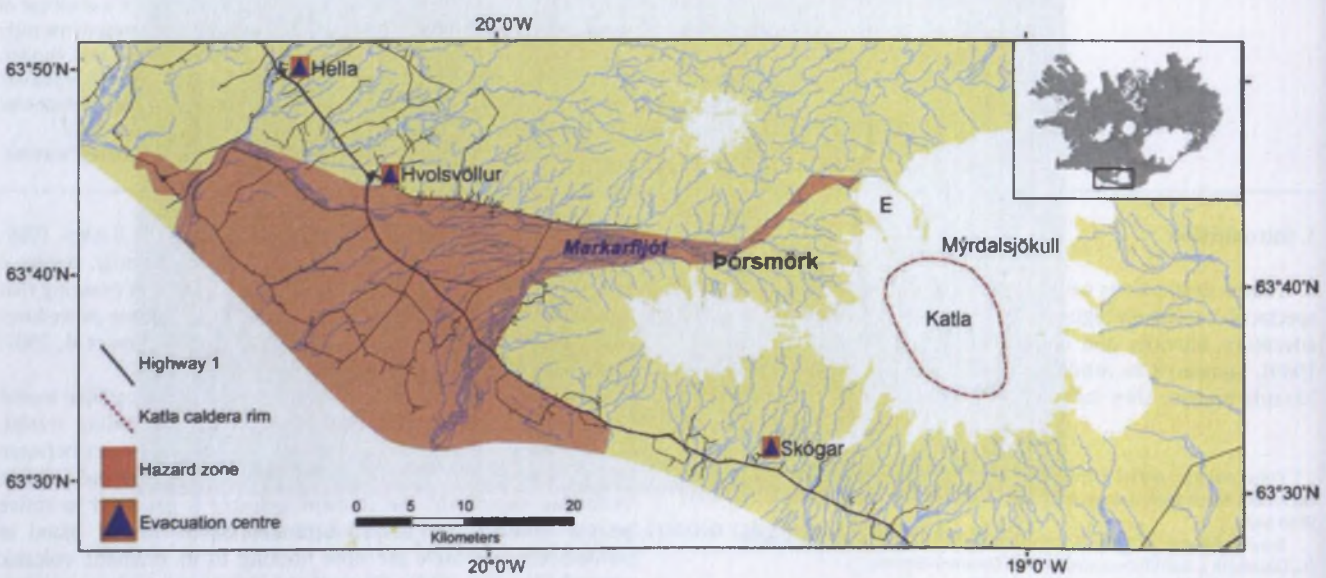

Fig. 1. Katla and the Mýrdalsjökull ice cap in southern Iceland (from Bird, 2009). The jökulhlaup hazard zone from the Entujökull (E) catchment of Mýrdalsjökull encompasses the river Markarfljót and Þórsmörk. Evacuation centres are located in Hella, Hvolsvöllur and Skógar. However, road closures will prevent people from evacuating Þórsmörk and the surrounding region (Fig 2).

Fig. 2. The Eruption Emergency Guidelines (published by the ICP (http://www.almannavarnir.is/displayarticle.do?id=1485).

reduces their acceptance of new hazard information (Johnston et al., 1999; Gregg et al., 2004a; Haynes et al., 2008a; Paton et al., 2008).

Although individuals may be capable of demonstrating basic volcanic knowledge, they may lack an understanding of hazards (Carlino et al., 2008). As such, researchers have recognised that major education efforts are needed to improve hazard knowledge. However, for these to be effective, gaps in hazard knowledge must first be identified.

2.2. Risk perception

Risk is defined as "the combination of the probability of an event and its negative consequences" (UNISDR, 2009; p. 11). Inherent to the cultural theoretical approach (Douglas, 1999), differences in the perception of risk are governed by a person's social context. In contrast, Sjöberg (2000) argued that social context by itself is not the sole determinant of risk perception but rather an expression of specific individual factors such as attitude, risk sensitivity and specific fear.

The perception of risk may be amplified or attenuated as it is communicated and filtered through various channels such as individuals, social groups and institutions (e.g. scientists or scientific organisations, reporters and the mass media, politicians and government agencies) (Kasperson et al., 2003). Direct experience of volcanic hazards may increase risk perception (Johnston et al., 1999; Paton et al., 2001a) but this increase results from the relationship between hazard effects and personal circumstances rather than by volcanic activity per se (Paton et al., 2001b).

Education campaigns have focused on increasing the public's perception of risk in order to increase the adoption of personal preparedness measures (e.g. Johnston et al., 2005) and therefore reduce their vulnerability. However, perceived risk does not necessarily relate to the adoption of these measures (Lindell and Whitney, 2000). While the public might perceive the risk from volcanic hazards, their knowledge of emergency procedures might remain low (Barberi et al., 2008; Carlino et al., 2008; Leonard et al., 2008) and they might not have implemented preparedness strategies (Johnston et al., 2005). Despite this, risk perception is still an important component of risk mitigation (Gaillard and Dibben, 2008) because unless a person perceives the risk associated with a hazardous event, it is highly unlikely that they will be motivated to deal with the consequences (Paton et al., 2006).

A successful understanding of people's perception of risk should aid emergency managers by improving communication networks with the public, by directing educational efforts to where it is needed and by predicting public response to events and new risk mitigation strategies (Slovic, 2000). This paper assesses tourists' and tourism employees' perception of the negative consequences of risk in terms of potential losses for Þórsmörk with respect to a Katla eruption.

2.3. Adoption of preparedness measures

Preparedness is defined as "the knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions" (UNISDR, 2009; p. 9). The adoption of personal preparedness measures to reduce the risk of volcanic hazard consequences may include (among others): knowledge of local alert systems and emergency response plans and, possession of first aid kits and masks for inhalation protection (Perry and Lindell, 2008). However, many factors influence and complicate people's decisions to adopt preparedness measures (UNISDR, 2009).

When hazard preparedness is assumed to be the responsibility of risk management officials, individuals may be less likely to heed warning information, follow hazard emergency response plans or adopt self protective behaviour as opposed to those who take responsibility upon themselves (Mulilis and Duval, 1995; Lindell and Whitney, 2000; Gregg et al., 2004a). People who do perceive personal responsibility might only adopt preparedness measures if they have a positive perception of outcome expectancy (i.e. personal preparation will reduce risk and therefore add value to one's life) and self-efficacy (i.e. the required action is within personal capabilities) (Paton and Johnston, 2001). Furthermore, informing the public of their proximity to volcanic hazards does not guarantee they will take appropriate actions to ensure their own personal safety (Paton et al., 2008).

In order to increase the levels of preparedness it is essential that education campaigns emphasise the population's personal responsibility for self protection. And in doing so, inform them of simple methods that will enable them to achieve a positive outcome that is within their individual limits (e.g. knowing the alert system and emergency response plan).

2.4. Behaviour when faced with a natural hazard

A natural hazard can become a catastrophe when emergency managers have a poor understanding of the public's potential response during a crisis (Haynes et al., 2008a). However, providing people with information on how to effectively respond during a volcanic crisis does not ensure they will do so. While people may have knowledge of the existence of hazard information (e.g. having seen hazard information signs or brochures) it does not guarantee they will recall this information and respond accordingly (Paton and Johnston, 2001).

Inadequate knowledge and high levels of uncertainty and apathy can lead to an unacceptable behavioural response where many individuals fail to respond appropriately (Johnston et al., 2005). Alternatively, when faced with a hazardous event, the public's initial response may be to evacuate before seeking appropriate emergency response information (Brilly and Polic, 2005). Additionally, long periods of quiescence (Gregg et al., 2004b), people's trust in hazard information (Haynes et al., 2008b) or confidence in the emergency plan (Barberi et al., 2008) can affect people's behavioural response when faced with the next volcanic event.

Socio-cultural (e.g. attachment to place, cultural and religious beliefs) or social and socio-economic (e.g. standard of living, strength of people's livelihoods, well-being) factors are also important when considering people's behaviour in the face of a volcanic eruption (Chester et al., 2008; Lavigne et al., 2008). Furthermore, with regard to tourist regions, correct behavioural response from tourists relies in part on mediated information from tourism employees (Leonard et al., 2008). Kelman et al. (2008) reported that tourists who survived the 2004 Indian Ocean tsunami looked to resort employees for guidance.

2.5. Education

Education campaigns inform people about the hazards they face and the preparedness measures and actions they can adopt to mitigate personal risk (Paton et al., 2008). In effect, education campaigns can influence risk perceptions, sense of personal responsibility for adopting preparedness measures and information seeking behaviour (Perry and Lindell, 2008). For that reason, good education can result in greater risk awareness and reduced hazard-related fears (Ronan and Johnston, 2001; Carlino et al., 2008) and as such, can help reduce a community's vulnerability (Blaikie et al., 1994).

Educating people about the natural warning signs that may precede a hazardous event (and therefore provide an early alert to local communities such as earthquakes preceding an eruption) can help improve behavioural response (Gregg et al., 2007, 2006). For example, older community members in Vanuatu recognise and respond to both directly sensed phenomena (e.g. explosive sounds,

gas release, steam plumes, acid rain, earthquakes) and indirect signs of activity (e.g. warm ground, strange activity of birds) as precursory warning signals for an impending volcanic eruption (Cronin et al., 2004). However, education campaigns on natural warning signs should also include information on their reliability or fallibility (Kelman et al., 2008).

Education campaigns often operate on the assumption that a better informed public will transfer into a better prepared public (Paton et al., 2001a), but the public are more than just passive receivers of hazard information (Horlick-Jones et al., 2003; Murdock et al., 2003). Education programs should build on the public's beliefs, needs and expectations rather than providing hazard and risk information that reflects only the knowledge and expectations of the scientific community (Alexander, 2007; Dominey-Howes and Minos-Minopoulos, 2004; Gregg et al., 2004a; Gregg et al., 2004b; Johnston et al., 2005; Paton, 2006; Haynes et al., 2008a; McIvor and Paton, 2007).

Hazard, risk and emergency response information must be issued through multiple sources (Sorensen, 2000; Mileti et al., 2004) because individuals of a heterogenous community prefer to access information from various forms of media (Haynes et al., 2008a). Perceived credibility and public trust in hazard information may be compromised if distribution is limited to only one or two media sources (e.g. radio and newspaper) (Paton et al., 2008). For example, Hoogenraad et al. (2004) reported guidebooks as a preferred source of hazard information prior to and during travel while up-to-date information was sourced from either local residents or the internet. Similarly, Bird et al. (2008) found that residents accessed near-real time hazard information from the internet after radio bulletins broadcasted details of the event.

Additionally, the quality of the relationship between the public and risk management officials and the complementary role they both play in developing appropriate risk mitigation strategies should be considered for the development of appropriate volcanic education programs (Paton et al., 2008).

It is evident from the literature that each of the above factors is interrelated and influenced by other external issues. As such, a holistic approach which considers each of these in a wider social context should be considered in order to develop effective risk mitigation strategies. This is because cultural, economic, political and social factors further influence decision making and affect people's ability to comply effectively with volcanic hazard warnings and evacuation messages (Dibben and Chester, 1999; Chester et al., 2008; Gaillard, 2008; Haynes et al., 2008a; Lavigne et al., 2008).

However, developing comprehensive risk mitigation strategies that encompass all of these factors is unachievable from a resource perspective especially when dealing with a transient tourist population who originate from considerably diverse backgrounds. Consequently, investigating the relationship between volcanic risk and tourism and applying the results to develop appropriate education programs creates a complex challenge for emergency management professionals.

This paper aims to tackle this issue by investigating the relationship between volcanic risk and tourism in Þórsmörk, south Iceland. Before presenting the results generated from the questionnaires and discussing their implications to risk mitigation, a review of volcanic hazards and tourism in Þórsmörk is presented.

3. Geographical congruence of volcanic hazards and tourism in Þórsmörk

Offering a multitude of outdoor adventure activities, Þórsmörk has profited from an increase in international tourism, although local tourism has decreased since 1998 (Fig. 3a). Sleeping bag accommodation and camping facilities are provided at three mountain hut communities. Operators access this area year round while mountain

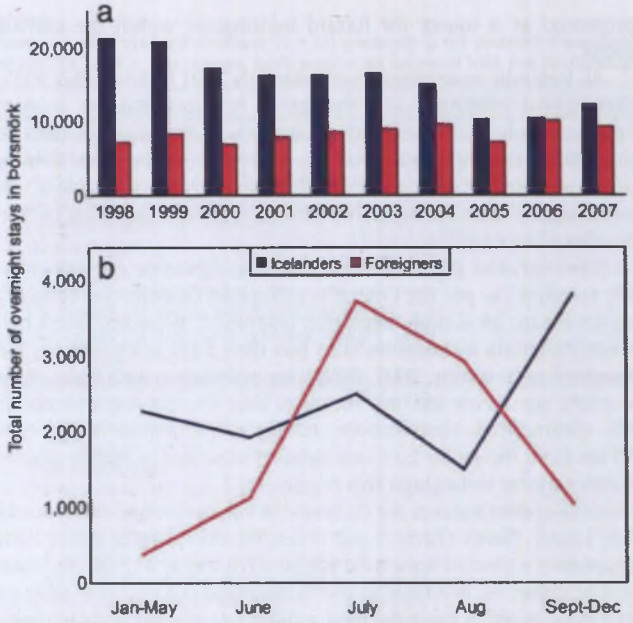

Fig. 3. a) The total number of overnight stays by local and international tourists in Þórsmörk from 1998 to 2007. b) The total number of overnight stays by local and international tourists in Þórsmörk during 2007. Data supplied by Statistics Iceland.

hut wardens manage accommodation facilities during the summer months. A local bus services each of these communities everyday from the beginning of June to mid September and visitation rates of international tourists increase accordingly (Fig. 3b).

Þórsmörk will be affected if a jökulhlaup were to flood to the west of Mýrdalsjökull. A catastrophic jökulhlaup (with a discharge $>100{,}000\ m^3\ s^{-1}$) would produce a flood height across the floodplain in excess of 20 m, reaching Þórsmörk no more than 2 hours after an eruption commences (Guðmundsson et al., 2005). The main threat during a Katla eruption is from jökulhlaup. However, tephra, lightning and blocks of glacial ice (referred to as ice floes in the Emergency Eruption Guidelines brochure, Fig. 2) are also important hazards.

A collection of eye-witness reports (Loftsson, 1930) from past Katla eruptions (1625, 1660, 1721, 1755, 1823, 1860 and 1918) catalogue various hazards which preceded the eruptions and consequent jökulhlaups. Residents described persistent seismic activity of varying magnitudes before observing a great tephra plume rising above Mýrdalsjökull. Prior to the 'massive flood' inundating farming communities, residents witnessed 'terrifying lightning and thunder'. Further, heavy tephra fall obstructed visibility throughout various regions of southern Iceland.

In addition to the Emergency Eruption Guidelines brochures, the ICP released a short film in Icelandic with English subtitles entitled "Katla og Kötluvá" in 2006. This film, available online (www.almannavarnir.is/default.asp?cat_id=197) and in DVD format, highlights facts about Katla, hazards associated with a subglacial eruption, the early warning system and emergency response procedures.

Furthermore, near-real time hazard information is available from the Icelandic Meteorological Office (IMO) website (www.vedur.is) and the Early Warning and Information System (EWIS) website (drifandi.vedur.is). Using results from the South Iceland Lowland (SIL) national seismic network, instrumentally detected earthquakes are automatically displayed on the IMO and EWIS websites within approximately 10 minutes of their occurrence (Bird et al., 2008).

While both the IMO and EWIS websites provide data on seismic and volcanic activities in Iceland, only the IMO website was available in English during the study period between July and September 2007. The IMO website is promoted within Iceland as a valuable site for weather information. However, none of these have been actively

promoted as a source for hazard information within the tourism sector.

An Icelandic newspaper reported in July 2007 (Fréttablaðið, 2007) that hazard education and emergency response training sessions were scheduled but these did not occur with hut wardens until 30 July 2008. During these sessions, emergency procedure training was conducted at each mountain hut community in Þórsmörk and hut wardens were instructed on how to fire warning signals to alert tourists of an eruption.

However, the effect of these warning signals is questionable—the maroons (as per the Emergency Eruption Guidelines brochures), which create an audible explosion on release, were not heard between mountain hut communities less than 3 km apart (various hut wardens, pers. comm., 2007; 2008). In combination with flares, these warning signals are the only means to alert tourists that an eruption has commenced. Furthermore, hiking paths venture more than 10 km from mountain huts and network coverage to mobile phones is inconsistent throughout this region.

Katla and its hazards are discussed in various Iceland travel books. The Lonely Planet (Parnell and O'Carroll, 2007) states that a Katla eruption is expected sometime before 2010 and as a result, the coast will be subjected to a flood of meltwater, sand and tephra in addition to a 'tidal wave'. A more detailed account describing the catastrophic nature of a Katla jökulhlaup is provided in the Rough Guide (Leffman and Proctor, 2007) and Globetrotters (Mead, 2007). Confirming that Katla last erupted in 1918 and stating the frequency of eruptions, both these books also highlight that a Katla eruption is overdue.

4. Methods

Two stakeholder groups were the focus of this investigation: tourists and tourism employees (here after referred to as employees). Specific questionnaires for each group were developed and implemented during a pilot study (Bird, 2009) and suggested improvements were applied to the originals for the current investigation.

The questionnaires were administered face-to-face by two interviewers from July to September 2007. Interviews were conducted in either English or Icelandic and all participants were recruited via a purposive sampling technique (i.e. participants working or staying in the Þórsmörk region were directly approached). This onsite sampling allowed us to target people located in the remote hazard zone of Þórsmörk. In other words, the sample was representative of tourists who could possibly be one of the first groups affected by a Katla eruption.

All visible tourists around the mountain hut were approached by the interviewers. However, it is possible that some tourists passed through the hut while interviews were being conducted. In order to adequately capture the heterogeneity of the population, both single and multiple day visitors were targeted and recruiting took place on weekdays and weekends from morning to late evening.

One representative (i.e. the leader) from each tourist group and all hut wardens working during the study period were asked to participate. Overall, 27 tourists and one employee (hut warden) declined to participate, generating a response rate of 81% and 96% respectively.

Integrating both open and closed questioning, the surveys collected data on participant demographics (e.g. age, residency, language spoken at home, highest level of completed education), general knowledge of volcanic activity and natural hazards in Iceland and more specifically, knowledge and perception of Katla and jökulhlaup hazards. For the Katla knowledge question, an accurate response was recorded if participants gave the approximate recurrence interval of eruptions or the year of the last eruption as 1918, 1955 or 1999. Definitions were given to participants who had not heard of Katla or jökulhlaup hazards.

Risk perception and knowledge of emergency response procedures were also assessed and a variety of questions were used to measure participants' level of preparedness and to consider their behaviour if faced with an eruption. General education questions were also incorporated into each questionnaire. Electronic copies of both questionnaires are available from the corresponding author.

Closed response questions were coded and recorded in *SPSS® 15.0* (Statistical Package for Social Science). Open response questions were recorded in *Microsoft Word®* and imported into *QSR NVivo 8®*. Data analysis consisted of frequency and cross tabulation tables in SPSS. NVivo was used to compare and contrast open response data with closed response. Each question, in conjunction with the results, is described in the next section.

5. Results

Questionnaires were administered to 116 tourists. The majority were residents of Iceland (24%), Holland (11%), France (10%), United States (10%), United Kingdom (9%) and Germany (9%). Respectively, Icelandic, English, Dutch, French and German were the main languages spoken at home (Table 1). Tourist participants were highly educated with 65% having completed a university degree or higher. The main reasons for visiting Þórsmörk were hiking, nature and sightseeing. Nearly two-thirds (62%) were travelling in groups of three adults or less.

Twenty three employees working in Þórsmörk completed the questionnaire. The sample consisted of hut wardens (61%), drivers (26%) and guides (13%). The majority (87%) were Icelandic residents while the international employees were German, Dutch and British. The employee group were less educated than the tourists with only 9% having completed a university degree or higher. However, many participants (26%) stated they were currently enrolled in a bachelor degree while nearly half recorded 'other' for completion of a trade certificate or similar.

5.1. Hazard knowledge

5.1.1. Tourists

Hazard knowledge was assessed by asking participants if they knew Iceland is volcanically active, if they are aware of the natural

Table 1
Classification questions identifying participant demographics. Different stakeholder responses are defined by T for tourist ($n = 116$) and E for employee ($n = 23$). All data are given as a percentage. Some sections do not equal 100% due to rounding.

Participant age	18 < 30 yrs		31 < 50 yrs		51+ yrs	
	T = 36	E = 35	T = 36	E = 48	T = 28	E = 17
Residency	Iceland			International		
	T = 24		E = 87	T = 76		E = 13
Main language spoken at home (tourists only)	Icelandic	English	Dutch		French	German
	24	19	12		11	10
Highest level of education	Up to high school		University degree or higher		Other	
	T = 21	E = 43	T = 65	E = 9	T = 15	E = 48

Table 2
Tourists' knowledge of volcanic activity and other natural hazards in Iceland, Katla and jökulhlaup ($n = 115/116$). All data are given as a percentage. Some sections do not equal 100% due to rounding.

% of participants who know Iceland is volcanically active	100
% of participants who are aware of the natural hazards occurring in Iceland	94
→ % of these participants who correctly stated at least 3 natural hazards	63
% of participants who have heard of Katla	62
→ % of these participants who correctly described Katla	16
% of participants who have heard of jökulhlaup	37
→ % of these participants who correctly described jökulhlaup	98

hazards that can occur in Iceland and if they had heard of Katla and the term jökulhlaup. Open questions, asking participants to describe what they know, followed. This allowed us to assess their actual knowledge.

All tourists stated they knew Iceland is volcanically active (Table 2). Nearly all indicated they are aware of the natural hazards that can occur and nearly two-thirds stated at least three hazards correctly. Volcanic eruption was the most common response (60%), followed by weather (including rain, blizzards and storms) (43%) and earthquakes (35%). Very few mentioned jökulhlaup (or glacial flood) (13%), tephra (3%) or lightning (3%).

Katla was moderately well known with 62% of participants indicating they had heard of Katla but only 16% of these participants could accurately describe a brief history. Far fewer participants had heard of the term jökulhlaup and of those who stated they had, nearly all correctly defined the term. Included in the 37% were participants who did not know the term jökulhlaup but could adequately demonstrate knowledge of one after jökulhlaup was described to them as a glacial outburst flood. These responses included:

- *I haven't heard of the term but I do know about the flooding mud. I saw the film in Skaftafell two times. I didn't know anything about this phenomenon before I came to Iceland. I found it quite fascinating and enjoyed watching it;*
- *I don't know the word but I know about the forceful flood with a lot of mud;*
- *Don't know jökulhlaup but I do know about glacial floods;*
- *I know what a jökulhlaup is but I didn't know the term. It is an extreme flood, forceful, with blocks and sediments, ice blocks and sand;* and,
- *Subglacial eruption causing an enormous amount of water coming from the glacier. I saw part of a video in Skaftafell.*

5.1.2. Employees

Since employees are working and mostly living in Iceland it was assumed that they know Iceland is volcanically active, they are aware of the natural hazards that can occur and they have heard of Katla and jökulhlaup. Therefore to assess their knowledge they were asked to describe a brief eruptive history of Katla and define jökulhlaup. Only 44% could describe a brief history accurately, 30% were incorrect and 26% stated they didn't know. In contrast, nearly all employees (91%) defined jökulhlaup correctly.

5.2. Risk perception

5.2.1. Tourists

Firstly, hazard perception was assessed by asking participants whether or not they think the Markarfljót could be affected by a jökulhlaup. Risk perception was then assessed by asking participants what negative consequences they perceive might occur if a jökulhlaup occurred. A predetermined list of human and biophysical consequences was provided (Table 3) and participants were instructed they could choose as many as they deemed suitable.

The majority of tourists indicated that they think the Markarfljót can be affected by a jökulhlaup and more than half indicated that all human (except tourism) and biophysical impacts will result. Those participants who did not recognise negative impacts on tourism

Table 3
Tourist ($n = 113/116$) and employee ($n = 23$) responses to risk perception questions. All data are given as a percentage. Some sections do not equal 100% due to rounding.

	Tourists	Employees
% of participants who think the Markarfljót could be affected by a jökulhlaup	86	100
% of participants who think a jökulhlaup affecting the Markarfljót region could have the following negative consequences		
Human impacts		
■ Death and injury of people	90	91
■ Damage and destruction to homes and businesses	91	91
■ Damage and destruction to critical lifelines	85	91
■ Damage and destruction to communication networks and infrastructure	69	78
■ Damage and destruction to transport networks and infrastructure	95	100
■ Impacts on agriculture	83	96
■ Impacts on tourism	41	39
Biophysical impacts		
■ Impacts on river systems	91	96
■ Impacts on beaches	71	96
■ Impacts on agricultural land	81	96
■ Impacts on submarine plants and animals	58	70
■ Impacts on natural plants and animals	91	96
% of participants who think the following hazard poses the most serious risk if Katla erupts		
■ Jökulhlaup	60	87
■ Ice blocks	3	0
■ Lightning	0	0
■ Tephra	6	4
■ Poisonous gases	10	0
■ Lava	10	4
■ Tsunami	2	0
■ Earthquake	7	4
■ Don't know	3	0

clarified their response by stating that tourism may benefit from a Katla eruption induced jökulhlaup (i.e. 38% stated both negative and positive impacts may occur while 11% believe a jökulhlaup will yield only positive impacts).

Participants were then asked which hazard they thought would pose the most serious risk. The majority selected jökulhlaup as the most serious and all hazards but lightning were nominated at least once.

5.2.2. Employees

All employees perceive the risk of jökulhlaup on the Markarfljót and the vast majority recognise negative human and biophysical impacts will result. However, only 39% perceive that impacts on tourism will be negative. This response is similar to the tourists' as the remaining employees explained that tourism will also benefit positively:

- *Impacts on tourism will be negative for the foreign tourists as it will scare them away but it will attract Icelanders;* and,
- *Impacts on tourism will be very negative for many years to come. Although, if no one gets hurt and there are ice blocks around then that may attract people to come and see.*

The employee's perception of the most serious threat was more specific than the tourists with 87% stating jökulhlaup and 4% of participants nominating each tephra, lava and earthquake.

5.3. Adoption of preparedness measures

5.3.1. Tourists

An open response question was used to assess whether or not participants adopted safety precautions before travelling in this region. Two-thirds stated they had taken some safety precautions. The most popular responses were: travelling with appropriate

clothing (e.g. wet weather clothes, good hiking boots etc.), registering at the mountain huts, carrying a first aid kit, using a map and hiking experience.

The survey also questioned whether or not participants travelled with a guide or carried a mobile or satellite phone and if someone was aware of their location (Table 4). The results show that very few participants were travelling with a guide, nearly three-quarters carried a mobile phone but only 13% carried a satellite phone. The majority of participants stated they had informed someone of their location while travelling in this region.

Hazard preparedness includes such activities as evacuation and public hazard, risk and emergency response information (UNISDR, 2009). Therefore, participants were asked if they had actively sought hazard and emergency response information. Of those participants who had previously stated they had heard of Katla, only 8% had actively sourced information from the ICP, IMO or EWIS websites and only a third had followed discussions on Katla in the media. Of those who had, newspapers were the most popular source of information followed by television and radio, while some participants stated that they had read about Katla in a guide book. Other comments included:

- *I think they should link this information to the tourist websites to inform people coming to Iceland. I would still come to hike here even if I previously knew about the active volcanoes. This sort of information would not scare me off travelling in the region. I would not travel to a country that is in war but natural hazards occur everywhere around the world and that does not stop people from travelling to those regions;*
- *There is nothing in the 2004 edition of Lonely Planet giving information about natural hazards in Iceland. I am not sure about the 2007 edition. They should have some sort of information there as many people use this book for travelling;*
- *I saw programs on television in Germany about Katla;*
- *They need to have more information brochures and signs for the people so they know what to do in an eruption. At the moment we have nothing. This would be very interesting and I would still come to visit the area. It would not scare me away;* and,
- *They should show a video when you arrive at the park. The ranger should show the video to you about the natural hazards and how they* [tourists] *are to respond.*

Table 4
Tourist ($n = 113/116$) and employee ($n = 22/23$) responses to questions used to measure preparedness. All data are given as a percentage. Some sections do not equal 100% due to rounding.

	Tourists	Employees
% of participants who were travelling with a guide	9	–
% of participants who carried a		
■ Mobile phone	71	61
■ Satellite phone	13	39
% of participants who had informed someone of their location in this region	78	–
% of participants who had accessed hazard information from		
■ ICP website	0	0
■ IMO website	8	48
■ EWIS website	8	41
% of participants who had followed discussions on Katla in the media	34	83
→ % of these participants who accessed this information from		
○ Newspaper	81	74
○ Radio	56	58
○ Television	69	68
○ Internet	25	32
○ Information brochures	0	16
○ Books	19	11
% of participants who stated they knew there was an early warning system	22	52
% of participants who stated they knew the emergency procedures	4	26

Another component of hazard preparedness is knowledge of the warning system and emergency response procedures. Only 22% of participants knew there was an early warning system in place and just 4% stated they knew the emergency response procedures. Participants were not prompted for details on these two questions.

5.3.2. Employees

Tourism employees were also asked if they carried a mobile or satellite phone of which 61% and 39% responded 'yes' respectively. Hazard information was actively sourced from the IMO and EWIS websites by nearly half of the participants but none had used the ICP website. To gain a better idea of website usage, participants who responded positively to using the IMO and EWIS websites were asked if they accessed regional information from each prior to travelling in Þórsmörk. This question was asked because both websites display near-real time hazard information. As a result, 48% of employees who use the IMO website and 33% who use the EWIS website stated that they had actively sourced up-to-date hazard information prior to coming to Þórsmörk.

The majority of employee participants indicated they had followed discussions on Katla in the media and this information was mostly accessed from newspaper, radio and television. Some participants stated they received information from local residents, from the outdoor travel association magazine 'Utivist' and in class at high school. About half the participants knew of the early warning system but only a quarter knew the emergency response procedures.

The employees group were asked additional questions to gain a better understanding of their level of preparedness since they will often be the first authority figure for tourists during a Katla eruption. Employees were asked if their companies provided emergency training in relation to regional natural hazards. Only 17% said 'yes'. Considering that the tourism sector was not involved in the 2006 evacuation exercise, participants were asked if they believe it is necessary to hold another evacuation exercise in order to train regional tour operators and employees. An overwhelming 96% responded 'yes' and most believe these exercises should be held at least once a year. Comments included:

- *Evacuations should be practiced once a year for everyone who works here. It doesn't have to be a full evacuation exercise but rather an information course on what to do and what to look for in case of an eruption;*
- *They should practice evacuation exercises every year at the start of the season (beginning to mid May) and they should publish a brochure with this information;*
- *They should practice evacuation exercises with the tour operators in Þórsmörk or at the very least inform and educate them;*
- *It is necessary to practice the evacuations every year as the staff aren't the same every year;*
- *Evacuations should be practiced every time they open and staff arrive;* and,
- *No it is not necessary to have an evacuation exercise in this area with tour operators as it will affect the tourists who are here and that may be a once in a life time visit for them.*

5.4. Behaviour when faced with a natural hazard

5.4.1. Tourists

To assess the possible behaviour of participants if faced with an eruption, they were asked to describe what they would do if a jökulhlaup warning was issued and how they would react if there was a volcanic eruption (i.e. if no warning was issued, how they would find out what to do). More than a third of participants (the highest recorded response) stated they would go to the highest point if a warning was

issued (Table 5) and more than half would report to the wardens or guide if a volcanic eruption occurred without warning.

5.4.2. Employees

Employees gave similar responses to the tourists in relation to predicted response behaviour if a warning was issued. Comparatively, if an eruption begins without warning more than half of the employees would call the emergency number 112 or the IMO.

5.5. Education

5.5.1. Tourists

Considering that hazard, risk and emergency response education campaigns (e.g. the 2006 evacuation exercise and the Emergency Eruption Guidelines brochure, Fig. 2) are inadequately implemented in Þórsmörk, participants were asked about their willingness to be involved in these campaigns. More specifically, questions were framed around the evacuation exercise with half the participants stating they believe tourists should be included in future exercises. Clarification from some participants who did not believe tourists should be included in a future evacuation exercise included:

- *I don't think they should include tourists in the evacuation exercise. They should just provide them with information about the hazards and the evacuation plan;*
- *They should provide a tourist video in the huts;*
- *They should not include the tourists in these evacuations exercises. It would be hard because people only stay here for 2 days. They should give them information on the buses since the majority of people come in here by bus;*
- *No evacuation exercises but educate in classrooms and hotels with leaflets and information in the hotel lobby*; and,
- *The tourists should be informed as soon as they enter Iceland.*

One aspect of education that was raised by participants was with respect to the video shown in the visitor centre at Skaftafell National Park. Highlighting the Gjálp eruption from Vatnajökull glacier and subsequent jökulhlaup in 1996, this video provides information on subglacial eruptions and their associated hazards such as jökulhlaup, tephra and lightning. All participants who had passed through the visitor centre were very positive about this video and other hazard information available at the centre.

5.5.2. Employees

The employees group questions focused on how they educate tourists. The survey asked if they inform tourists about Iceland's volcanic activity and natural hazards in general, and more specifically natural hazards associated with Katla and Mýrdalsjökull. Only 37% of employee participants discuss Iceland's hazards with tourists while 32% share their knowledge of Katla and the associated hazards. Reasons given for not imparting this knowledge included:

- *We don't tell the tourists about Katla, if we did then nobody would come;*
- *I don't tell the tourists about any hazards. I only tell them about the hiking paths. I would tell them if they asked but that is hardly ever;*
- *They use a CD in the bus from Hvolsvöllur. This informs the tourists of the different natural attractions in the region as well as the natural hazards associated with the volcano. But I don't think it's very informative;*
- *I don't tell tourists about natural hazards in this area. I only tell them if the path is bad*; and,
- *I only inform tourists about hazards if they ask.*

Table 5
Tourists ($n=114$) and employees ($n=23$) predicted behavioural response if faced with a Katla eruption. All data are given as a percentage. Some sections do not equal 100% due to rounding.

	Tourists	Employees
If a jökulhlaup warning is issued, % of participants who would:		
■ Go to the highest point	40	44
■ Escape Þórsmörk	18	30
■ Report to wardens	15	4
■ Follow procedures	12	13
■ Other	14	9
If there was a volcanic eruption at Katla, % of participants who would		
■ Report to wardens or guide	54	13
■ Call an emergency number (e.g. 112) or friend	19	56
■ Listen to radio	9	13
■ Evacuate Þórsmörk	5	13
■ Other	13	4

6. Discussion

In this section the implications of hazard knowledge, risk perception, adoption of preparedness measures, behavioural response and hazard, risk and emergency response education are addressed and their relevance to risk mitigation and the tourism sector discussed.

6.1. Hazard knowledge

The majority of tourists demonstrated general hazard knowledge. However, one-third of the group failed to mention volcanic eruption as a natural hazard despite all indicating they knew Iceland is volcanically active. This suggests that although people know Iceland is volcanically active they do not necessarily think of volcanic eruptions as hazard events. Indeed, unless an extreme event (such as a volcanic eruption) affects people, it will remain a natural occurrence without social significance (Haque and Etkin, 2007). However, it is likely that a future Katla eruption will affect (to some degree) the tourist population. Therefore tourists should be informed of the various hazards that result from a Katla eruption. This will enable them to decide if they should engage in personal preparedness measures and what the best methods for self protection might be.

In the case of Katla, it is particularly important that people know about jökulhlaup in addition to tephra and lightning. However, the tourist participants demonstrated little knowledge of these hazards. Additionally, almost none of the tourists could give a brief account of Katla's history and very few demonstrated jökulhlaup knowledge. This result is significant because hazard knowledge is a critical component of the decision making process (Siegrist and Cvetkovich, 2000; Paton et al., 2008) and as such, these tourists are vulnerable. Possessing knowledge that the volcano is active and an eruption is expected in the near future may influence an individual's decision to adopt personal preparedness measures.

Employee knowledge of Katla was also low with less than half accurately describing a brief history but reassuringly, nearly all correctly defined jökulhlaup. This result will be discussed further with respect to the other four factors that influence people's ability to effectively respond to warnings and evacuation orders.

6.2. Risk perception

Participants from the tourist group revealed a high perception of jökulhlaup hazard and risk, but considering they lacked knowledge of Katla and jökulhlaup, it is difficult to judge their response to the perception questions as it is likely that they were influenced by the interviewers' explanations. Conversely, nearly all employees demonstrated adequate knowledge of jökulhlaup, all perceived the threat of this hazard on the Markarfljót and the majority recognised that jökulhlaup would pose the most serious risk if Katla were to erupt. Overall, it can be stated that the employees demonstrated high hazard and risk perception.

The majority of participants from both stakeholder groups shared the same perception that tourism will benefit positively after a future Katla eruption. In contrast to these results, Dominey-Howes and Minos-Minopoulos (2004) found that many residents feared that negative impacts on tourism will have the greatest community effect following an eruption on Santorini.

To avoid this scenario, tourism agencies need to counteract any negative media and resolve public uncertainty about the safety of the destination and functionality of its services following an extreme event by developing partnerships with stakeholders to manage information and increase confidence. A positive example of this occurred after the 1980 Mount St. Helens eruption where tourism operations increased and diversified. This was achieved through the establishment of comprehensive communication linkages between emergency services and tourism industries with local residents and potential tourists, in addition to the creation of a monument area and construction of a visitor centre (Murphy and Bayley, 1989).

6.3. Adoption of preparedness measures

Safety precautions adopted by most participants were in preparation for extreme weather conditions (i.e. travelling with appropriate clothing) but not specific preparedness measures to deal with the consequences of a volcanic eruption. Precautions such as registering at each mountain hut and carrying a first aid kit may however, provide some aid during any hazardous situation (including volcanic eruptions).

Considering that (a) most participants were not travelling with a guide, (b) network coverage to mobile phones is inconsistent and (c) very few participants carried a satellite phone, mountain hut registration will be an essential element for emergency response capabilities in locating and accounting for every individual during an extreme event. Taking into account that regional hiking trails pass through at least one mountain hut community, registration is a simple and easy preparedness measure for each individual to apply on an almost daily basis.

Essentially, mountain hut registration supports *self-efficacy* and promotes *positive outcome expectancy* for volcanic eruptions as well as other hazardous events such as extreme weather. That is, the required action is within personal capabilities as tourists need apply little effort to use this free service. Additionally, mountain hut registration will provide emergency management officials with vital information for rescue operations. If tourists are registered, they should have a better chance of being located if an extreme event occurs.

Although not effective at mitigating the direct impact of volcanic hazards, mountain hut registration currently provides one of the only sources of information on the number of people in the hazard zone and their approximate location. Regional tourist operators will provide additional sources of information but many tourists travel independently. At present, this practice is encouraged but not enforced, and it is not listed in the Eruption Emergency Guidelines brochure (Fig. 2).

Tourists did not actively seek hazard, risk and emergency response information as personal preparedness. This result is not surprising however, considering knowledge of Katla and jökulhlaup hazards was low. Encouragingly, tourists were positive about receiving information and were not alarmed when provided with details on Katla. Instead, they were curious and interested. Leonard et al. (2005) reported similar results with tourists stating they felt 'reassured' when provided with emergency response information and, despite being involved in evacuation training exercises, they would continue visiting the region.

Although internet and books were not popular media sources for participants who had followed Katla media discussions, they were mentioned by several others. Interestingly, as a reflection of poor dissemination of the educational brochures (they were only available online), not one tourist had accessed information from the 'Emergency Eruption Guidelines' information brochures. Considering the lack of hazard knowledge, and coupled with the inadequate distribution of information prior to and during the 2007 summer tourist season, the lack of knowledge of the warning system and emergency response procedures is not surprising.

Our research suggests that it is essential for the ICP to ensure adequate dissemination of Katla information through all media sources to improve knowledge of the hazards and emergency response procedures. Many studies (e.g. Sorensen, 2000; Mileti et al., 2004; Haynes et al., 2008a; Paton et al., 2008) endorse this recommendation. Additionally, research (Bird et al., 2008) suggests that the public use scientific information available on the internet (i.e. the EWIS website) to verify hazard information broadcast by other media sources (i.e. radio). According to Barberi et al. (2008) the public have greater confidence in scientists' ability to provide accurate information about potential eruptions than either government or media sources.

Employees were a little more active in seeking hazard information from the IMO and EWIS websites but considering they all perceived the risk from jökulhlaup hazards this result (less than half) is not good. More promisingly, the majority followed Katla discussions in the media. However, this did not generate interest in accessing more detailed information from the ICP website. Furthermore, high-risk perception among employees did not translate into knowledge of the early warning system and emergency response procedures. Not surprisingly, tourism companies are not providing emergency training to increase employee awareness.

Nearly all participants were positive about future evacuation exercises and emergency education and they emphasised the necessity to conduct such training every year due to high staff turnover. The importance of regular staff training and exercise due to high staff turnover is supported in the literature (Leonard et al., 2005; Johnston et al., 2007; Leonard et al., 2008).

6.4. Behaviour when faced with a natural hazard

Common sense prevailed among tourists when asked to predict their behavioural response if a jökulhlaup warning was issued. The vast majority stated they would go to higher ground, report to the hut warden or follow procedures. However, considering that very few tourists demonstrated knowledge of jökulhlaup, it is likely that this result is biased due to the description given by the interviewer. If tourists are unaware of jökulhlaup hazards and an eruption warning is issued, it is unlikely they will instinctively go to higher ground.

The tourists were again eager to transfer responsibility to tourism employees when asked how they would react if Katla erupted without warning. In response to both these questions, some participants indicated they would try to evacuate Þórsmörk. Due to the possibility of a jökulhlaup flooding this region approximately 2 hours after Katla erupts and coupled with multiple river crossings along the only access road, it is essential that people do not try to evacuate.

The predicted behavioural response from the employees is of concern. Alarmingly, more participants instinctively responded they would try to escape Þórsmörk than follow procedures if a jökulhlaup warning was issued. Furthermore, if Katla erupted without warning the majority stated they would call an emergency number instead of sourcing information from the radio. However, considering network coverage is inconsistent to mobile phones and few participants carried a satellite phone, this response is unlikely to be viable. Additionally, the capacity of the regional telecommunication system could fail due to oversaturation of the network. Emergency management officials will be relying on the telephone network to broadcast warning messages to residents (Bird et al., 2009).

6.5. Education

Tourists reiterated their interest in receiving emergency information when asked about education strategies. Adding to the discussion on sources for information in Section 6.3, many participants noted the

use of film. Interestingly, the film entitled "Katla og Kötluvá" was not explicitly used by any of the main tourist companies. However, many participants expressed interest in viewing such a film.

The positive opinion toward receiving information counteracts the employees' negativity toward apprising tourists of Katla and associated hazards. These results indicate that the reticence of tourism operators with respect to hazard, risk and emergency information is unjustified. As Murphy and Bayley (1989; p. 38) highlighted, "safety drills and messages have become standard features of sea and air travel". Risk mitigation procedures for high-risk tourist destinations should be dealt with similarly.

One of the contributing factors to community vulnerability is a lack of public information and awareness (UNISDR, 2009). In order to reduce the vulnerability of the tourism community in Þórsmörk better dissemination of hazard, risk and emergency response information is an essential element for future education campaigns.

Demographic data generated from this survey suggests that this information should be provided in Icelandic, English, Dutch, French and German (although all our participants spoke either Icelandic or English). Furthermore, education campaigns should feature detailed information for both stakeholder groups on the early warning system and appropriate emergency response if a warning is issued.

Good education campaigns stimulate people to ask further questions and search for more knowledge (Mileti et al., 2004). Therefore, the IMO and EWIS websites should be promoted as alternate sources for hazard information. Although these sites are passive information sources, they do provide valuable near-real time data on seismic and volcanic activities. As such, tourists and employees can gain access to current scientific information on regional activity prior to and during their visit to Þórsmörk—an extremely important service for identifying the epicentral location of a regionally felt earthquake (see Bird et al., 2008).

Tourist specific education campaigns should focus on providing information on Katla (i.e. that the volcano is active), the regional threat of a future Katla eruption and associated hazards with an emphasis on jökulhlaup, tephra and lightning. However, volcanic education needs to consider the uncertainty of forecasting an eruption (Carlino et al., 2008) instead of reporting a false deadline.

Personal responsibility for adopting simple preparedness measures such as mountain hut registration, possessing knowledge of the local alert system and appropriate behavioural response to emergency warnings should also be emphasised in education programs.

Bearing in mind that tourists might not hear an eruption warning due to their location on a remote hiking trail, education campaigns should include information about natural warning signals including their reliability and fallibility. Various hazards such as earthquakes, lightning and tephra have preceded past jökulhlaup (Loftsson, 1930). As such, this information can provide vital precursory warning signals to an impending jökulhlaup. Therefore tourists and employees should be educated to recognise felt earthquakes, regional lightning, a tephra plume above Mýrdalsjökull or tephra fall throughout the southern region as precursory warning signals for possible jökulhlaup.

Despite employees' limited knowledge of Katla, they demonstrated knowledge and perception of jökulhlaup. Considering effective hazard education is ongoing (Mileti et al., 2004), education campaigns should therefore focus on maintaining knowledge levels and preventing poor knowledge to become engrained. Assimilating ongoing employee education and training strategies into normal practice fosters the successful reduction of community vulnerability (Blaikie et al., 1994).

Employee specific education in Þórsmörk should encourage employees to communicate their knowledge of volcanic hazards associated with a Katla eruption and emergency response procedures. Considering tourists are likely to transfer responsibility for their safety to employees during a future volcanic event it is essential that education campaigns are effective in instructing employees of appropriate emergency procedures.

Employee education and training on how to effectively respond to a warning has been identified as a key component of mitigation strategies within the tourism sector and should be included as an essential part of employee orientation programs (Johnston et al., 2007). This is especially significant for employees working in Þórsmörk due to high staff turnover. Furthermore, staff training, such as an evacuation exercise at the beginning of the tourist season, not only provides valuable feedback for education programs but can also highlight necessary improvements to the warning system (Leonard et al., 2005).

Emergency training and exercises give staff useful hands-on experience on appropriate behavioural response when an eruption warning is issued. Given the possible short time frame between cause and impact (i.e. <2 h), tourism employees must be quick and precise at implementing the warning signal (i.e. maroons and flares).

Since tourism employees will be responsible for mediating official information it is essential that a relationship is established between emergency management officials and tourism operators. Including tour companies in the development of emergency response procedures helps facilitate a solid and trustworthy relationship (Johnston et al., 2007; Paton et al., 2008).

6.6. Limitations

Sampling bias is potentially present within all methods of non-probability sampling including purposive sampling. This potential is eliminated with respect to hut wardens as all but one who were working during the study period participated in the study. However, bias cannot be ruled out for the tourist group or from the small sample of tour guides and drivers included within the employee group.

Tourists passing through the Þórsmörk region were deliberately selected in order to achieve a representative sample of the Þórsmörk tourist population (i.e. they *are* members of the tourist population). However, due to the remoteness of Þórsmörk and the lack of data regarding daily tourist numbers, it is impossible to determine what percentage of tourists participated in the study. Further bias exists within the tourist group since interviews were conducted with only those who were proficient in English or Icelandic.

Hut wardens collect limited data on tourist residency but these records do not provide sufficient information for comparison. Consequently, due to the lack of regional demographic data, it is impossible to determine whether or not the tourist sample is representative of the Þórsmörk summer population overall. Nevertheless, the purposive sampling technique was considered most appropriate due to the study's focus, its remote location and the availability of demographic data.

Risk perception analysis is limited because participants were not asked about their perception of the probability of a future Katla eruption—an important component of risk perception. Future research should incorporate 'eruption probability' questions in order to provide a better understanding of tourists' and employees' risk perception. For example, participants could be asked 'How likely do you think will there be a Katla eruption in the next 10 years?'

Despite these shortcomings, it is important to note the high response rate especially with respect to the employee group (tourists 81%, employees 96%). Not only does this indicate the success of the survey with respect to a low non-response error but also its success in generating interest in the topic. People were willing to give up their free time to respond to the questionnaire. Coupled with people's comments regarding education, it is evident that people are open to receiving and discussing regional volcanic information.

The results of this research indicate that further developments, which incorporate the human dimension of risk alongside the physical, should help improve the tourism sectors' collective capacity to respond during a future Katla eruption. The next section highlights the key outcomes of the research and provides specific recommendations to improve volcanic mitigation in Þórsmörk.

6.7. Key outcomes and recommendations

The key outcomes of this investigation on the relationship between volcanic risk and tourism in Þórsmörk are:

- Tourists lack knowledge of Katla;
- Tourists lack knowledge of jökulhlaup and other volcanic hazards;
- Tourists do *not* adopt preparedness measures to deal with the consequences of a volcanic eruption;
- Tourists lack knowledge of the warning system and emergency response procedures;
- In contrast with the employees' perception, tourists *are* positive about receiving hazard, risk and emergency information;
- Tourists will rely on hut wardens if Katla erupts without warning;
- Employees have a high perception of volcanic risk;
- Employees lack knowledge of the early warning system and emergency response procedures;
- Prior to and during the 2007 tourist season, emergency training was not provided to increase employee awareness of Katla, the early warning system and emergency response procedures;
- Employees are positive about receiving emergency education; and,
- Employees will call an emergency number if Katla erupts without warning.

Based on these key outcomes, our recommendations include:

- Hazard and emergency response information is provided to all tourists travelling in the Þórsmörk region;
- Mountain hut registration is enforced throughout the region;
- Education campaigns focus on:
  - Increasing tourists' knowledge of Katla, jökulhlaup and other volcanic hazards including natural warning signs;
  - Increasing tourist and employee awareness of the early warning system and appropriate behavioural response if a warning is issued;
- Katla information is adequately disseminated through all media sources;
- Preparedness measures listed in the Eruption Emergency Guidelines brochure highlight the importance of *not* evacuating Þórsmörk if an eruption occurs in addition to listing the necessity of mountain hut registration;
- The film "Katla og Kötluvá" is used as an educational tool (e.g. this can be shown on buses accessing Þórsmörk and in mountain huts if facilities exist);
- Guidebooks such as the Lonely Planet and Rough Guide provide correct and detailed up-to-date hazard, risk and emergency response information in consideration of the uncertainty of forecasting an eruption;
- The IMO and EWIS websites are promoted within the tourism industry for near-real time hazard information; and,
- Tourism employees undergo emergency training and evacuation exercises at least once a year.

6.8. Further developments and future research

An information meeting was held on 19 June 2008 with tourism companies operating in Þórsmörk. During this meeting, Katla and the proposed emergency procedures were discussed and instruction on how to fire warning signals was given. This meeting was followed up by onsite instruction at each of the mountain communities in Þórsmörk on 30 July 2008 as discussed in Section 3. Also on this day, the 'Eruption Emergency Guidelines' brochures were distributed to mountain hut wardens throughout Þórsmörk and hazard and emergency response information signs were erected in mountain huts and in prominent positions along hiking trails.

Future research investigations should be conducted to determine whether or not these education strategies are effective at: (a) increasing tourists' knowledge of Katla, jökulhlaup and other volcanic hazards and (b) increasing tourists' and employees' awareness of the warning system and appropriate behavioural response if a warning is issued. To achieve this, a similar questionnaire survey should be used to conduct face-to-face interviews with both stakeholder groups.

7. Conclusion

In Iceland there is an urgency to address the needs of the tourism sector as they are often located in high-risk regions and they lack knowledge of hazards and appropriate emergency response procedures. This is a difficult task considering tourists come from such diverse cultural, economic and social backgrounds. Furthermore, their transient nature increases the complexity of reducing their risk to natural hazards.

Emergency management agencies tasked with the responsibility of developing effective risk mitigation strategies for the region surrounding the Katla volcano are making positive progress toward incorporating the tourism sector in regional planning. However, to achieve a much more effective and comprehensive approach, risk mitigation efforts must incorporate the human dimension of risk alongside the physical assessment of volcanic hazards. This task was not achieved during the development of mitigation strategies in Þórsmörk. This paper addresses this gap and provides support to current risk mitigation efforts by offering the first step toward identifying the relationship between volcanic hazards and the tourism sector.

The results of this study have shown that tourists lack knowledge of Katla, volcanic hazards, the warning system and emergency response procedures and are therefore vulnerable. Furthermore, tourists do not adopt appropriate preparedness measures to deal with the consequences of a volcanic eruption. Despite demonstrating a high perception of volcanic risk, the employees lacked knowledge of the early warning system and emergency response procedures. This result was not surprising however, since emergency training was not provided to increase employee awareness of Katla and risk mitigation. The employees informed us that they are positive about receiving emergency education and, in contrast to the employees' perception, tourists are also positive about receiving hazard, risk and emergency response information.

This research shows that more direct and specific education campaigns are needed to increase knowledge among tourists and employees. Following recent hazard and emergency response education in Þórsmörk, it is necessary to reassess these issues of knowledge and then, based on the results, focus resources where needed to improve the tourism sector's collective capacity to cope with a future Katla eruption.

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Chapter 4

Resident perception of volcanic hazards and evacuation procedures

The following chapter consists of:

- Overview
- Motivations and contributions
- Images from the case study
- The paper -

Overview

The paper presented in this chapter has been published in the journal *Natural Hazards and Earth System Sciences*[1]. This research investigates residents' knowledge and perception of Katla, jökulhlaup hazards and evacuation strategies in the case study region of Rangárvallasýsla in the western jökulhlaup hazard zone. It incorporates:

- Field observations during an evacuation exercise on 26 March 2006.
- Semi-structured interviews with 6 emergency management officials between April and June 2006.
- Face-to-face structured questionnaire interviews with 54 residents from May to October 2006.

Motivations and contributions

I arrived in Iceland in February 2006 and began meetings with key officials from the Icelandic Civil Protection Department and scientists from the Icelandic Meteorological

[1] Errata to the published paper are as follows:

Eyjafallajökull should be Eyjafjallajökull in Fig. 1 on page 252.

Rangávallasýsla should be Rangárvallasýsla on pages 252, 253, 256, 257, 259 and 264.

The 26 March 2008 should be 26 March 2006 on pages 256 and 257.

Office. I learnt that an evacuation exercise was planned for communities located in the western hazard zone on 26 March 2006 and Guðrún Gísladóttir and I were invited to observe the proceedings from the emergency headquarters. We interacted with various emergency management officials during the exercise and held follow-up meetings in order to discuss their involvement in and perception of the exercise. This information and the residents' interviews are presented in this chapter.

I developed the questionnaire used in this study and took an active role as Chief Investigator during the interviews. The lessons learned while developing the questionnaires in Chapter 2, and during previous survey research conducted in 2005 in Australia (see Bird and Dominey-Howes, 2008 referenced in this chapter), helped inform the data collection methods used in the subsequent chapters.

All data entry, analysis and compilation were conducted by me, I produced Figure 1 and I wrote the manuscript. Both co-authors and Damian Gore provided critical reviews of early drafts that significantly helped improve the research. This manuscript benefited from invaluable comments and suggestions from Chris Gregg, Katharine Haynes, Douglas Paton and one anonymous reviewer. I addressed all suggested amendments and responded to each reviewer's comments as per the journal's specifications.

The interview schedule used during the semi-structured interviews with emergency management officials, the introductory cover letter and the resident questionnaire are provided in Appendix I, J and K respectively. Please note: the introductory cover letter in Appendix B was used for the interviews with officials.

This paper was accepted for publication in the journal of *Natural Hazards and Earth System Sciences* on 17 February 2009 and is available electronically via the journal's website.

The following selection of photographs is included in order to set the scene for the study presented in this chapter. The first photograph shows emergency management officials in a meeting during the evacuation exercise on 26 March 2006. The second, third and fourth photograph show two of the farmhouses and one of the summerhouses that are located in the western jökulhlaup hazard zone.

Photographs from the case study

An official meeting during the evacuation exercise on 26 March 2006 at the emergency management headquarters in Hella (photo taken by Deanne K. Bird)

Farmhouse in Fljótshlíð and the low lying road which residents must drive along to the evacuation centre in Hvolsvöllur (photo taken by Guðrún Gísladóttir)

Farmhouse on higher ground in Vestur-Eyjafjöll (photo taken by Deanne K. Bird)

Summerhouse on the Markarfljót floodplain (photo taken by Deanne K. Bird)

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Natural Hazards and Earth System Sciences

Resident perception of volcanic hazards and evacuation procedures

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Abstract. Katla volcano, located beneath the Mýrdalsjökull ice cap in southern Iceland, is capable of producing catastrophic jökulhlaup. The Icelandic Civil Protection (ICP), in conjunction with scientists, local police and emergency managers, developed mitigation strategies for possible jökulhlaup produced during future Katla eruptions. These strategies were tested during a full-scale evacuation exercise in March 2006. A positive public response during a volcanic crisis not only depends upon the public's knowledge of the evacuation plan but also their knowledge and perception of the possible hazards. To improve the effectiveness of residents' compliance with warning and evacuation messages it is important that emergency management officials understand how the public interpret their situation in relation to volcanic hazards and their potential response during a crisis and apply this information to the ongoing development of risk mitigation strategies. We adopted a mixed methods approach in order to gain a broad understanding of residents' knowledge and perception of the Katla volcano in general, jökulhlaup hazards specifically and the regional emergency evacuation plan. This entailed field observations during the major evacuation exercise, interviews with key emergency management officials and questionnaire survey interviews with local residents. Our survey shows that despite living within the hazard zone, many residents do not perceive that their homes could be affected by a jökulhlaup, and many participants who perceive that their homes are safe, stated that they would not evacuate if an evacuation warning was issued. Alarmingly, most participants did not receive an evacuation message during the exercise. However, the majority of participants who took part in the exercise were positive about its implementation. This assessment of resident knowledge and perception of volcanic hazards and the evacuation plan is the first of its kind in this region. Our data can be used as a baseline by the ICP for more detailed studies in Iceland's volcanic regions.

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1 Introduction

The Icelandic term "jökulhlaup" is defined as a sudden burst of meltwater from a glacier and may occur for a period of several minutes to several weeks (Björnsson, 2002). All confirmed historic eruptions of Katla, the volcano underlying the Mýrdalsjökull ice cap in southern Iceland (Fig. 1), have produced jökulhlaup (Thordarson and Larsen, 2007). A Katla eruption can melt through the ~400 m of ice covering the Katla caldera in 1–2 h, producing a catastrophic jökulhlaup with a peak discharge of 100 000–300 000 $m^3 s^{-1}$ (Björnsson, 2002).

Transporting volcanic debris and large ice blocks, jökulhlaup have been the most serious hazard during historic Katla eruptions but not the only hazard. Local communities 30 km from the eruption site have been subjected to heavy tephra fallout and lightning strikes (Larsen, 2000) while jökulhlaup have triggered small tsunami during past volcanic events (Guðmundsson et al., 2008). Earthquakes, felt by local communities, signify the start of an eruption. They are not however, of sufficient magnitude to cause major damage (Guðmundsson et al., 2008). Furthermore, not all Katla eruptions have been subglacial. Lava covered ~780 km^2 of land during the 934–938 AD Eldgjá flood lava eruption which occurred along a 75 km discontinuous and predominately subaerial volcanic fissure extending from the Katla caldera (Thordarson and Larsen, 2007).

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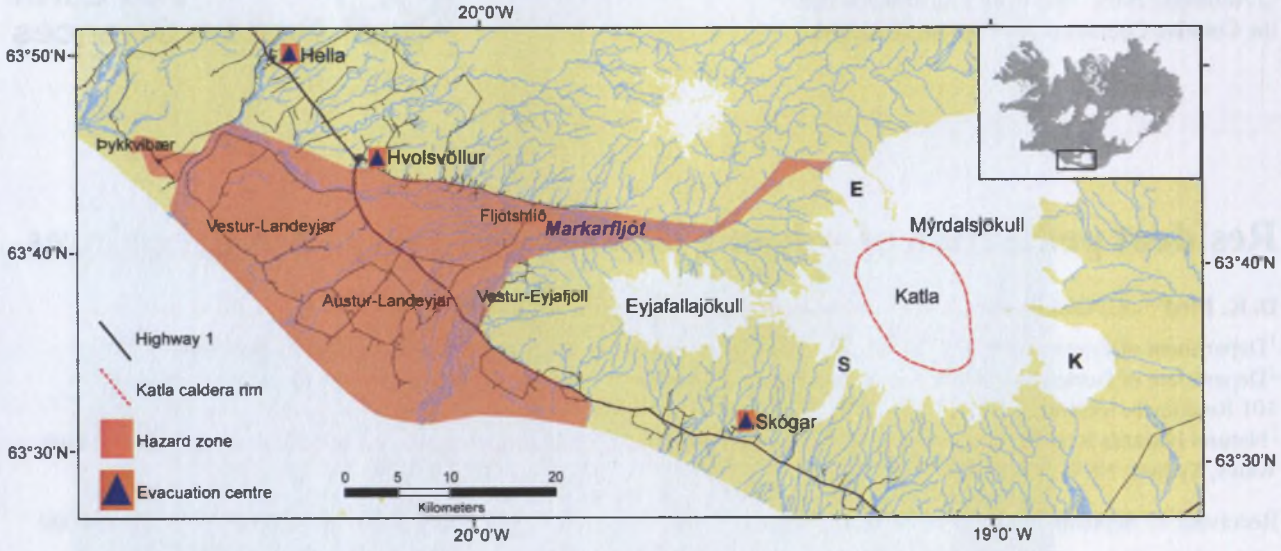

Fig. 1. The jökulhlaup hazard zone of Rangávallasýsla. The hazard zone is determined to be the maximum flood area for a catastrophic jökulhlaup. Communities located within the hazard zone are Vestur-Eyjafjöll, Fljótshlíð, Austur and Vestur-Landeyjar and Þykkvibær. Evacuation centres are located in Hella, Hvolsvöllur and Skógar. The three catchment areas of Mýrdalsjökull: Entujökull, Sólheimajökull and Kötlujökull are represented by E, S and K respectively.

Since settlement in the 9th century Katla has erupted approximately 1–3 times per century (Thordarson and Larsen, 2007). At least 21 eruptions have occurred during this time with the last confirmed eruption in 1918 AD (Larsen, 2000). All historic jökulhlaup have emanated from the catchment areas of Kötlujökull and Sólheimajökull while none have come from the Entujökull catchment. Unconfirmed volcanic activity may have created the jökulhlaup which occurred in 1955 AD and 1999 AD from the Kötlujökull and Sólheimajökull catchments, respectively (Björnsson et al., 2000; Russell et al., 2000; Guðmundsson, 2005).

The Markarfljót valley was subjected to volcanic jökulhlaup emanating from the Entujökull catchment prior to settlement. A series of large, valley-filling prehistoric jökulhlaup were identified by Smith (2004) and Larsen et al. (2005) from sedimentary deposits within the Markarfljót valley. Further, Smith and Haraldsson (2005) determined that the last volcanic jökulhlaup on the Markarfljót occurred 1200 yrs before present. Other types of jökulhlaup have flooded the Markarfljót in more recent times. In 1967 AD, a rock/ice avalanche caused an outburst flood from the proglacial lake of Steinsholtsjökull on the northern flank of Eyjafjallajökull. This flood transported boulders measuring up to 80 m^3 5 km from the rockslide scar (Kjartansson, 1967). Lastly, geothermal meltwater drains from subglacial lakes in small, more frequent jökulhlaup from all three catchment areas (Björnsson et al., 2000).

Flood simulation models based on data from prehistoric jökulhlaup were used to identify peak discharge and temporal and spatial distribution of a possible catastrophic jökulhlaup flooding from the Entujökull catchment down the Markarfljót (Hólm and Kjaran, 2005). This populated farming region forms part of the Rangávallasýsla municipality. The models show that a catastrophic jökulhlaup with a peak discharge of 300 000 $m^3 s^{-1}$ would reach its maximum within 2 h, flooding to a depth of up to 15 m, at the uppermost farms in Fljótshlíð and up to 10 m in Vestur-Eyjafjöll. However, many of the farmhouses in these communities are elevated above the floodplain. In contrast, the roads leading up to these farms parallel the Markarfljót and some sections of these roads are positioned at similar base heights to the river channel. Dykes approximately 2 m in height have been constructed to protect the roads but these flood mitigation structures were not built to withstand a catastrophic jökulhlaup. Within 3 h Highway 1 would be inundated and the entire outwash plain surrounding the Markarfljót would be flooded within 10 h. With a maximum flood depth of up to 2 m, low lying regions could remain submerged for over 24 h.

In view of the potential future hazard presented by jökulhlaup, the Icelandic Civil Protection organisation (ICP) developed regional evacuation strategies based on a worst case scenario as described in the report edited by Guðmundsson and Gylfason (2005). This report and consequent strategies were the culmination of a multidisciplinary investigation into the physical threat of jökulhlaup produced from a Katla eruption. It did not however, include research from a societal aspect. Researchers argue that a collaboration between the physical and social sciences is a key step toward achieving a greater understanding of the consequences of volcanic hazards (e.g. Johnston et al., 1999). Following the investigation

communication sessions were held with residents from communities located within the hazard zone in Rangávallasýsla: Vestur-Eyjafjöll, Fljótshlíð, Landeyjar and Þykkvibær. These consisted of information meetings in 2005 and 2006 regarding the possibility of a future Katla eruption and the proposed evacuation plan for a jökulhlaup hazard. During these meetings residents were informed that they could collect an evacuation and hazard information sign from local police (Fig. 2) (K. Þorkelsson, personal communication, 2006).

If an eruption is imminent residents would be notified via a text message to their mobile phone. If residents do not have a registered mobile phone number a recorded message would call through to their landline. Upon receiving this message residents have 30 minutes to prepare to evacuate. However, if an eruption occurs without precursory activity, residents will be instructed to evacuate immediately. Before leaving, they are required to hang the evacuation sign outside their house to indicate that they have left. Certain residents in each region have volunteered to 'sweep' their local area to ensure their neighbours have left for the evacuation centres located in Hella, Hvolsvöllur and Skógar. In order to reach these centres some residents must evacuate via the roads that parallel the Markarfljót and along Highway 1.

To test the proposed evacuation plan the ICP conducted a full scale evacuation exercise on 26 March 2006 in Rangávallasýsla. Approximately 1200 residents live within the hazard zone (K. Þorkelsson, personal communication, 2006) and for the purpose of fully testing the evacuation plan residents were not informed of the timing of the eruption scenario. Instead residents were instructed to go about their business as usual until they received an evacuation message (R. Ólafsson, personal communication, 2006). The mock eruption began at 10:55 local time (LT) and the first evacuation message was communicated to residents at 10:59 LT. Residents then had 30 minutes to complete the instructions on the hazard sign (Fig. 2) before evacuating their homes to their designated centre.

To improve the effectiveness of residents' compliance with warning and evacuation messages it is important that emergency management officials understand how the public interpret their situation in relation to volcanic hazards and their potential response during a crisis (Ronan et al., 2000; Dominey-Howes and Minos-Minopoulos, 2004; Gregg et al., 2004; Bird and Dominey-Howes, 2006, 2008; Haynes et al., 2008; Paton et al., 2008). Therefore, this study (1) investigates resident's knowledge and perception of Katla, jökulhlaup hazard and their views of the evacuation plan and exercise, and (2) reports the findings to help the ICP improve mitigation strategies. To achieve this, field observations were made during the evacuation exercise, semi-structured interviews with key emergency management officials were held after the evacuation exercise, and questionnaire survey interviews were conducted with local residents. The rationale for using this sequential mixed methods approach is to better understand the evacuation procedure from both a management and public perspective and to develop and implement a questionnaire survey interview to further explore participant views and knowledge. Before addressing the aim of our research we will describe the methods used to conduct the analysis.

2 Methods

A mixed methods approach, drawing from both qualitative and quantitative data collection practices was used to obtain public perception data. We were invited to observe the evacuation exercise from within the emergency headquarters (EH) in Hella in addition to monitoring the proceedings at the evacuation centres (EC) in Hvolsvöllur and Hella. Following the exercise, we conducted semi-structured interviews with emergency management officials and face-to-face questionnaire survey interviews with local residents living within the hazard zone. Public perception research based solely on data generated from questionnaire surveys is unable to capture the complexity of a hazard in a societal context whereas a mixed-methods approach, employing both qualitative and quantitative techniques, provides the researcher with the opportunity to acquire a variety of information on the same topic allowing for a more accurate interpretation of the issues at hand (Horlick-Jones et al., 2003; Haynes et al., 2007). In this section, we describe the methods employed for field observations and interviews followed by those adopted to construct and deliver the questionnaire survey.

2.1 Observing the evacuation exercise

Located within the main EH, we (Bird and Gisladottir) observed and documented the development and management of the evacuation exercise. We were at the EH during the most critical stages of the eruption scenario. As the eruption developed we visited the EC in Hella and Hvolsvöllur to observe the emergency management proceedings of the Red Cross and to witness how the public behaved and responded to the evacuation. Some informal discussions were held with evacuees and Red Cross personnel at both centres. During our observations we made written notes to ensure the most significant points were recorded.

2.2 Interviewing emergency management officials

Follow-up interviews were conducted with the project manager of ICP, the Chief of Police in Rangávallasýsla, the president of the Icelandic Association for Search and Rescue (ICE-SAR), a research scientist involved in the hazard assessment report and coordination of the eruption scenario for the evacuation exercise, a regional manager for the Red Cross, and the Director of Communication for the Red Cross. The format of the interview was semi-structured whereby specific questions were asked about their departments' role in an emergency situation, their role during the exercise,

Fig. 2. Evacuation and hazard information sign distributed to residents located in the volcanic hazard zone surrounding Katla. English translations follow.

A House Evacuation (front)

When a warning is given by the ICP that an eruption in Katla is starting residents and their guests must evacuate within 30 min (15 min for Sólheimar) to the nearest evacuation centre.

- Get the first aid kit, follow this list and secure or collect the valuables you want to take with you.
- Unplug all electrical equipment as well as antennas.
- Set household heaters to a minimum temperature.
- Remove fencing from the house and unplug all electric fences from the house electricity.
- In the space provided indicate how many people have evacuated from this property and the number of vehicles used to evacuate. Fasten this sign on the predetermined spot.
- Check on neighbours if possible and share vehicles to avoid unnecessary traffic. Use vehicles that can drive faster than 50 km/hr.
- Call 112 if there has been an accident or if you need help.
- It is not possible to move animals due to short evacuation time (30 min, except for Sólheimar 15 min).
  - For animals that are housed, open the house and pen for all animals except bulls. Open gates and ensure that they can flee to higher ground.
  - For animals that are outside, open gate and/or cut fences so that they can flee to higher ground.
- Go straight to the nearest evacuation centre and register.
- Listen to announcements and news on radio.

Number of people evacuated from house: Number of vehicles used for evacuation:

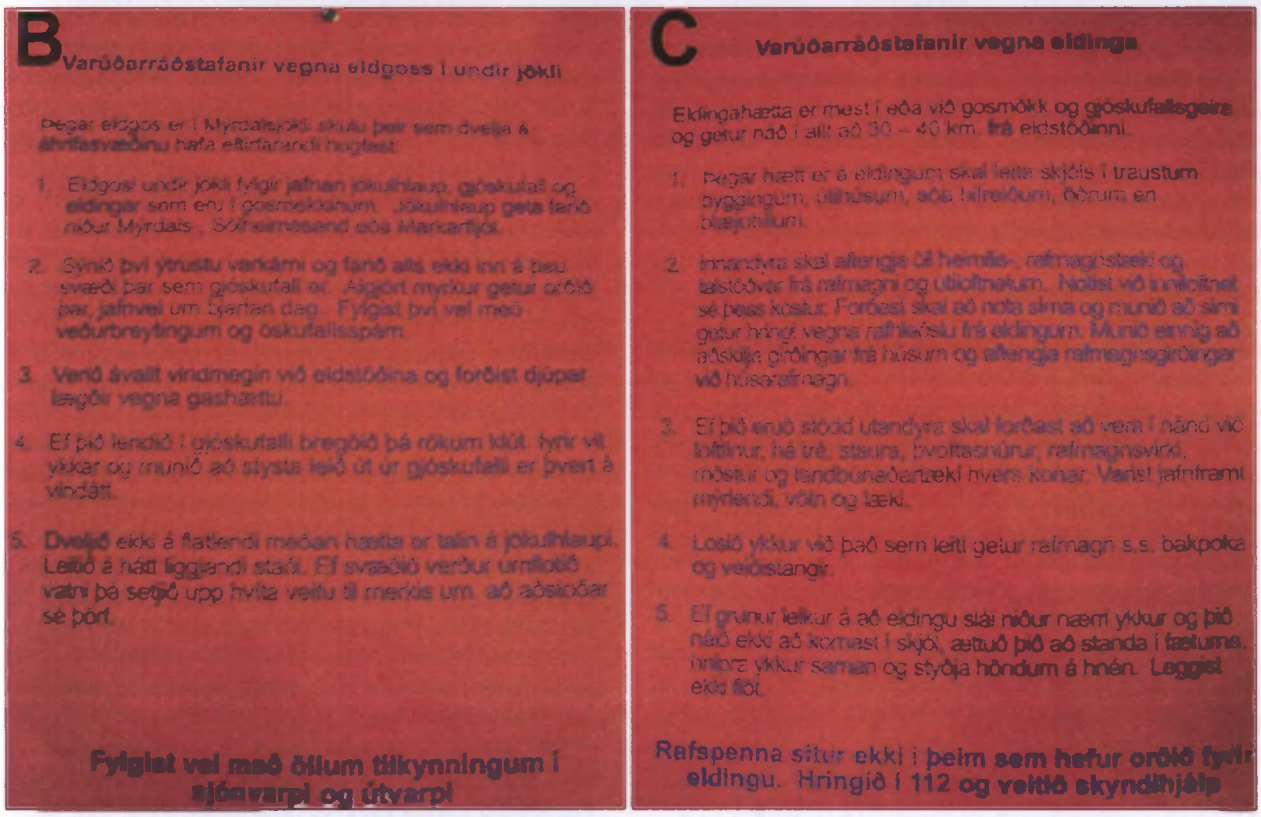

Fig. 2. Continued.

B Precautions due to subglacial eruptions (back left hand side)

During an eruption in Mýrdalsjökull those staying in the hazard area should think of the following:

1. Jökulhlaup, tephra fall and lightning within the plume usually follow a subglacial eruption. Jökulhlaup can go down Mýrdalssandur, Sólheimasandur or the Markarfljót.
2. You should be very careful not enter areas of tephra fall as it can be completely dark even during the day. You should be observant of weather changes and forecast of tephra fall.
3. Always stay on the side of the volcano in the direction of the wind. Avoid deep topographical depressions due to the accumulation of poisonous gases.
4. If you happen to be in tephra fall use a moist cloth to cover your mouth and nose. Remember that the shortest distance from the ash plume is transverse to the wind direction.
5. Do not stay on flat land while the risk from jökulhlaup is predicted. Go to higher areas. If you are in an area that is flooded by water use a white flag to signal for assistance.

Follow all announcements on TV and radio.

C Precautions due to lightning (back right hand side)

The risk for lightning is greatest in or close to the plume and can reach to a distance of 30–40 km from the volcano itself.

1. When there is the risk of lightning you should seek shelter in secure buildings, out-houses or cars (not convertibles).
2. Unplug all equipment from electricity inside the house and from outdoor antennas including electrical equipment, radio transmitters. Use indoor antennas if possible. Avoid using the telephone and remember that a phone may ring due to electricity from the lightning. Disconnect all fences from the house and unplug electrical fences from the house electricity.
3. If you are outdoors you should avoid being close to high lines, high trees, poles, laundry lines, electrical poles, masts and agricultural equipment of any kind. Try to avoid wetlands, water, and rivers.
4. Unload things that can attract electricity such as rucksacks and fishing rods.
5. If you think that lightning will hit close to you and you cannot find shelter, stay on your feet and crouch down with your hands on your knees. Do not lay flat.

Electricity does not remain in someone who has been hit by lightning. Call 112 and administer first aid.

their perception of the response behaviour of evacuees, and whether or not they viewed the exercise to be a success. In addition to reviewing their perception of the evacuation exercise, the contents of the resident questionnaire were discussed with each person. A tape recorder was used for interviews when permission was granted. Written notes were taken during all interviews and these were transcribed into Microsoft Word® directly after each interview.

2.3 Conducting questionnaire survey interviews

Our questionnaire was constructed using a format developed and tested by Bird and Dominey-Howes (2008) and adapted to the geographic and hazard focus of Katla. Further questions were developed based on residents' experience and discussion during the evacuation exercise. The final structure of the specific questions we included were discussed and negotiated with regional emergency personnel to ensure that the survey generated data of value to them in reviewing and improving their emergency management strategies. Therefore, it was important to pre-test our new questionnaire in order to highlight any errors or inconsistencies and to assess whether or not it would generate valuable data which are conducive to the goals of the project (McGuirk and O'Neill, 2005; Parfitt, 2005; Bird and Dominey-Howes, 2008). The pilot phase was carried out with local residents in April 2006. A few minor problems arose with respect to wording and sequencing of two questions. These issues were addressed prior to the main study.

Each questionnaire was printed in English with Icelandic translations. Translations were undertaken by a bilingual translator and then sent to another bilingual translator for verification. Participants were given the choice of conducting the interview in either English or Icelandic. To avoid misinterpretations and miscommunications translations were conducted during the interview and only one translator was used during the course of the study. Special and concise training of translators is critical to ensure that questions are asked exactly as intended and that participant responses are translated fully and completely (Patton, 1990). Our translator received thorough training prior to the study.

Face-to-face questionnaire survey interviews were conducted with local residents in the hazard zone of Rangávallasýsla from May to October 2006. Since this was the first time an evacuation plan had been introduced to these communities and this study was the first of its kind to be held in this region, face-to-face interviews were deemed to be the most effective method for data collection. This is because it allows the interviewer to probe for more detailed responses when required as well as providing clarification if necessary (McGuirk and O'Neill, 2005; Parfitt, 2005).

Participants were recruited using two non-probability qualitative sampling methods. Firstly, a purposive sampling technique was used to target residents living within the hazard zone (i.e. residents registered in each community within the hazard zone were directly contacted). Purposive sampling is used to deliberately select subjects who are thought to be relevant to the research topic (Sarantakos, 1998). Secondly, a snow-ball sampling technique was employed whereby the first recruitment of participants suggested other residents who might be available to participate during the research period (Sarantakos, 1998). Despite apparent biases with both these sampling techniques, each was deemed appropriate to the study as we were actively seeking knowledge and perception data from residents from each community in the hazard zone. Furthermore, it is not our intention to generalise our results from this sample to the population as a whole, but rather provide a more descriptive preliminary investigation of public perception in this region.

All residents were initially contacted by telephone and interviews were arranged at a time convenient to them. Residents over 18 years of age were targeted and all participants were guaranteed anonymity. Prior to the interview each participant was informed about the purpose of the questionnaire and the proposed use of the data. They were also told that they were free to withdraw from the survey at any given time without consequence. Participants were required to sign Human Ethics forms to indicate that they agreed with the terms of the survey interview.

The questionnaire was divided into three sections. The first section gathered classification data about the participant. The second section gathered information about their knowledge and perception of Katla, jökulhlaup hazards and emergency procedures. While the third section gathered information about their attendance at, and their perception of, the information meetings on Katla, the evacuation plan and exercise and their use of hazard information available through various media sources. Each section contained both open (free answer) and closed (check-list) questions. In total, the questionnaire contained 52 questions and took approximately 45 min to complete. However, participants were given as much time as needed to complete the interview. All data were analysed within SPSS® 15.0 (Statistical Package for Social Science) and Microsoft Word®.

It is beyond the scope of this paper to present data generated from all 52 questions. The questions we present here were selected on the basis of the information they provide (i.e. we believe they have generated significant data which may be useful to emergency managers charged with the responsibility of the ongoing development of risk mitigation procedures). An electronic copy of the questionnaire is available at http://www.nat-hazards-earth-syst-sci.net/9/251/2009/nhess-9-251-2009-supplement..pdf or from the corresponding author.

3 Results

Our results are divided into three sections. Firstly, we report on our observations during the evacuation exercise on 26 March 2008. Secondly, information derived from the inter-

views with emergency management officials is documented. Thirdly, we present results generated from the questionnaire survey interviews with the residents. Comments recorded verbatim are presented in bullet form. In total, 60 individuals were interviewed; 6 emergency personnel and 54 residents.

3.1 The evacuation exercise of 26 March 2008

All people involved in the evacuation exercise were instructed to treat it as a real volcanic emergency situation. Details on weather conditions were determined by ICP and emergency personnel were expected to consider wind speed and direction in relation to the development of the volcanic plume. Regular updates of the height and width of the plume were broadcast. Due to the possible hazard from tephra, helicopter pilots refused to fly until EH gave them a direct order. Following this, one helicopter was despatched with a leading scientist to assess the eruption and another was on standby at a nearby airstrip.

All officials within EH held a round table meeting to discuss the progress of the eruption and evacuation every half hour. The Chief of Police of Rangávallasýsla was in charge. Everybody reported to him and he delegated responsibilities as the day progressed. He enforced the need to stay in constant contact with all personnel out in the field. To test the emergency teams for different situations actors were employed to role play residents who refused to evacuate, residents who required medical assistance, people located in a high risk area and in need of helicopter evacuation, and tourists travelling within the hazard zone. The police were instructed to arrest residents if they refused to evacuate (this did not actually occur but residents who were refusing to evacuate were told that they would be arrested in a real evacuation).

The main problem brought to the attention of the Red Cross at the EC was the failure in communication – many residents did not receive the evacuation message and during the evacuation, the EH did not receive this message from the EC. Despite this, approximately 65% of the population located within the hazard zone of Rangávallasýsla registered at the ECs. Talk amongst the residents at the EC included the communication failure while many voiced their concerns about leaving their animals. Another problem witnessed at the EC was the time it took to manually register residents.

Several instances occurred where residents had not received an evacuation warning but were asked to leave by the sweepers and one family was rescued by the emergency helicopter. Four elderly men arrived at the EC 3 hours after receiving the initial evacuation message. They were surprised that no one had come to check on them. They were not aware they were allocated 30 minutes for preparation before evacuating. Red Cross personnel reported a misunderstanding about the time allocation for evacuation. Some people were anxious to get to the EC within 30 min while others thought they had a lot longer. Furthermore, the EC in Hvolsvöllur was not well signposted and some people (including the present authors) could not easily find it.

Regardless of the problems that arose during the evacuation exercise, the general mood at each centre was good-humoured. Residents joked about the fact that the communication system did not work as planned. Some participants light-heartedly explained that they would have been inundated by flood water due to the fact that they had not received any evacuation message (these residents went to the evacuation centre on their own accord since they knew the exercise was taking place). Resident behaviour and comments indicated that many of them were there for the social aspect of the day.

As a result of our observations during the exercise, specific questions were developed for the questionnaire survey to investigate the failure in communicating the evacuation message, the time allocated to residents to evacuate and whether residents would refuse to evacuate during a real situation.

3.2 Interviews with emergency management officials

All emergency management officials gave a clear description of their departments' role and their own personal role during an emergency situation. Each person that was in direct contact with the evacuees reported an overall positive public response. Comments in relation to this included:

- Approximately 65% of residents took part in the exercise which suggests that people are probably taking this seriously.
- Almost everyone was positive about the evacuation. Some who didn't receive the evacuation message were mixed. Those who were not positive didn't bother coming.
- The evacuees were extremely positive about the exercise. People were willing to participate probably due to the major earthquakes that occurred in 2000.

The evacuation was viewed as a success by all emergency management officials. The main negative comments that arose were attributable to the problem with the communication system. Comments in relation to this included:

- The information that is given to the people is crucial. They need to know how long they have before the flood comes. Also timing of the warnings should allow time for the rescue teams to help the evacuees if the weather conditions are bad. The sweepers can play this role.
- Phone calls and sms (text messages) were not good. People joked about this at the time but once they went home they were probably more concerned that they could have been stuck in a real flood.

- It is always the communication that breaks down and therefore the sweeper's role should be more concentrated on (providing warning and evacuation information to people). Technology can break down especially in a volcanic disaster. It must be organised as a door-to-door operation.
- We have broadcast advertisements asking people to report if they did not receive a message during the exercise. We have asked them to give their details to the local police and ICP directly so we can try to sort out this problem.

3.3 Questionnaire survey interviews with residents

This section is divided as per the three sections of the questionnaire. The first section describes participant demographics based on their responses to classification questions. Participants' responses to both open and closed knowledge and perception questions of Katla, jökulhlaup hazards and emergency procedures are presented in the second section. The third section reports participants' responses to questions relating to their attendance at and their perception of the information meetings on Katla, the evacuation plan and exercise and their use of hazard information available through various media sources. The sequence of questions presented here is the same sequence as that within the questionnaire. Quick-look summary tables have been provided in each section for specific closed questions.

3.3.1 Participant demographic

A total of 54 participants were recruited from 67 residents who were approached to take part in the questionnaire survey interviews, providing a response rate of 81%. Our sample included 19% of participants from Vestur-Eyjafjöll, 26% of participants from Fljótshlíð, 15% of participants from Vestur-Landeyjar and 20% of participants from each Austur-Landeyjar and Þykkvibær (Table 1). The majority (57%) of participants were 51 years of age or over and 57% of participants lived within 2 km of either the river Markarfljót or Þverá. Nearly all participants (98%) had lived in Iceland most of their lives. Education qualifications of our participants was quite diverse; 28% held a trade certificate or diploma, 15% had a university degree or higher and a further 13% stated an education qualification from another source. Fifty percent of participants were full-time farmers while another 9% were part-time farmers.

3.3.2 Residents' knowledge and perception of Katla, jökulhlaup hazard and emergency procedures

Participants were asked if they could give a brief eruptive history of Katla and a definition of jökulhlaup. In order to be counted as correct for the history of Katla, participants were expected to mention: the last confirmed eruption in 1918; or, the possible eruptions in 1955 and/or 1999; and, the frequency of Katla eruptions as 1, 2 or 3 times per century. However, some participants were counted as correct if they mentioned just one of the above in addition to detailed information about other aspects of Katla. Based on this, a correct response was given by 63% of participants, 7% were incorrect while a further 30% stated they did not know (Table 2). None of the participants in the 18–30 year age group gave a correct answer while only 27% of the correct answers came from the 31–50 year age group. A correct response for jökulhlaup was credited to answers that defined a flood of water from a glacier. Nearly all participants (94%) gave a correct response. Only 6% stated they did not know.

Sixty-seven percent of participants perceive that their region could be affected while 32% of participants stated no they do not perceive the hazard could affect their region. Eighty percent of participants from the community of Vestur-Eyjafjöll do not perceive the threat to their area and 93% of these people live within 2 km of the Markarfljót.

When the participants were asked if they are aware of the emergency procedures they need to follow if a jökulhlaup warning is issued 89% responded "yes". Seventy-one percent of participants correctly described the evacuation procedure, 19% stated that they would stay in their homes while the remaining 10% said that it would depend on:

- If it was occurring right away we would stay. If we had a few hours we might go to Hvolsvöllur;
- I would go to higher ground if at night or during bad weather. If the weather is good and it is daylight I would follow the evacuation procedure and go to Hvolsvöllur; and,
- I would follow the plan to some extent but I would use commonsense especially if they tell me to do something that I know is wrong or dangerous.

Of the participants that live in Vestur-Eyjafjöll 60% of them said they would stay in their homes. Reasons given to clarify their response were:

- We consider ourselves safe where we live and therefore we will not evacuate. Also, for health reasons I feel better about staying at home;
- All farms in this community are 30–40 m higher than the river bed;
- I would not evacuate as I feel safe and comfortable in my own home. I am concerned about driving along the road which in my opinion is very dangerous as the road is in the lowland area and close to the river. After 30 minutes we will spend much time in the danger zone driving out of this area; and,

Table 1. Participant responses from Sect. 1: Classification questions. All data are given as a percentage. Some sections do not equal 100% due to rounding.

In what region of Rangávallasýsla do you live?	Vestur-Eyjafjöll 19	Fljótshlíð 26	Vestur-Landeyjar 15	Austur-Landeyjar 20	Þykkvibær 20	
What is your age group?	18–30 years old 7	31–50 years old 35	51+ years old 57			
How far from the river do you live?	0<2 km 57	2<5 km 33	5<10 km 7	10+ km 2		
In which country have you lived the longest?	Iceland 98	Other 2				
What is the highest level of education you have completed?	Some schooling 9	Educated 6–16 years 20	Educated 6–20 years 15	Trade certificate/ Diploma 28	University degree or higher 15	Other 13
What is your occupation?	Full-time farmer 50	Part-time farmer 9	Other 41			

Table 2. Participant responses from Sect. 2: Questions on Katla, jökulhlaup hazards and the warning system. All data are given as a percentage. The second question does not equal 100% due to rounding. The last question totals more than 100% as participants were allowed to rank several hazards as the most serious.

	Correct	Incorrect	Don't know
Can you tell me a brief eruptive history of Katla?	63	7	30
How would you define jökulhlaup?	94	0	6
Do you think the region where you live could be affected by a jökulhlaup?	Yes 67	No 32	Don't know 2
Are you aware of the emergency procedures you need to follow if a jökulhlaup warning is issued?	Yes 89	No 11	
What would you define as the most serious hazard in your area if Katla were to erupt?	Jökulhlaup Ice blocks Lightning Tephra Poisonous gases Lava Tsunami Earthquake	62 11 9 26 2 0 0 4	

- We would not evacuate. We would stay here on the farm. It is safer here than on the road. Tephra may block the road and rock fall may occur due to seismic activity.

If a Katla eruption commenced prior to the ICP issuing a warning 55% of participants stated that they would call 112 or the police (the most popular response) for information while a further 28% would seek information from the radio, television or internet. Sixty-two percent of participants considered jökulhlaup as the most serious hazard in their area if Katla were to erupt while tephra was deemed most serious by 26% (Table 2). We then allocated scores to the rankings (i.e. the most serious hazard was allocated a score of 8; the second most serious was allocated a score of 7 and so on). A nil score was allocated if no ranking was given. Each hazard was ranked at least once (Fig. 3) with jökulhlaup and tephra scoring the highest respectively.

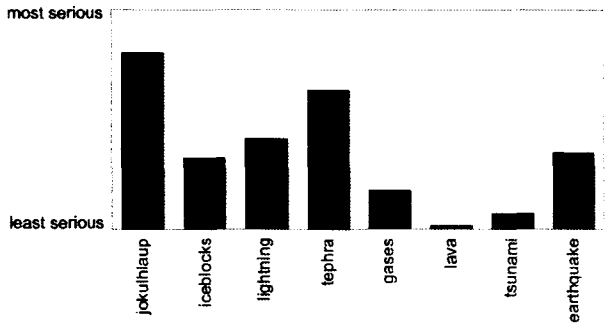

Fig. 3.Participants' perception of the most serious hazards produced during a Katla eruption.

3.3.3 Residents' knowledge and perception of the information meetings on Katla, evacuation plan and exercise, and hazard information in the media

More than half the participants did not attend information meetings on Katla and the proposed evacuation plan and exercise. Reasons stated for not attending included:

- Could not attend due to health reasons;
- At work;
- Too busy when they were on; and,
- Not interested.

Other people stated they did not attend but others within their household did. For those that did attend, we enquired whether they found them informative. Only 5% of participants did not find them informative. Participant perceptions of the meetings included:

- The simulation and displays were very informative but the sound system was very bad and therefore I could not hear the talks so well.
- It is good to talk about this and make people aware.
- I found the meetings very informative and now there is direct information on what to do if something happens. They educated people and now the local people should not be as afraid as they know what to do.
- I found the meeting informative but they needed more preparation. The people in charge lacked knowledge and those presenting the meetings were not the most experienced. There was no geologist at the last meeting.
- Most of it was nonsense. In the Westman Islands in 1973 everyone had to save themselves and it worked. Here will be the same.

Sixty nine percent of participants did not receive any evacuation message during the exercise (Table 3) and of these, 49% did not receive a message to their landline. When asked if they always carried their mobile phone 68% of participants responded "yes". However, only 52% of farmers carry their mobile phone with them at all times. Of those participants that always carry their mobile phone, 34% said they do not always have an active connection in their area.

Participation during the evacuation exercise was rather high with 68% of participants stating they did take part. Their reasons for participation included:

- It is part of my duties as an Icelandic citizen;
- I took part in the evacuation for my own safety and my family's;
- I thought it would be good for people to know how to act;
- I wanted to participate to check how long it would take us to prepare but we didn't complete the whole list on the evacuation sign; and,
- I did take part but I didn't really gain anything from it.

Those who did not take part clarified their actions by stating:

- Too tired and sick;
- I was at work but everyone else in the house took part;
- We would have participated if we had received the evacuation message; and,
- Not interested as I do not perceive that I will be in danger.

Despite some people's negativity toward the evacuation exercise of those who did participate 82% of them were positive about the exercise.

Thirty minutes was deemed enough time to complete the list as described on the evacuation sign (Fig. 2) before evacuating their property by 52% of participants. Of the 48% that stated no or don't know they responded with:

- It is not enough time if you have to let the animals out (as per the instructions);
- 30 min is not enough time for farmers;
- 30 min may not be enough depending where I am on the farm; and,
- It depends if the kids are at home from school and if I am at work in Hvolsvöllur then I would have to drive back to the house to collect them.

Table 3. Participant responses from Sect. 3: Questions on Katla information meetings, evacuation plan, evacuation exercise and hazard information available in the media. All data are given as a percentage.

	None	One	Two	Three
How many Katla information meetings did you attend?	55	29	4	12
How many evacuation messages did you receive on the 26 March 2006?	69	19	6	6
If you did not receive any messages did you receive a phone call to the landline or your mobile phone?	Yes 51	No 49		
Do you always carry your mobile phone with you?	68	32		
Do you always have service coverage to your mobile phone around your area?	Yes 64	No 34	Don't know 2	
Did you take part in the evacuation exercise?	Yes 68	No 32		
If you did take part in the exercise on 26 March 2006 how did you feel about it?	Positive 82	Negative 8	Mixed 10	
Do you think 30 min is enough time to complete the list (on the evacuation sign) and evacuate?	Yes 52	No 42	Don't know 6	
Would you follow this procedure if there was a real evacuation?	74	18	8	
Have you looked up the ICP website and familiarised yourself with information on the possible natural hazards connected to a Katla eruption?	Yes 19	No 81		
Have you ever used the Skjálftavefsjá/IMO website for hazard information?	26	74		
Have you followed discussions in the media about natural hazards connected to a Katla eruption?	89	11		

With these comments in mind it is not surprising that 64% of farmers do not believe that 30 min is enough time. Furthermore, several participants were under the impression that they had 30 min to complete the list and get to the evacuation centre. These people expressed great concern about this because for some of them it takes 30 min to drive to the closest evacuation centre. These residents were located in Austur and Vestur-Landeyjar (Fig. 1).

Only 19% of participants had accessed hazard information related to a Katla eruption from the ICP website (www.almannavarnir.is) while 26% of participants had accessed hazard information from the Skjálftavefsjá (earthquake webviewer) website (drifandi.vedur.is/) and the Icelandic Meteorological Office (IMO) website (www.vedur.is). Media discussions about natural hazards connected to a Katla eruption were followed by 89% of participants and they sourced this information from television (88%), radio (82%), newspaper (72%), information brochures (54%), books (40%) and the internet (20%).

Once the questionnaire had been completed the participants were given the opportunity to engage in open discussion. Many participants stated their reluctance to leave their animals and some believe that due to this many farmers may choose to stay at home during an actual evacuation. Some participants would like to see the hazard zone reclassified in order to rank the areas according to the level of risk. These participants felt that people may be complacent as they do not recognise they are actually living in a high risk area and therefore they may prefer to stay at home with their animals during a Katla eruption. Furthermore, many people expressed concern about completing all the instructions on the evacuation list and of particular concern was the instruction to release animals from their enclosures.

Another important message communicated during the discussions was the great concern for tephra fallout. Participants not only feared personal health risks – one participant stated "we have bought ourselves gas masks in case of tephra" – but also related risks associated with the complete darkness that can be experienced during the middle of the day, the threat to agricultural land and the threat to car engines. However, one of the most important statements that arose during these discussions was regarding residents' involvement in the development of the evacuation plan. Several residents objected that they had no say in how the evacuation should be implemented within their communities and following the exercise they were not informed about how successful the drill had been.

4 Discussion

A unique opportunity was presented during and after the evacuation exercise to assess resident knowledge, behaviour and perception of Katla, jökulhlaup hazard and the evacuation plan – a task which had never been done for volcanic hazards in Iceland. A short time window was offered to capture residents' views of the exercise before they forgot this practical experience of risk mitigation. Our small sample size reflects this brief window of opportunity but the data collected provide an in-depth account stemming from a mixed methods approach which incorporated field observations, semi-structured interviews with emergency management officials and questionnaire survey interviews with residents.

The problem of poor communication became evident through our field observations at the EC and was later reiterated during interviews with emergency management officials and residents. The issue of communication between scientists, emergency management officials and the public can inhibit a successful response to evacuation orders (Chester et al., 2002). During the exercise, communication of the evacuation warning was not adequate and some residents were unaware the drill had commenced. This was confirmed in a post-exercise assessment report, where it was stated that the evacuation warning was not communicated effectively to residents (Almannavarnir, 2006). Effective communication not only refers to broadcasting hazard information but also the public and media's ability to understand the nature, meaning and intent of the warning (Dominey-Howes et al., 2007). Communication strategies should be developed with respect to the intended audience and in consideration of social psychological factors which may influence whether or not people assimilate this information and respond accordingly (Paton and Johnston, 2001).

The particular role of communication was noted by the president of the International Union of Geodesy and Geophysics (IUGG) during the 2008 International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) conference held in Iceland. He emphasised the need for successful communication in volcanic crises and questioned the reliance on modern technology to relay hazard information. This strong dependence on modern technology created problems during the evacuation exercise. To exacerbate this situation, approximately half the farmers in this region stated they do not carry a mobile phone with them at all times and it is these residents who are most likely to be away from a landline. It is therefore critical they receive an evacuation message through an alternative mode. The sweepers in some regions were able to notify those residents who were unaware that the evacuation had commenced. However, through our interviews we were able to ascertain that certain residents were not contacted by phone or sweeper.

Residents were concerned about their own personal safety due to the time it would take them to release livestock from the enclosures. Other residents were concerned about the safety of their animals after being released. They believe it would be safer to leave them inside especially with respect to tephra fall out. Time was a recurring issue as people were confused about the time allocated for them to evacuate particularly with residents located 30 min from the EC.

Empowerment is described by Paton et al. (2008) as an individual's capacity to have control over their personal affairs and confront hazard issues while receiving the necessary support from emergency management officials. Some residents described a loss of empowerment as they were not involved in the development of the evacuation plan and they were told they had to follow the plan (or be arrested) contrary to their own knowledge and perception. Furthermore, during the interview period residents had not received any feedback regarding the success of the exercise. Despite these shortcomings all the emergency management officials interviewed in this study deemed the evacuation exercise a success. This notion was enforced by the majority of our participants who took part in the exercise.

The questionnaire survey interviews revealed that even though most participants were able to demonstrate an accurate understanding of the eruptive history of Katla and nearly all participants correctly defined jökulhlaup, many (32%) think their area of residence would not be affected by a jökulhlaup. Alarmingly, 80% of participants from Vestur-Eyjafjöll share this view even though 93% of them live within 2 km of the river. However, these participants clarified their beliefs by stating their homes, like others in this community, are located approximately 30–40 m above the river bed. Considering that the hazard assessment and consequent hazard map modelled a catastrophic jökulhlaup reaching a maximum flood depth of at least 15 m upstream of these houses it is understandable that many participants feel it is safer to stay in their homes during a Katla eruption.

Notably, none of the participants from the 18–30 year age group and very few from the 31–50 year age group could correctly describe a brief volcanic history of Katla. An important element for community resilience is inherited memory of volcanic activity (Dominey-Howes and Minos-Minopoulos, 2004). Those residents whose parents experienced the 1918 Katla eruption displayed inherited memory of the eruption. However, this knowledge has not been passed down to the next generation.

Reassuringly, nearly all participants are aware of the emergency procedures they need to follow if an evacuation warning is issued even though some participants stated they would not evacuate. Again, Vestur-Eyjafjöll participant responses stood out from the group with 60% of them replying they would stay in their homes. In addition to their homes being located higher than the river, the evacuation route for this community travels alongside the Markarfljót. To further exacerbate their concerns residents feel that the evacuation route may place them in a vulnerable position to other hazards such as rock fall and tephra. However, non-hazard re-

lated factors may also influence residents' decision making process during a Katla eruption. It is possible that socio-economic constraints such as personal and economic connection to livestock may influence residents' decision on whether or not to evacuate.

Regardless of the communication failures during the evacuation exercise most participants said they would call the emergency number 112 or the police to obtain information about a Katla eruption. However, telephone communication is likely to fail or yield busy signals for specific phone numbers if the network is oversaturated with calls. Exceeding the capacity of regional telecommunication systems complicates the task for emergency management officials and scientific agencies to gather and distribute hazard information by telephone (Gregg et al., 2004). It is therefore optimal for emergency management officials to promote public use of the media during a volcanic crisis. The media can provide an important source of volcanic hazard information for the public and attention should focus on increasing the planned use of this resource and ensuring that it provides consistently accurate information (Johnston et al., 1999). Risk mitigation strategies should include developing a mutually productive relationship between media organisations and emergency management officials in the form of a crisis communication plan to manage the media during a disaster (Hughes and White, 2006).

Participants demonstrated good knowledge of possible hazards that can occur during a future Katla eruption with jökulhlaup, tephra and lightning cited as the most serious. Possessing knowledge of possible hazards ensures that the individual is better equipped to decide whether they should engage in personal preparedness measures and the most appropriate way to achieve this goal (Paton et al., 2008). Our participants' knowledge and concern of tephra was highlighted by one individual who stated that they had taken their own preparedness measures for tephra by purchasing gas masks.

Participant feedback on information provided at the town meetings held to discuss the possibility of a Katla eruption and the proposed evacuation plan was positive. Nearly all participants stated that the scientific information presented through talks, simulations and displays was very informative. A fundamental element of the pathway of information from scientists, emergency management officials and the media is ensuring that it is delivered to the public in a form that represents community needs and functions (Ronan et al., 2000; Gregg et al., 2004). Critical feedback relating to the lack of knowledge and experience of those presenting material at the meetings and technical difficulties should be addressed. Considering that the public are more than just passive receivers of hazard information (Horlick-Jones et al., 2003; Murdock et al., 2003), an integrated approach, that facilitates active participation from both residents and emergency management officials within a risk mitigation framework will help increase public trust, risk acceptance and willingness to adopt personal preparedness measures (Paton et al., 2008).

Participation during the evacuation exercise was reasonably good with approximately 65% of residents taking part. Our sample group of residents reflected this rate with 68% stating that they took part. Apart from participating in order to improve personal safety and preparedness, many participants stated they took part in the exercise as they believed it was "their duty" to do so. Similarly, Haynes et al. (2008) reported that during an ongoing volcanic crisis on the Caribbean Island of Montserrat participants followed orders because it was the right thing to do.

Although an overwhelming majority of participants have followed media discussions concerning Katla most have not actively sourced hazard information available on the internet. Internet usage was quite low even though Bird et al. (2008) reported that 83% of Icelandic households have internet connection and 79% of internet users interact with public authorities. Despite this, it is important to utilise all forms of media as individuals prefer various means of acquiring information (Haynes et al., 2008). Furthermore, the perceived credibility and trust in hazard information can be compromised if forms of distribution are limited (e.g. just pamphlets and TV advertising) (Paton et al., 2008).

The precise location of a future eruption is uncertain therefore making it impossible to predict which direction the jökulhlaup will flow from the glacier margin (Sturkell et al., 2008). Furthermore, adequate preparation for all hazard consequences, such as lightning and tephra, is essential for all residents. The infrequent and complex nature of volcanic hazards increases the public's need to have easily accessible expert information in order to guide their risk management decisions (Paton et al., 2008).

In summary, the key outcomes of this research are:

- Improve the communication system.
- Emphasise the sweepers' role in supporting the dissemination of warning and evacuation information.
- Provide more detailed information on the effects of other volcanic hazards such as tephra, lightning and rock fall and what preparedness measures can be applied to best protect person, property and livestock.
- Ensure that all residents know exactly how much time they have to evacuate.
- Empower residents through involvement in risk mitigation planning.
- Provide feedback on proposed strategy outcomes within a reasonable timeframe (for example, within 3 months after completion).
- Continue to provide hazard information within an appropriate timeframe at town meetings with knowledgeable experts. The timeframe should be based on the

level of alert (i.e. meetings should be more frequent when there is a higher risk of an eruption).

- Promote the use of all media sources for volcanic hazard information.

4.1 Further developments and future research

Sturkell et al. (2008) report on seismic and geodetic measurements from around Katla between 1999 and 2005. Although increasing rates of crustal deformation and seismicity have lowered considerably, they believe that the volcano remains in an agitated state and an eruption in the near future should be expected. Therefore continued development of risk mitigation procedures is essential.

Improvements have been made to the communication system following the failures during the evacuation exercise and plans are underway to test the network (K. Þorkelsson, personal communication, 2008). The ICP has confirmed the problem is being rectified and that the chief of police in Rangávallasýsla is charged with the responsibility of testing the communication system during a follow-up exercise (R. Ólafsson, personal communication, 2008). Town meetings were organised with local residents in Rangávallasýsla during 2008. Residents were given the opportunity to voice their concerns with the evacuation plan (K. Þorkelsson, personal communication, 2008). In order to better suit community needs and expectations, information gathered during these meetings is being used to develop more appropriate evacuation procedures.

Our preliminary investigation entails a descriptive view of public knowledge and perception from a select group of residents living in each community in the Rangávallasýsla hazard zone. As a result it is impossible to infer that results generated through our research apply to the population as a whole. In order to establish a clear idea of how the general public will respond during a future volcanic event and the complex range of natural and social phenomena that affect the decision making process, more detailed research needs to be conducted with a much larger sample group. Considering that the residents of Rangávallasýsla are not the only ones located in the hazard zone this investigation has been expanded to include residents located in the hazards zones to the south and east of Mýrdalsjökull. A parallel study is also being conducted with tourists and tourism employees within Þórsmörk, a popular tour destination located west of Mýrdalsjökull. Following the recent meetings with residents and current progress toward developing more appropriate evacuation procedures further studies should investigate whether or not they suit community needs and expectations.

5 Conclusions

The evacuation plan is the first to be developed and implemented in the municipality of Rangávallasýsla and the ICP, scientists, local police and rescue teams should be commended for their efforts. However, more work needs to be done to reduce the impact of a future Katla eruption. This can be achieved by addressing some of the main issues raised by our participants. The data provides an insight into how residents interpret their situation in relation to Katla, its associated hazards and their potential response during a crisis. This information highlights the importance of integrating the physical characteristics of Katla's volcanic hazards within context of the communities at risk. Our participants are aware of jökulhlaup, tephra, lightning and rock fall hazards but they have not been provided with enough information to enable them to make an informed decision on whether to evacuate or take shelter in place and how to best protect their livestock. Comparatively, from the information provided, residents in Vestur-Eyjafjöll have been able to conclude that their homes will not be directly affected by jökulhlaup and therefore they are not willing to evacuate. However, non-hazard related factors such as not wanting to leave animals unattended may also influence their decision to evacuate. Furthermore, residents' participation in the evacuation exercise does not necessarily reflect their willingness to evacuate. These examples underline the complex range of natural and social phenomena that affect the individual's decision making process and as a result may inhibit a successful evacuation.

Results from our study highlighted problems associated with communication during the evacuation exercise and the possible need to find alternative modes which do not rely so heavily on technology. In light of this, scientists and emergency management officials should collaborate with media agencies and the public in order to promote the use of media resources and, to ensure hazard information is accurately distributed in an understandable form. Furthermore, the importance of the sweepers' role during an evacuation should be emphasised as they may provide the only communication link between emergency management and farming communities. Recent public meetings which involved residents in risk mitigation efforts are a positive step toward empowering residents with evacuation procedures and preparedness strategies.

This paper presents the first results on residents' knowledge and perception of Katla, jökulhlaup hazard and their views of the evacuation plan and exercise in Rangávallasýsla. The key outcomes, as summarised above, should help provide considerable value to the ongoing development of an effective response capability. Considering this research is the first of its kind in this region the results can be used as a baseline by the ICP for more robust surveys in Iceland's volcanic regions.

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Chapter 5

Residents' perception of and response to volcanic risk mitigation strategies in a small rural community, southern Iceland

The following chapter consists of:

- Overview
- Motivations and contributions
- Images from the case study
- The paper –

Overview

The paper presented in this chapter was submitted for publication to the *Bulletin of Volcanology* on 23 December 2009. This research provides the first analysis of residents' perception of and response to emergency response procedures and the evacuation exercise. The case study focuses on the small rural community of Álftaver in the municipality of Vestur-Skaftafellssýla in the eastern hazard zone. It incorporates:

- Field observations during the evacuation exercise on 25 March 2006.
- Semi-structured interviews with 6 emergency management officials between April and June 2006.
- Semi-structured interviews with 13 residents during April 2006.

Motivations and contributions

During the evacuation exercise on 25 March 2006 in the southern and eastern hazard zones I carried out field observations and documented the proceedings from a resident's perspective. Based on these observations and discussions with emergency management officials, I developed questions for the semi-structured interviews. Guðrún Gísladóttir conducted the

interviews in Icelandic and translated participant responses directly to me for recording and questioning.

Within this case study, all data entry and analysis were conducted by me and I compiled and wrote the paper. Both co-authors, and Damian Gore and Benjamin Gillespie provided invaluable comments and suggestions to help improve the research.

The introductory cover letter in Appendix J and the interview schedule in Appendix L were used during the semi-structured interviews with residents in this survey.

The following selection of photographs is included in order to set the scene for the study presented in this chapter. The first two photographs were taken during the evacuation exercise on 25 March 2006. The first photograph shows residents conversing with an official and the second shows a family registering with the Red Cross at the evacuation centre. The next two photographs are included as a representation of livelihood connections within this society.

Photographs from the case study

An official with residents at the first check point on the main highway during the evacuation exercise on 25 March 2006 (photo taken by Deanne K. Bird)

Residents registering with the Red Cross at the evacuation centre in Kirkjubæjarklaustur during the exercise on 25 March 2006 (photo taken by Deanne K. Bird)

Icelandic horses in Álftaver (photo taken by Deanne K. Bird)

Icelandic sheep in Álftaver (photo taken by Deanne K. Bird)

Residents' perception of and response to volcanic risk mitigation strategies in a small rural community, southern Iceland

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Abstract

Volcanic risk mitigation strategies, namely evacuation plans, were revised by emergency management agencies for residents living in the eastern jökulhlaup hazard zone of Mýrdalsjökull, southern Iceland. These plans were trialled during a full-scale evacuation exercise on 25 March 2006. In order to assess residents' perception of and response to the exercise and plans, field observations were conducted during the exercise and semi-structured interviews were conducted with emergency management officials and residents of a small rural community after the exercise. This community was the focus of this survey because these residents did not consider the previous plan appropriate to their beliefs and needs. The results of the survey revealed that residents are reluctant to evacuate and do not agree with the proposed strategies. Residents believe that the newly devised plans do not address the contextual issues of their community. Factors influencing the residents' perception are inherited knowledge, attachment to place and livelihood connections (i.e. concern for livestock). Residents' requests for alternative plans, in case adverse environmental conditions

prevent evacuation, were ignored. Consequently, emergency managers failed to resolve residents' risk mitigation concerns prior to the evacuation exercise. We recommend that emergency managers should incorporate local knowledge and perceptions to ensure reduced vulnerability and enhanced community resilience.

Keywords: community perception, evacuation exercise, emergency response, mixed methods, Iceland

1 Introduction

Volcanic risk mitigation procedures for communities to the east of the Mýrdalsjökull ice cap, Iceland, have undergone revision since 2002. The motivation for this effort is the ongoing risk posed by the Katla volcano (Guðmundsson and Gylfason, 2005; Sturkell et al., 2008), which underlies the Mýrdalsjökull icecap (Fig. 1). Katla is renowned for catastrophic jökulhlaup (glacial outburst floods) with peak discharge rates of 100,000-300,000 m^3s^{-1}. Heavy tephra fallout and lightning hazards also affect communities up to 30 km from the eruption site (Larsen, 2000) and past eruptions have triggered small coastal tsunami (Guðmundsson et al., 2008).

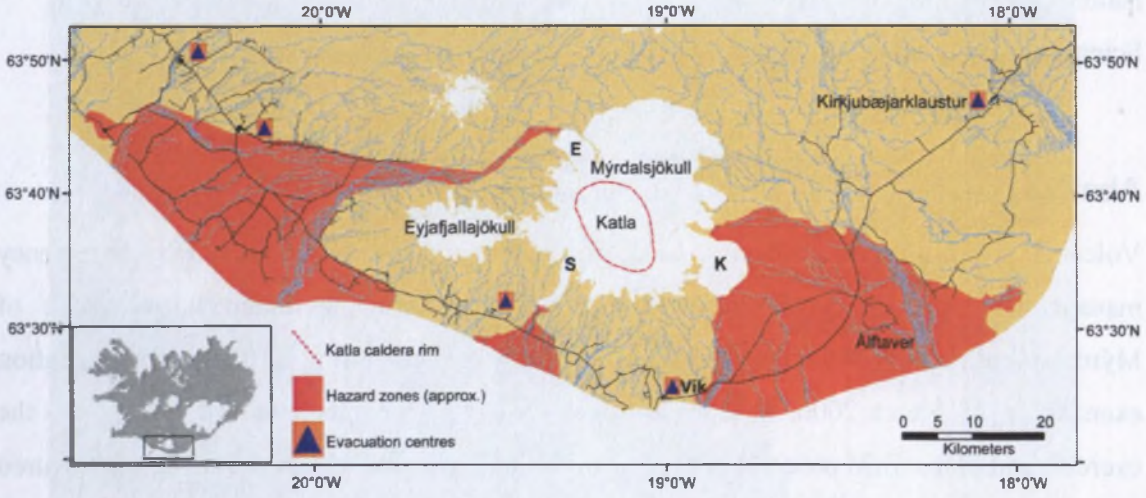

Figure 1. Jökulhlaup hazard zones around the Mýrdalsjökull icecap showing the Entujökull (E), Kötlujökull (K) and Sólheimajökull (S) catchments, small rural community of Álftaver and their designated evacuation centre in Kirkjubæjarklaustur. Following a Katla eruption, it is estimated that the jökulhlaup will flood the main highway, bridges and electric power lines and reach the community of community of Álftaver within three hours (Almannavarnir, 2009).

All confirmed historic Katla eruptions have produced jökulhlaup which have emanated from the Kötlujökull or Sólheimajökull catchments while only *prehistoric* jökulhlaup have flooded from the Entujökull catchment (Larsen et al., 2005). Consequently, emergency response procedures were established for communities located in the southern and eastern hazard zones. However, Jóhannesdóttir (2005) found that no evacuation exercises have been conducted to test these plans since 1973, accept for those held within the local school. Jóhannesdóttir (2005) also revealed that collaboration and trust was limited between local residents and emergency management agencies.

Successful risk mitigation for a Katla eruption cannot be achieved without proper consideration of the contextual issues of place, whether these are of a physical nature or human induced (Tobin, 1999). Therefore, risk mitigation should be conducted at the local level with community involvement (Lewis, 1999; Wisner et al., 2004).

The revised evacuation plans were tested during a full-scale exercise for communities located in the southern and eastern hazard zones on the 25 March 2006. In conjunction with this event, a mixed methods survey was used to assess residents' response to and perception of the exercise and proposed procedures. The small rural community of Álftaver was the focus of this research because residents within this community did not consider that the previous plan or communication strategies were appropriate (Johannesdottir and Gisladottir, 2008).

This research aims to expose the contextual issues relating to risk mitigation at the community level and provide support for future developments in volcanic disaster risk reduction. To provide context for this study, a review of volcanic risk mitigation follows.

2 Volcanic risk mitigation and the community

Although Álftaver has flooded during past Katla eruptions, there is no indication that farmhouses on the properties of Herjólfsstaðir and Mýrar have been affected (Jóhannesson, 1919; Loftsson, 1930). This information is based on residents' personal accounts of eruptions since 1625. Positioned on a topographical high, residents safely evacuated to Herjólfsstaðir and remained there while the lower regions of Álftaver flooded during the last eruption in 1918 (Bjarnason, 1985). This jökulhlaup was catastrophic, with an estimated maximum discharge of 300,000 m^3s^{-1}. Real-time resident descriptions, recorded in annals, suggests that

the jökulhlaup produced during the 1755 eruption was most likely larger (Guðmundsson and Högnadóttir, 2006).

The flood simulation model however, on which emergency response strategies are based, indicates that the entire region of Álftaver is vulnerable to jökulhlaup hazards (Guðmundsson and Gylfason, 2005) and as such, residents are at risk and are required to evacuate. In the likelihood of a future Katla eruption, residents in Álftaver will be instructed that they have 30 minutes to prepare before they have to evacuate to the EC in Kirkjubæjarklaustur, a town located approximately 45 minutes to the north east of Álftaver. Residents will be notified of an eruption via a short messaging service (sms) text message sent to their mobile phone or a recorded message called through to their landline.

The Iceland Civil Protection (ICP), in conjunction with scientists and local police, held hazard and response information meetings in 2005/06 to discuss the possibility of a Katla eruption and the proposed evacuation plan with residents. During these meetings residents were informed that they could collect an evacuation and hazard information sign from the local police station (pers. comm. K. Þorkelsson, 2006). This sign detailed appropriate behavioural response for hazards associated with a subglacial eruption and how to prepare for an evacuation. Instructions included: collect a first aid kit and valuables, switch off electricity, remove fencing from around the house, unplug electric fences and release livestock from enclosures, among others (for details see Fig. 2 in Bird et al., 2009).

The success of any risk mitigation effort is dependent on the ability of emergency management agencies to recommend appropriate response actions to the public and on the public's ability to act on those recommendations (Mileti and Sorensen, 1990). However, it is uncertain whether or not Álftaver residents will act in accordance to emergency managers' recommendations because they did not consider the previous plan (developed in 1973) or communication strategies appropriate for their rural community (Jóhannesdóttir, 2005). Furthermore, rural residents in the western hazard zone (Rangárvallasýsla) were dissatisfied with newly developed evacuation and communication strategies (Bird et al., 2009).

Emergency managers need to reach diverse and heterogeneous communities when communicating hazard, risk and emergency response information (Mileti and Sorensen, 1990). Communication efforts will often fail, before and during a volcanic crisis, if not placed within an appropriate socio-cultural or socio-economic framework (e.g. Cronin et al., 2004;

Gaillard, 2008; Gregg et al., 2004; Haynes et al., 2008a; Lavigne et al., 2008; Tobin, 1999; Tobin and Whiteford, 2002).

Socio-cultural factors include sense of community and attachment to place whereas socio-economic factors include standard of living and strength of people's livelihoods (Lavigne et al., 2008). In addition to these factors, emergency management agencies must incorporate residents' risk perceptions in the development of volcanic risk mitigation strategies (Barberi et al., 2008; Carlino et al., 2008; Davis et al., 2005; Dominey-Howes and Minos-Minopoulos, 2004). The combination of scientific and local knowledge, without one dominating the other, helps provide a more comprehensive and practical understanding of volcanic risk (Kelman, 2006).

Differences in perspectives between local beliefs, scientists and emergency managers however, can lead to feelings of distrust (Cronin et al., 2004). Open and robust communication practices between communities and emergency managers are therefore pertinent to attain a mutual understanding of risk (Haynes et al., 2008b). People are willing to accept some risk in exchange for perceived benefits such as sustaining livelihoods (Newhall et al., 1999).

Furthermore, hazard, risk and emergency response communication should focus on tangible factors (e.g. safeguarding livestock) which encourage community resilience (Miller et al., 1999). To achieve this, emergency managers need to promote resilience and growth by ensuring that communities have the internal resources and capabilities necessary to manage the demands, challenges and changes encountered before, during and following an event (Paton and Johnston, 2001). When residents perceive that emergency managers have met public needs they will be more likely to trust the information provided and as such, use this knowledge to establish their own personal preparations for a volcanic crisis (Paton et al., 2008).

By examining residents' response to and perception of volcanic risk mitigation strategies this paper aims to uncover the various factors which influence this rural community's behaviour and perception.

3 Methods

A mixed methods approach was applied whereby different qualitative methods (i.e. field observations and semi-structured interviews) contributed to different aspects of the study. A mixed methods approach not only provides a more comprehensive view of residents' hazard knowledge and risk perception (Bird, 2009; Bird et al., 2009; Haynes et al., 2007; Horlick-Jones et al., 2003) but also reduces the possibility of systematic biases or limitations compared with a single data source or method (Maxwell, 2005).

3.1 Field observations during the evacuation exercise

Field observations are a direct and powerful method of learning about people's behaviour and perspectives in the context in which they occur (Maxwell, 2005). As part of our observation schedule we sought to discover firsthand (1) how people responded to the evacuation exercise and (2) their feelings towards the exercise and evacuation plan.

Located on a farm in Álftaver, we (Bird and Gísladóttir) observed and documented the evacuation exercise on 25 March 2006 from a resident's perspective. After the eruption warning was issued at 10:37 GMT (local time), we observed how directions on the evacuation and hazard information sign were followed by one household. Later, we observed and documented residents' discussions at the EC in Kirkjubæjarklaustur. Written notes of our observations were transcribed in *Microsoft Word®* and imported into *QSR NVivo®* for coding to enable interrogation of the data.

3.2 Face-to-face interviews with emergency management officials

Interviews were conducted with the project manager of ICP, the regional Chief of Police, the president of the Icelandic Association for Search and Rescue (ICE-SAR), a research scientist involved in the hazard assessment report and coordination of the eruption scenario for the evacuation exercise, a regional manager for the Red Cross, and the Director of Communication for the Red Cross. These officials were selected based on their key roles during the evacuation exercise. A description of the interview schedule is given by Bird et al. (2009). Following the exercise and interviews, notes were copied into *Microsoft Word®* and imported into *NVivo®* for coding to enable interrogation of the data.

3.3 Face-to-face interviews with residents in Álftaver

Face-to-face interviews were conducted within three weeks of the evacuation exercise in order to complement our field observations and provide a more detailed description of

residents' behaviour and perspective of the evacuation exercise and plan. These consisted of semi-structured interviews with residents from 8-12 April 2006. Residents were contacted by telephone and at least one resident from each of the 10 permanent households in Álftaver agreed to participate. A total of 13 people were interviewed and all participants had family or friendship connections to the interviewer (Gísladóttir).

All interviews were conducted in Icelandic and were focused on questions relating to the perception of hazard and emergency response information meetings, the evacuation exercise and proposed emergency procedures. Electronic copies of the interview schedules are available from the lead author on request. Interview details were translated from Icelandic to English (by Gísladóttir) at the time of interview. These were later transcribed in *Microsoft Word*® and imported into *QSR NVivo*® for coding to enable interrogation of the data.

All qualitative data was coded by tagging sections of text which related to specific categories. While these categories related to the issues raised by Jóhannesdóttir (2005) and Bird (2009) they became more coherent during data collection and analysis. These categories are presented as prominent factors that influence residents' perception of and response to volcanic risk mitigation in the discussion section. Due to the exploratory nature of this study, the data generated from this analysis are presented descriptively in order to identify patterning and facilitate comparison of responses. The results are then challenged or supported by the broader literature on volcanic risk perception and behavioural response in the discussion section which follows.

4 Results

4.1 Field observations during the evacuation exercise

The household under observation participated earnestly. However, they were confused after receiving a colour-coded (green) warning message. This was the first message received via sms and they were not certain of its meaning. After receiving a second colour-coded (yellow) sms warning message, the residents simulated the instructions listed on the evacuation and hazard information sign (see Fig. 2 Bird et al., 2009 for details). Assuming they had 30 minutes from the second (yellow) warning, the resident stated it was "*impossible to complete*" the comprehensive list of instructions within this timeframe.

The first check-point was reached 20 minutes after evacuating the house. A third colour-coded (red) sms warning message was received while driving along the evacuation route.

Authorities at the check-point could not explain the multiple colour-coded messages to members of this household (according to official reports the green message was issued at 10:37 GMT, yellow at 10:58 GMT, yellow again at 11:22 GMT and red at 11:51 GMT).

We reached the EC approximately 45 minutes after evacuating the house. Although authorities and most residents considered the exercise seriously, there was a social atmosphere at the EC. Registration of each and every individual was undertaken by the Red Cross on entry. Details included name, address, identification number and mobile telephone number. All information was handwritten on a registration form.

The main highway remained closed at each of the check points for at least two hours. During this time, no one was allowed to return home. Some residents appeared annoyed by this as they were eager to "*get back to work*" on their farms. However, food and drinks were offered at the EC which made residents a little more relaxed and open to discussions.

Residents discussed their confusion regarding the multiple colour-coded warning messages. Some residents received all three warning messages while others received only one. According to residents, the plan was not properly reviewed at the town information meetings prior to the exercise. Rather, discussions centred on the hazard: "*This is why there was so much confusion during the exercise*". Residents discussed that they should all receive three warnings so they have "*extra time to prepare their houses and animals*".

Other residents voiced their concern about the safety of summerhouse (holiday house) occupants. Many summerhouses are located in the hazard zone and despite occupants "*passing on their numbers to the authorities*" they did not receive any warning messages. Reportedly, no contact was made to two families with "*four mobile phones in total and one satellite phone*". Further, the police started evacuating farms at "*the highest points*" and did not reach these summerhouses until 12:50 GMT despite their location "*low lying in the landscape and much closer to the flood path*".

Many residents at the EC discussed whether or not they would evacuate to Kirkjubæjarklaustur during a Katla eruption. Some residents stated they would miss seeing Katla erupt which they considered "*a-once-in-a-lifetime opportunity*". These residents stated they would "*make the first check-point, if we have time*" and then they would stay there. They declared that they will be "*safe from the flood*" at this check point while still being able to

watch "*their Katla*" erupt. Nevertheless, this area *is* located in the current jökulhlaup hazard zone. However, residents quoted stories from relatives who witnessed the 1918 Katla eruption and according to them this area was "*safe during the 1918 eruption and flood so it will be safe today*".

If residents from Álftaver believed the jökulhlaup would flood the region sooner than the authorities anticipated, or if weather conditions were not favourable (i.e. bad visibility), they would *not* evacuate across the floodplain and river channels: "*It is wrong to travel all the way to Kirkjubœjarklaustur since we have to drive a good way up toward the flood plus cross over the path of the flood*".

Further, Álftaver residents expressed their disagreement with the order to evacuate to Kirkjubæjarklaustur even when conditions were acceptable. In general, "*most people would feel much safer on their own farms or nearby*". Supporting this reasoning, residents stated: "*It would be hard to leave the animals during milking and lambing. Lambing is very labour-intensive and someone needs to be with the sheep at all times*".

Also, residents expressed their concern about having only 30 minutes to prepare for evacuation. These discussions centred on the impracticality of completing the specified tasks and the inappropriateness of several instructions. For example, residents are reluctant to release their livestock particularly if it is during winter.

4.2 Face-to-face interviews with residents in Álftaver *after* the evacuation exercise

In general, the interviews took approximately 2 hours to complete. The survey included two participants who were 31–50 years of age while the remaining were 51+ years. All participants had resided in Iceland all of their lives and Icelandic was their main language. Also, all participants' families had lived in the region for many generations.

Attendance at and perception of community information meetings

Community information meetings were well attended with many people confirming they eagerly participated because: "*they were curious*", "*they were interested in hearing the scientific presentation*" and "*they wished to gain knowledge*" or "*voice their opinions*". One participant opened the conversation with: "*We think of ourselves as taking part in Katla*

eruptions since we have heard so much about them. The stories have been passed down the generations."

Participants stated they had "*trust*" in the scientist and the information he presented while many residents declared they attended the meetings *because* this particular scientist was presenting information. Despite having trust in the scientist, participants had little faith in the jökulhlaup flood simulation model he presented. One participant stated: "*I do not agree with his [the scientist's] simulation model that predicted a 1-2 metre uniform water level around Álftaver. The flow of water was more accurate and I trust this. It was the level of water that I did not trust.*"

Another participant explained: "*They have made their estimates from the model simulations that use old measurements for the size of the glacier. The outlets are much smaller than in 1918 and the glacier is much lower, it's not as thick as the description that they use and therefore the flood will be quicker to come out.*" One participant declared: "*The locals here do not think that this is possible. The eruption would have to be bigger than in 1918 for this to occur.*"

While another added: "*The model itself is based on a uniform landscape and it does not take into account all the depressions around this area. When we asked the scientist about this he admitted that it was not entirely correct and the reason for it not being more accurate was due to a lack of funds to take more accurate measurements. He told us that this region would not be flooded, even though the model showed that it would. When he said this, the police chief became upset with him and said 'what are you saying are you trying to ruin our plan?' Because of this, I have faith and respect in the scientist but not with the police.*" Supporting the scientist's integrity, another participant stated: "*I was very impressed with his answers and the discussions he held with us.*"

One participant criticised the timing of scheduled meetings stating: "*they need to consider what the farmers might be doing. There was a meeting regarding Katla but this was held in the spring during lambing so none of the farmers could attend.*"

Perception of and behaviour during the evacuation exercise

The interviews revealed there is a lack of confidence in the proposed evacuation procedures and residents were "*reluctant to take part*" in the exercise on the 25 March 2006. However, many participants said they took part in the exercise because: "*it was expected of them*", "*they were curious*" or "*to obey orders*".

All but one interviewee declared they participated in the evacuation exercise. However, some residents' perception of 'participation' was somewhat obscure. Two households did not evacuate to the centre in Kirkjubæjarklaustur. Instead, they tested emergency response capabilities by staying home in order to place "*the police in danger*". Some participants believed they had the option of 'Plan A' (evacuate to Kirkjubæjarklaustur) or 'Plan B' (evacuate to the highest farmhouse in Álftaver, either Mýrar or Herjólfsstaðir). These participants stated: "*we feel much more secure about plan B and that is why we stayed here* [in Álftaver]".

One participant stated they knew about both Plan A and B and they think Plan B is much better. Clarifying this statement, the participant explained: "*there has never been a flood covering these farms and therefore this area is the most secure place. It is very dangerous for the police to have to come out to Álftaver to check on the residents. However, it is also very dangerous for these residents to have to go against the flood to Kirkjubæjarklaustur.*"

Another participant criticised the organisation of the exercise for not including Plan B: "*At some stage they have to do something else instead of going to Kirkjubæjarklaustur because the* [evacuation] *message failed. They should have tested people taking Plan B. Plan B was our idea originally. This was a compromise of Plan A. The authorities did not plan to have any alternative plan but the local residents pushed for this to happen.*"

Supporting comments recorded as field observations during the exercise, participants stated that their participation during the exercise does not reflect their willingness to follow procedures during a Katla eruption. One participant stated "*I know I am supposed to evacuate and if I don't the police will come and arrest me. I know I had no choice and that is why I participated* [in the exercise]". While another participant affirmed "*I took part in the exercise to be obedient but this was against my better knowledge*".

Some participants admitted to having greater confidence during previous evacuation exercises and this was attributed to the involvement of the local rescue team. Consisting of residents in Álftaver, the rescue team were involved in previous emergency response procedures. However, they were excluded from any involvement during the 2006 exercise. Participants felt that this exercise would have been "*more relevant and significant*" to Álftaver residents if the local rescue team were involved. Subsequently, one participant declared: "*this exercise has left a negative feeling in the local community*".

An interviewed member of the rescue team stated: "*I am very unhappy that our rescue team does not have a role in the procedure...I have been in the rescue team for 40 years and therefore I am very upset with this exclusion. I am trained to save these people and considering that I am closest I would do that...I know all the local tracks and areas whereas they* [the police] *don't know so it would be more appropriate for me to look after emergencies in this area...I have voiced my concern about us not having a role and the police chief has now decided to change this system. I haven't heard anything about this but I am expecting an update soon.*"

One participant commented on his feelings towards the huge rift between police and locals: "*I am being driven like the sheep are driven to a slaughter place*". Another stated: "*The authorities have not given us any alternatives to Plan A. The authorities believe that they will have perfect conditions when an eruption occurs, the weather will be fine, it will be daytime, there will be no snow blocking the road and all the people will be in the house and ready to start the evacuation plan.*"

"*They have not considered tephra*" a participant stated. Another revealed: "*During past eruptions in this region the historic records and knowledge indicate that visibility is always very poor. Therefore there is no way we will be able to evacuate to Kirkjubœjarklaustur.*"

Repeating the sentiment that was shared during the exercise, participants conveyed their reluctance towards releasing and leaving their livestock unattended during an evacuation. Comments supporting their concern included: "*How long should we expect to be away from the farm? Will someone else be able to come and feed them* [the livestock]?" "*I am concerned if the evacuation was to occur during the lambing.*" "*The animals are most important to us...We would rather stay and attend to them.*"

Nevertheless, not all comments were negative. One participant declared: "*the exercise was better this time because more people took part*" while others understood that these exercises provide exceptional benefits to emergency management officials for improving volcanic response capabilities. One participant considered the reason for greater participation in this exercise as: "*The former exercise was organised by the local rescue team. Since this exercise was organised by the authorities I think people were keener to obey the law and do what they said.*"

4.3 Face-to-face interviews with emergency management officials

Each official who was in direct contact with the evacuees reported an overall positive public response and all officials interviewed in the survey considered the evacuation exercise a success. Comments included:

- *This was the largest exercise in Icelandic history. I feel that everyone evacuated on time and on cue.*
- *There was over 60 % participation in the exercise. We were very pleased with this.*
- *I believe the exercise was a great success.*
- *It was useful in obliging the public and also useful for the local authorities and rescue people in how to deal with this situation. The turn out suggests that people are probably taking this seriously.*

One official admitted that some residents were "*reluctant to take part*" in the exercise. He could not offer an explanation but said: "*I am hoping that you will be able to tell me from your research*".

A few critical comments centred on the problems associated with the communication system. During and after the exercise, officials became aware that the evacuation message failed to reach many summerhouse residents and other residents erroneously received three colour-coded messages. One official stated: "*We will figure out why it occurred. It is usually due to the phone not being registered in the area, or registered to a company, or not registered at all.*" He further explained: "*One part of the region had a technical difficulty and that is why they did not receive the message.*"

An official explained that the three colour-coded messages should be circulated to emergency response personnel: "*The public will not get these colour coded messages. They don't need to*

know the stages. They will just be told there is a possible eruption about to occur and they should evacuate." The purpose of each colour-coded message is:

- Green=Preparedness Stage to alert all emergency response personnel to organise and coordinate evacuation centres and emergency response headquarters.
- Yellow=Action Stage which indicates public evacuation has commenced. It is during this phase that residents will receive the evacuation message and they have 15 to 30 minutes to prepare before evacuating.
- Red=Critical Stage indicating that Katla is erupting and all people should evacuate the hazard zones.

A further explanation in regards to the warning messages was: "*The communication system is limited and cannot send the message out to everyone all at once. They will be sent to those in the most dangerous areas first and then to the ones in the least dangerous areas. That is, closest to the flood path to further away. This will also help reduce traffic on the road.*"

According to one official "*the people of Vik are very used to the presence of Katla and they have rehearsed the response to a Katla eruption for many years and it is quite clear that everyone knows how to do that*". However, the interviews revealed that officials are aware of the problematic situation in Álftaver with respect to the residents' willingness to evacuate. In relation to this, one official stated that residents in Álftaver "*know better than the scientists and emergency personnel*" and as such the officials are "*using reverse psychology on them by giving them a role and therefore making them take part*". Another official stated that residents who were in the emergency team in Álftaver played a role in evacuation procedures according to the previous plan but they did not have a role in the current one.

Another official was more positive about these residents' opinions toward emergency response procedures. In reference to the hazard and response information meetings held in Álftaver, this official stated "*it was a splendid meeting as it was a two-way dialogue...I enjoyed the information that was passed down from the generations that have experienced past floods, such as that in 1918.*" Consequently, this official felt that he had learnt a lot from these meetings.

This official also recognised the importance of providing clear and concise hazard information to residents, especially those located in Álftaver. To clarify this remark he added: "*They* [the residents] *need to know how long they have before the flood comes. Then there*

should be no concern about them evacuating in bad [weather] *conditions. Also, the timing of the warnings should allow time for rescue teams to help the evacuees if the conditions are bad. The sweepers can play this role.*" He also acknowledged the importance of having the option of 'Plan B' for residents located in Álftaver if conditions were not favourable (i.e. Katla erupted without warning). However, no other official endorsed Plan B.

Unlike Rangárvallasýsla, the southern and eastern hazard zones do not have a 'sweeper' system. Sweepers are "*designated farmers who are meant to drive a specific route as they leave the area to check that all farms have evacuated*". This official explained that this only exists for Rangárvallasýsla because "*this is such a large area with many people*".

Also, one official stated in relation to the ICP hazard and response information meetings: "*The scientist is excellent at communicating the facts to the residents and they trust him. He uses basic terms, not scientific jargon. This is why people can relate to him and trust what he says.*"

5 Discussion

The most prominent factors influencing residents' perception of and response to volcanic risk mitigation in this small rural community are: inherited local knowledge, attachment to place, livelihood connections (i.e. concern for livestock) and community involvement in emergency response procedures. This section explores these factors in relation to their importance for effecting more appropriate volcanic risk mitigation strategies.

Álftaver residents are well aware of how devastating Katla can be. They have inherited knowledge from relatives who experienced previous eruptions including details of the extent of flooding and the limited visibility due to tephra. However, they are reluctant to evacuate during a volcanic crisis. Furthermore, despite the implementation of new evacuation plans residents did not believe that emergency response recommendations were appropriate for their community.

Influencing residents' perception is their inherited knowledge. Residents are reluctant to evacuate to their designated EC because they perceive, based on historical accounts, that their region will not be inundated by a jökulhlaup to the extent depicted by the flood simulation

model. However, the extent of their local knowledge indicates that residents have a realistic view of the risk and do not refute potential threats of a Katla eruption.

Residents also demonstrated a strong attachment to place. Their ancestors have lived in the region for many generations and residents refer to the volcano as '*their Katla*'. Similarly, Lavigne et al. (2008) revealed a very strong link between culture and the volcanic environment in areas where residents live on and cultivate the land of their ancestors. As witnessed in Álftaver, attachment to place enhances residents' reluctance to evacuate and their desire to return immediately after an evacuation (Tobin and Whiteford, 2002). An additional component of attachment to place is illustrated by residents' belief that they have a right to watch Katla erupt. This indicates that residents do not necessarily perceive an eruption as entirely negative.

Not all reluctance to evacuate is based on stories of past events and rights to observe the eruption. Álftaver residents are justifiably reluctant to evacuate from their homes because the evacuation route proceeds towards the volcano before cutting directly across the flood path. A similar result was found among rural residents in Rangárvallasýsla (Bird et al., 2009). Álftaver residents are not only concerned about personal safety but also for the safety and well-being of the police who are charged with the responsibility of evacuating the community.

Residents' demand for 'Plan B' and for the local rescue team to direct the evacuation is not only practical but also logical. However, only one official recognised the importance of their inherited knowledge and was positive towards incorporating local knowledge in emergency response procedures.

Contrary to other studies (e.g. Gregg et al., 2004; Lindell and Whitney, 2000; Mulilis and Duval, 1995) where residents transferred their personal safety, Álftaver residents demonstrated a strong desire to deal with mitigation locally and with community involvement. However, adjustments were not made according to residents' feedback and disagreements with the proposed plan. Emergency response procedures remained unchanged during the exercise and residents concerns were unresolved. No 'Plan B' was developed and consequently, residents were confused about recommended procedures during the exercise. This is surprising since community discussions were instigated through the hazard and response information meetings.

Understandably, residents had a '*negative feeling*' following the exercise. Not only were their concerns ignored but they were also threatened with arrest if they did not participate in the exercise. The issue of advising versus ordering public evacuation is not easily resolved and solutions will vary geographically, spatially and temporally (Mileti and Sorensen, 1990). As observed in Álftaver, forced evacuations can reduce public trust and create negative consequences for emergency managers (Tobin and Whiteford, 2002).

The obligation of providing accurate and up-to-date hazard information is emphasised by residents' criticism regarding the limitations of the flood simulation model. Local people can often underestimate the scientifically estimated risk (Lavigne et al., 2008). However, based on inherited knowledge and an acute awareness of their surrounding area, it is not surprising that Álftaver residents underestimate the scientifically predicted risk from jökulhlaup, as depicted by the model.

Residents further questioned whether or not emergency managers considered the characteristics of *all* hazards (including lightning, tephra and adverse climatic conditions) when recommending appropriate emergency response actions. It is vital to determine whether or not additional factors will hamper or enhance the effectiveness of protective actions (Mileti and Sorensen, 1990). In the case of Álftaver, emergency managers need to consider if their stringent evacuation policy will increase residents' vulnerability to the variety of hazards that might occur during the next Katla eruption. This underlines some serious issues as residents questioned their trust in the scientific information on which risk mitigation strategies are based. Furthermore, it highlighted apparent conflicts between emergency management officials and scientists. Essential components of effective hazard warnings include accuracy, certainty and clarity (Peterson and Tilling, 1993) and when scientific disagreements are involved, it is vital to use one single consistent voice (Newhall et al., 1999). Within this context, scientists need to take an applied role in educating end-users about hazard information and the implications of any uncertainty within the data (Ronan et al., 2000).

The problem regarding the use of multiple warnings further highlights the need for consistency. Hazard communication is only effective when the public and media have the ability to understand the nature, meaning and intent of the warning (Dominey-Howes et al., 2007). In accordance with recommendations made by Gregg et al. (2007), a single warning system that comprises of a simple and consistent message is essential for facilitating an appropriate response. Also, it is critical that communication is effective at reaching all people

located in the hazard zone. Bird et al. (2009) contains a more thorough discussion on poor communication during the evacuation exercise in southern Iceland.

The general consensus in this community is that the local rescue team, located in Álftaver and comprised of local residents, is better equipped to execute emergency response procedures rather than external authorities. Residents feel that they should have the option of 'Plan B' (and some believe they already do) where the local rescue team coordinates the evacuation to local farmhouses which are not vulnerable to jökulhlaup hazards.

Haynes et al. (2008a) investigated the importance of identifying trusted communicators for improving the efficacy of volcanic risk communication. Considering Álftaver residents have demonstrated trust in their local rescue team, it would be wise for emergency managers to capitalise on this source. We therefore recommend that emergency managers use the local rescue team as intermediaries to communicate hazard, risk and emergency response information between scientists, officials and residents.

Despite residents' disagreement with the flood simulation model, they expressed feelings of trust in the scientist. Other studies (Carlino et al., 2008; Haynes et al., 2008a) have also revealed a greater trust in scientists over emergency managers. As recommended by Haynes et al. (2008a), scientists need to be perceived as approachable and honest with their scientific information. It appears that this was achieved in Álftaver.

Communicating hazard, risk and emergency response information in a relaxed setting allows officials to engage with the community and therefore gain a greater understanding of community perceptions (Haynes et al., 2008a). In view of the contextual issues in Álftaver (i.e. inherited knowledge, attachment to place), all emergency managers would benefit from adopting these communication techniques.

Research has shown (e.g. Barberi et al., 2008) that residents want to be involved in emergency response planning and the residents of Álftaver are no exception. The residents in Álftaver want to be empowered. They want to be involved in emergency response planning and they want the local rescue team to direct evacuation procedures.

Considering that successful disaster risk reduction can be achieved with broad community support and action from local residents (Kelman and Mather, 2008), Álftaver should be given

the support to develop risk mitigation at the local level. Through the implementation of projects and activities that encourage community participation in problem solving, empowerment can be attained and community resilience preserved (Paton and Johnston, 2001).

Empowering residents, having them contribute to emergency response planning, will also allow for the development of more appropriate evacuation instructions. Descriptions about the warning signal would be more suitably detailed on the evacuation and hazard information sign instead of itemising an unrealistic list of instructions such as releasing livestock from enclosures and removing fencing.

Furthermore, the issue of community resilience by safeguarding livestock during a volcanic crisis needs to be addressed. From a resident's perspective, it appears that emergency managers have not considered the community's livelihood. Residents have been instructed to release their livestock during an eruption (against their better judgement) and the exercise and information meetings interfered with daily agricultural practices. Despite the risk, residents have been known to return home during a volcanic crisis to earn an income or attend livestock (Haynes et al., 2008b; Lavigne et al., 2008). This scenario might occur in Álftaver if emergency managers do not address this issue.

Although the sample size was small, one resident from each of the permanent households located in Álftaver participated in the survey. Therefore, this research is representative of the local population. Furthermore, this research benefited from personal connections between the interviewer and participants because a rapport was already established. Sharing the same background can have a positive effect by facilitating a rich and detailed conversation based on empathy, mutual respect and understanding (Valentine, 2005). Initiating, negotiating and maintaining relationships with survey participants is an essential component of qualitative research as they help facilitate access to rich and detailed information (Maxwell, 2005). Within this context, a rapport was particularly important considering the divide between some residents and emergency management officials.

Interviewer bias is predominantly related to unstructured surveys and the impact of using semi-structured or structured questionnaires is considered is relatively minor (Sjöberg, 2000). However, the issue of bias must always be considered and attempts to minimise its impact adopted. While it is possible that the interviewers might have influenced participant responses

in some way, all care was taken to avoid this occurrence. This included using only one translator during the course of the study in order to avoid misinterpretations and miscommunications.

Both interviewers had previous experience conducting face-to-face surveys. As such, the interviewers were able to ensure that questions were asked exactly as intended and that participant responses were translated fully and completely (Patton, 1990). Also, using two methods of qualitative enquiry further lessons the impact of bias. This form of triangulation helps overcome the intrinsic bias that is inherent within single-method, single-observer and single-theory studies and as such, offers greater validity (Denzin, 2006).

6 Conclusions and recommendations

In light of the apparent conflicts revealed by Jóhannesdóttir (2005) in the rural community of Álftaver, this research aimed to provide the first step towards identifying the contextual issues that influenced residents' perception of and response to volcanic risk mitigation strategies. The results confirmed socio-cultural and socio-economic factors play a pivotal role in shaping residents' behaviour and perceptions. Inherited local knowledge has provided residents with a rational view of the risk. Consequently, they are equipped to question emergency response recommendations. Residents have a very strong attachment to place and as such are reluctant to evacuate. Corresponding to sustaining community resilience, residents are justifiably concerned for their livestock.

Álftaver residents are curious and knowledgeable and are willing to be involved in the development of volcanic risk mitigation procedures. Emergency management agencies should embrace this by empowering residents. These residents not only have invaluable inherited knowledge but they are also environmentally aware. Álftaver has traditionally been resilient to Katla eruptions. It is therefore essential that emergency management agencies incorporate local knowledge and perceptions to ensure reduced vulnerability and sustain community resilience.

Emergency managers need to revise their stringent evacuation policy and investigate alternative emergency response recommendations with community consultation. All hazard events are unique. Risk mitigation strategies need flexibility in order to evolve with the complex and dynamic nature of natural hazards. The residents' call for an alternative option,

if evacuation is deemed hazardous, must be answered. Considering Álftaver residents trust their local rescue team, emergency management agencies should capitalise on this resource by allowing them to direct community evacuation in close consultation with officials. This trust could also help facilitate communication between residents and emergency management agencies.

As numerous studies have demonstrated, effective disaster risk reduction must integrate research of the wider culture and society in conjunction with volcanic hazards and risk perception. Up until the evacuation exercise in 2006, emergency management agencies have remained focused on hazard-related factors of a Katla eruption. However, this exercise has served as an effective mechanism to encourage community dialogue.

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Chapter 6

Different communities, different perspectives, different mitigation strategies? Issues affecting resident's behaviour and response in southern Iceland

The following chapter consists of:

- Overview
- Motivations and contributions
- Images from the case study
- The paper –

Overview

The paper presented in this chapter was submitted for publication to the *Bulletin of Volcanology* on 23 December 2009. This research explores residents' knowledge, perceptions, behaviour and characteristics in relation to disaster risk reduction in communities located in the eastern and southern jökulhlaup hazard zones in the municipality of Vestur-Skaftafellssýsla. It incorporates 66 face-to-face structured questionnaire interviews which were conducted with residents between April and September 2008.

Motivations and contributions

To complete the survey of residents' knowledge and perception, a sequential study, which involved residents living in *all* communities within the eastern and southern hazard zones (i.e. Vestur-Skaftafellssýsla), was undertaken. This study, presented in this chapter, expands on the issues revealed in Chapter 5 and based on the findings, provides recommendations for improving volcanic disaster risk reduction strategies.

I developed the instrument used in this research based on previous questionnaires. Guðrún conducted the interviews in Icelandic and translated participant responses directly to me for recording and questioning. This also allowed me to take an active role as Chief Investigator during the interview process.

I conducted all data entry, analysis and compilation and I developed Figure 1. Invaluable advice was provided by Associate Professor Peter Petocz and Professor Gunnar Stefánsson on statistical methods and by Pat Bazeley on the applications of NVivo. The complete manuscript was written by me with insightful comments and suggestions from both co-authors, Damian Gore and Benjamin Gillespie.

The introductory cover letters in Appendix M and N and the questionnaire in Appendix O were used in this survey.

The following selection of photographs is included in order to set the scene for the study presented in this chapter. The first photograph shows the low-lying coastal area of Vík looking north from the beach. The houses located in this area will be evacuated during a Katla emergency. The second and third photographs were taken while interviewing residents and the fourth photograph illustrates the farming region on Mýrdalssandur in the eastern jökulhlaup hazard zone.

Photographs from the case study

The community of Vík (photo taken by Deanne K. Bird)

Álftaver resident signing an ethics approval form with coffee and kleinur ready to go (photo taken by Guðrún Gísldóttir)

Guðrún interviewing an Álftaver resident (photo taken by Deanne K. Bird)

Northeast view to Mýrar with the Vatnajökull ice cap in the background (photo taken by Deanne K. Bird)

Different communities, different perspectives, different mitigation strategies? Issues affecting resident's behaviour and response in southern Iceland

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Abstract

This research investigates residents' knowledge and perception of the Katla volcano and emergency response procedures in all rural and urban communities located in the eastern and southern Katla hazard zones. Using a questionnaire survey, we demonstrated that there is a difference between rural and urban community's knowledge and perceptions and we identified the contextual issues influencing residents' perspectives. All rural and most urban residents demonstrated accurate knowledge of Katla, the warning system and emergency response procedures. Urban residents believed the emergency response plan to be appropriate. In comparison, rural residents did not perceive the emergency response plan as appropriate and if conditions are bad they would personally assess the situation before deciding on a course of action. Livelihood connections and inherited knowledge affect rural residents' ability to comply with the recommended procedures. Factors such as hazard knowledge, sense of community and attachment to place indicate that rural residents are more resilient to

volcanic hazards. Based on our findings we recommend that emergency management agencies use contextual issues, such as personal responsibility, neighbourliness and, community involvement and cooperation to develop and implement more appropriate volcanic risk mitigation strategies.

Keywords: attachment to place, local knowledge, community cohesion, trust, preparedness, Katla

1 Introduction

Developments in volcanic risk mitigation, including full-scale evacuation exercises in March 2006, have been based on physical studies of a Katla volcano eruption (Guðmundsson and Gylfason, 2005). Researchers and emergency management agencies (EMA) failed to account for the heterogeneity of people and communities occupying the hazard zone (Bird et al., in review). This goes against recommendations of the past decades (e.g. Barclay et al., 2008; Chester et al., 2002; Cronin et al., 2004; Dibben and Chester, 1999; Mileti et al., 2004; Paton et al., 2008; Tobin, 1999, among others) which supports a more thorough approach to disaster risk reduction, where social investigations complement physical assessments, to reduce the risk associated with disasters.

In light of this omission, social studies were conducted in order to provide a more comprehensive evaluation of risk. Bird et al. (2009; in review) explored perceptions of emergency response procedures among residents in all communities in the western hazard zone in the municipality of Rangárvallasýsla and in the small rural community of Álftaver in the municipality of Vestur-Skaftafellssýsla (Fig. 1). Bird et al. (2009) showed that despite living in a jökulhlaup (glacial outburst flood) hazard zone, some residents did not perceive that their homes could be at risk and as such would not obey official evacuation orders. Bird et al. (in review) described similar results and provided an in-depth account of social issues, such as inherited local knowledge, attachment to place and livelihood connections. These factors were instrumental in influencing residents' perceptions and responses.

No assessment however, encompasses *all* communities located in the southern and eastern hazard zones in Vestur-Skaftafellsýsla despite historic jökulhlaup, tephra, lightning and in some instances, tsunami (Guðmundsson et al., 2008) affecting these regions. In order to address this gap, this paper explores the contextual issues which influence the perceptions of

residents in Álftaver, Meðalland, Sólheimar and Vík and their ability to positively respond to emergency management recommendations.

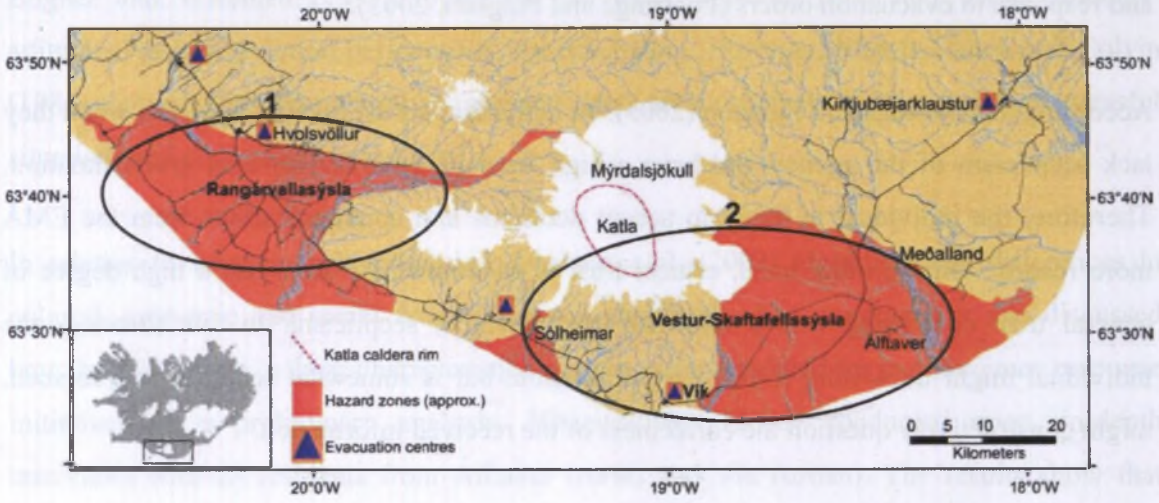

Figure 1. The Katla jökulhlaup hazard zones in southern Iceland. The encircled region labelled 1 encompasses the municipality of Rangárvallasýsla in the western jökulhlaup hazard zone. The encircled region labelled 2 encompasses the communities of Álftaver, Meðalland, Sólheimar and Vík in the municipality of Vestur-Skaftafellsýsla in the eastern and southern jökulhlaup hazard zones. Please note: although it appears that Meðalland is outside the jökulhlaup hazard zone, eight permanently occupied properties are situated *within* the hazard zone.

Not only is this work essential in light of the conflicts revealed by Bird et al. (2009; in review) but it also:

1. Provides the first investigation of residents' knowledge and perception of Katla, associated volcanic hazards and proposed emergency response procedures in *all* communities located in the hazard zones in the municipality of Vestur-Skaftafellsýsla,
2. Encompasses residents' knowledge and perception from both rural *and* urban communities within the eastern and southern hazard zones facilitating comparison between the two groups and,
3. Revisits a small rural community following talks with EMA in the spring of 2008 to improve the evacuation procedures developed in 2006.

Furthermore, the police have undergone restructuring in southern Iceland since the 2006 evacuation exercise. Amendments to the Police Act No. 90 and the Act on District Executive Power No. 92 (Lög nr 46/2006) amalgamated the police districts of Rangárvallasýsla (based in Hvolsvöllur) and Vestur-Skaftafellssýsla (based in Vík). Consequently, the Rangárvallasýla Chief of Police now governs Vestur-Skaftafellssýsla from Hvolsvöllur. This may have serious

implications for regional risk mitigation because the Chief of Police is responsible for an evacuation and trust in such institutions is an important factor in influencing risk perceptions and response to evacuation orders (Poortinga and Pidgeon, 2003).

According to Poortinga and Pidgeon (2003), an individual's trust in an EMA arises when they lack scepticism of the agency and have a high level of general trust in a given situation. Therefore, the individual is likely to accept decisions and communications from the EMA more readily. On the other hand, critical trust is where an individual has a high degree of general trust coinciding with a relatively high level of scepticism. In this situation, the individual might be willing to rely on information, but is somewhat sceptical and as such, might constructively question the correctness of the received information.

Residents from the rural communities of Álftaver, Meðalland and Sólheimar and the urban community of Vík are the focus of this study (Fig. 1). While the town of Vík might not be considered as urban internationally, it is regarded as an 'urban nuclei' by Statistics Iceland (Statistics Iceland, 2010). Therefore the residents living in Vík are classed as 'urban' within this study.

In addition to the rural/urban classification of the communities in the eastern and southern hazard zones, they may further be categorised by their vulnerability to different volcanic hazards. For example, properties located in the *rural* communities of Álftaver, Meðalland and Sólheimar will be evacuated because of the risk from jökulhlaup. However, properties in the low lying coastal *urban* area of Vík will be evacuated because of the risk from tsunami.

Residents in Álftaver and Meðalland have been notified that they have 30 minutes to prepare to evacuate to Kirkjubæjarklaustur. Residents in Sólheimar have been informed that they have 15 minutes to prepare to evacuate to Vík. Lastly, residents in Vík have been told that they have 30 minutes to prepare to evacuate to their local evacuation centre. To aid their evacuations, residents have been issued with an 'Evacuation and Hazard Information Sign' which lists instructions for 'house evacuation', 'precautions due to subglacial eruptions' and 'precautions due to lightning' (for further details, see Fig. 2 in Bird et al., 2009).

The perception of risk and assessment of hazard by communities stems from the relationships with their physical and social environments (Oliver-Smith, 1996). Blong (1984) suggested that rural communities who are 'closer to earth' generally perceive hazards more realistically

than urban communities. Conversely, Fortmann and Kusel (1990) argued that residential status had no such effect since rural and urban communities are not homogenous. Similarly, Bogner and Wiseman (1997) found no difference between rural and urban students' attitudinal and behavioural perspectives towards nature. However, Marotz-Baden and Colvin (1986) showed that rural rather than urban residents are more likely to take control of stressful situations and adopt coping strategies.

In relation to volcanic risk mitigation, Chester et al. (2002) identified vast differences in cultural, economic and social factors between rural and urban communities and discussed how the differences in these characteristics must be accommodated for in emergency response initiatives. In a preliminary analysis, Jóhannesdóttir (2005) conducted open, in-depth interviews with 28 residents from Álftaver (rural) and Vík (urban). The results show that urban residents were more confident in the plan (developed in 1973) while rural residents did not consider the plan appropriate to their community (Jóhannesdóttir and Gísladóttir, 2010).

The dynamic nature of society means that many communities are in a state of flux as people and businesses move in or out of the area and different issues spark public debate (Tobin, 1999). King and MacGregor (2000) identified 'one person households' and 'newcomers to the community and migrants' among specific groups of people likely to be highly vulnerable to hazards. Risk mitigation efforts therefore need to recognise and accommodate these vulnerabilities in order to minimise the detrimental effects of hazards on a community and thereby increase resilience. To be resilient, communities must have the internal resources necessary to resist, absorb, accommodate and recover from the effects of hazardous events in a timely and efficient manner (UNISDR, 2009; p. 10).

King and MacGregor (2000) described the required community behaviour and characteristics, which reduce vulnerability as: the ability and willingness of residents to evacuate, community involvement, an ability to access warnings, instruction and advice, no dependents, and general and local knowledge, among others. Furthermore, sense of community and attachment to place are important aspects of cohesion within a society and fundamentally, resilience to hazards. Therefore, examining the concepts of 'community' and 'vulnerability' as functional key elements of risk management encourages the development of more effective strategies and greater community participation in disaster risk reduction (Buckle, 1999).

It is therefore the purpose of this paper to investigate Álftaver, Meðalland, Sólheimar and Vík residents' knowledge, perception, behaviour and characteristics in order to compare differences and explore how these might impact disaster risk reduction. We achieve this via a questionnaire measuring hazard knowledge, risk perception, proposed behaviour when faced with a Katla eruption and various aspects of trust and preparedness in addition to recording participant demographics. After describing the questionnaire interview process and presenting selected results of the survey, recommendations are made for improving volcanic disaster risk reduction in southern Iceland.

2 Methods

2.1 Face-to-face questionnaire interviews

Questionnaires were administered face-to-face with local residents from April to September 2008. We endeavoured to sample one key decision maker from *every* permanent household located in the hazard zones in Álftaver, Meðalland, Sólheimar and Vík. Initial contact was established by phone or direct approach (i.e. door knocking). Interviews were conducted by Bird and Gísladóttir in the participants' home or place of work. Many residents who were approached to participate in the survey had family or friendship connections with Gísladóttir.

To meet University ethical requirements potential participants were given an introductory letter before interviewing commenced. This letter described the nature of the research, what was required of the participant and the proposed use of data. Participants were given the opportunity to withdraw from the survey at any time without consequence.

A total of 66 interviews were conducted with residents. This involved 9 out of 10 permanent households in Álftaver, 5 out of 8 permanent households in Meðalland, 5 out of 6 permanent households in Sólheimar and 47 out of 62 permanent households in Vík. An overall response rate of 77% was achieved. Residents' reasons for not participating in the survey were in relation to heath issues and unavailability (14%) or lack of interest (9%).

Based on the questionnaire instrument used by Bird et al. (2009), our questionnaire consisted of five sections with a total of 53 open and closed format questions. Section topics were as follows:

1. Participant demographics;
2. Katla, jökulhlaup (for Álftaver, Meðalland and Sólheimar residents), tsunami (for Vík residents) and emergency procedures;

3. Emergency communication and evacuation plans;
4. Personal use of media sources for acquiring hazard information (e.g. use of the Icelandic Civil Protection (ICP) website (www.almannavarnir.is), the EWIS (near-real time earthquake web-viewer) website (drifandi.vedur.is/) and the Icelandic Meteorological Office (IMO) website (www.vedur.is)); and,
5. Personal and official preparedness for a Katla eruption, the *possibility* of a future Katla eruption and its effects and personal trust in hazard information.

An electronic copy of the questionnaire is available from the lead author on request.

The interviews were conducted in either English or Icelandic and responses were translated from Icelandic to English (by Gísladóttir) at the time of interview. Participants were given the opportunity for open, unstructured discussion during and after the administration of the questionnaire.

Questionnaire data were transferred into *SPSS® 17.0* (Statistical Package for Social Science) and *Microsoft Word®*. *SPSS* data were coded and analysed using frequency and cross-tabulation tables and participants were assigned to either the rural group (Álftaver, Meðalland and Solheimar (n=19)) or the urban group (Vík (n=47)). Results were assessed for statistically significant differences based on p values using Fischer's exact (2-sided) chi-square test for 2x2 tables (e.g. yes/no response), Pearson (2-sided) chi-square test for other tables (i.e. multiple response) and independent samples t-tests (Pallant, 2007). We considered $p<0.01$ as highly significant and $0.01<p>0.05$ as significant. The number of participants (n) who responded to each question was 66. However, n is indicated if a non-response was recorded.

All data were transferred to *QSR NVivo 8®* for coding in order to compare, contrast and link open-response data with closed-response. All qualitative data was coded by tagging sections of text which related to specific categories. These categories relate to the issues raised by Jóhannesdóttir (2005) and Bird et al. (2009; in review). Links between open-response answers, additional comments and closed-response answers are identified and presented for each section in the results. In addition, comments from Álftaver residents with respect to changes in the 2006 emergency procedures are presented. The results are then challenged or supported by the broader literature on volcanic risk perception and behavioural response in the discussion section which follows the results.

3 Results

Nearly all residents offered us a warm welcome and many were very appreciative of being given the opportunity to share their thoughts and opinions. When informed of the questionnaire's topic, many residents declared "*I don't know anything about Katla*". However, many homes contained landscape paintings and photographs of Mýrdalsjökull (the glacier overlying Katla, Fig. 1) and the surrounding region.

Questionnaire interviews took approximately 45 minutes to complete. However, residents who had recently moved into the region took approximately 20 minutes while those who had lived in the region for many generations discussed Katla for almost 2 hours. All participants (except one urban) had lived in Iceland most of their life and Icelandic was the main language spoken in the home. A summary of participant demographics is given in Table 1.

Table 1. Demographic details of rural and urban participants. All data are given as a percentage. Some sections do not equal 100% due to rounding.

	Rural	Urban
Participant age:		
▪ 18-30 yrs	0	11
▪ 31-50 yrs	32	21
▪ 51+ yrs	68	68
Distance of house from river/coast:		
▪ $0 < 2$ km	47	98
▪ $2 \leq 5$ km	53	2
Number of generations lived in region:		
▪ 1^{st}	11	32
▪ 2^{nd}	5	9
▪ 3^{rd} +	84	60
Number of adults living at this address:		
▪ 1 adult	26	36
▪ 2+ adults	74	64
Number of children living at this address:		
▪ 0 children	53	70
▪ 1+ children	47	30
Highest level of education achieved:		
▪ Up to high school	79	66
▪ University degree or higher	0	15
▪ Other	21	19
Occupation:		
▪ Farmer	100	4
▪ Other	0	96

There is a highly significant difference ($p<0.001$) between each group's occupation. All rural participants are farmers compared to only 4% of urban participants. Furthermore, all rural

participants moved to their current residence in the hazard zone prior to the 2006 exercise and 74% settled there prior to the development of the last evacuation plans in 1973. In comparison, 13% of urban participants moved to their current residence after the 2006 exercise and only 38% had lived there prior to the 1973 plans. Consequently, a significant difference was found between the length of time residents had lived at their present address ($p=0.023$).

When asked about Katla, many participants from both groups stated '*I never think of Katla*', before describing their experience of unconfirmed eruptions in 1955 and 1999 and relaying stories from friends and relatives who experienced the 1918 eruption. Those participants determined to have an accurate knowledge of Katla described the last confirmed eruption in 1918 or the possible eruptions in 1955 or 1999 and, the frequency of Katla eruptions as 1, 2 or 3 times per century. However, some participants were counted as correct if they mentioned just one of the above in addition to detailed information about other aspects of Katla.

All rural residents accurately described Katla (Fig. 2) and *all* rural residents reported inherited local knowledge or direct experience of the 1955 or 1999 jökulhlaups. Further, participants whose relatives had resided in the region for several generations referenced other events such as the 1625 and 1755 Katla eruptions. Only one urban participant who had taken up their current residence after the 2006 exercise accurately described Katla.

Participant comments indicating their perceptions of Katla included:

- *We never think about Katla but when something happens we first think of Katla and we look up to her to see if she is coming. I did this after the earthquake on 17th June 2000* (rural).
- *The timeline in this society is based on Katla eruptions - "fyrir og eftir Kötlu" (before and after Katla)* (rural).
- *The older people often talk about what followed Katla. They didn't like her but I don't know her so I don't think about her* (rural).
- *Every morning my father-in-law always looked out and up to Katla and crossed his chest in prayer to god* (rural).
- *It is never a question of if Katla will come; it is a question of when. We recognise Katla as a person - she is an unfriendly woman who is not welcome but we just have to deal with her when she arrives* (urban).

- *What is that? I don't know anything about Katla. I haven't heard of it* (urban - new resident).
- *Once she comes she comes, there isn't anything we can do* (urban).
- *We don't think about Katla. We couldn't live here if we always thought about Katla. Natural hazards can happen everywhere in Iceland. You can't escape it* (urban).
- *At the school we have Katlaljós–torches specifically ready in case Katla were to erupt. We taught the children that if Katla were to erupt, and this would probably be sudden, and they were outside playing, they should not try to come home in the dark but just go to the nearest house and stay there and contact the parents to let them know that they are OK* (urban).

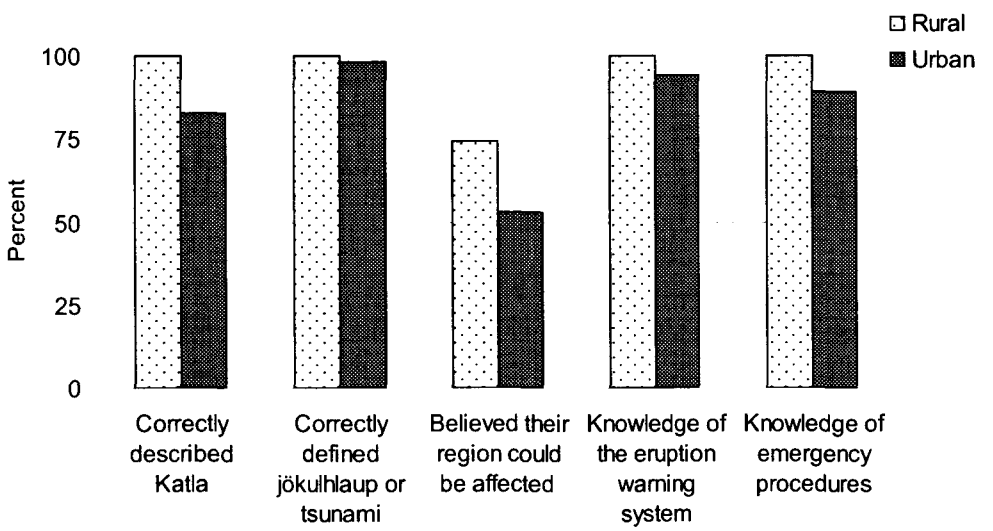

Figure 2. Percent of participants who: correctly described Katla, correctly defined jökulhlaup or tsunami, believed the region where they live could be affected by a jökulhlaup or tsunami (n=65), stated knowledge of the eruption warning system and stated knowledge of the emergency procedures they need to follow.

Almost three-quarters (74%) of rural participants believed their region could be at risk from jökulhlaup whereas slightly more than half (53%) of urban participants believed their region could be at risk of tsunami. All Álftaver residents believed their region could be at risk while two Sólheimar and one Meðalland resident did not perceive a risk. The remaining rural participants stated 'don't know'.

In relation to risk perception one urban participant stated: "*Local knowledge is fading as people who experienced the last Katla eruption have passed away, now people are allowed to build down here* [near the coast] *when it used to be banned.*" Despite living in the defined

tsunami hazard zone, other comments from urban residents in relation to their disbelief that their region could be at risk included:

- *In 1918 there was quite a lot of water but no tsunami.*
- *I never worry about Katla. If it comes up in the regular places then Vík would be fine.*
- *In 1918 they experienced the tsunami in Vestmannaeyjar but not here in Vík.*
- *Vegetation is much more on the coast and it is higher therefore it will be safe* [from tsunami].
- *I've not heard about it. The people in 1918 talked about lightning, darkness and tephra but not tsunami.*

Overall, nearly all participants knew of the eruption warning system and were aware of the emergency procedures they should follow if a warning is issued. Three out of five of the urban participants who were not aware of the emergency procedures were new residents. Many urban residents expressed concern about the need to educate new residents on emergency response procedures. One participant echoed the sentiment of many by stating: "*It is not very good as there are many new people who are not sure. This should be part of welcoming new residents to Vík.*"

There is a highly significant difference ($p=0.003$) between group responses to the open question 'If a hazard warning is issued what would you do?' Urban participants are more likely to follow the recommended procedures than rural participants are (Table 2). Many Álftaver residents stated they would go to Herjólfsstaðir, a local farmhouse located on higher ground. Other comments included:

- *I believe that we should work out for ourselves what we should do. We should go to Herjólfsstaðir. My mother in 1918 went to Virki* [a building located in Álftaver] *and the most important thing was that all the people were together even though our home was safe... The community had decided that was the best plan for everyone* (Álftaver).
- *If I am certain that the animals will suffer I will disobey and stay. But if I am guaranteed that I can return to tend the animals then I will obey the plan and go to Kirkjubæjarklaustur* (Álftaver).
- *I would stay for 2 reasons: 1. I believe that I am safe here and 2. I am responsible for my livestock. We have an emotional connection to our animals. It is not just a business/economic connection. It would be different if we had a hotel business. I would evacuate all the tourists and take them to the evacuation centre but I can't do that with my animals* (Álftaver) (see Fig. 3).

- *I would stay but if I found myself threatened I would go to higher ground* (Sólheimar).
- *I would wait a bit and then just follow. We are supposed to let all the animals out but if it's in the winter it is just stupid. All the animals would be safe in the houses. The flood wave in 1918 was 1 m here. It's more logical for us to go to higher ground. Just like Álftaver. It's silly for them to go to Kirkjubæjarklaustur. Also, it's a-once-in-a-lifetime show. We would like to watch! But if you haven't followed the procedure then the police would come here and arrest you. We have been told that someone will come in and feed our animals but we are a bit reluctant to just have 'someone' come into our place. And if someone is allowed to come why can't it be us?* (Meðalland).

Table 2. Participants' predicted behavioural response to a hazard warning and a Katla eruption (n=65). All data are given as a percentage. Some sections do not equal 100% due to rounding.

	Rural	Urban
If a hazard warning is issued, % of participants who would:		
• Follow procedures	58	91
• Other	42	9
If a Katla eruption commenced without warning, % of participants who would:		
• Call 112, police or neighbour	63	51
• Wait for text message or phone call	5	13
• Turn on radio, TV or internet	0	9
• Other	26	23
• Don't know	5	4

Comments relating to urban participants who said 'other' include:

- *I am supposed to go up there but I wouldn't go. I will only go when I see the flood coming up to my window.*
- *I would wait until they come and take me.*
- *I would get in my car and drive away.*
- *I am supposed to evacuate but I am not sure exactly where to...It is not very good as there are many new people who are not sure.*

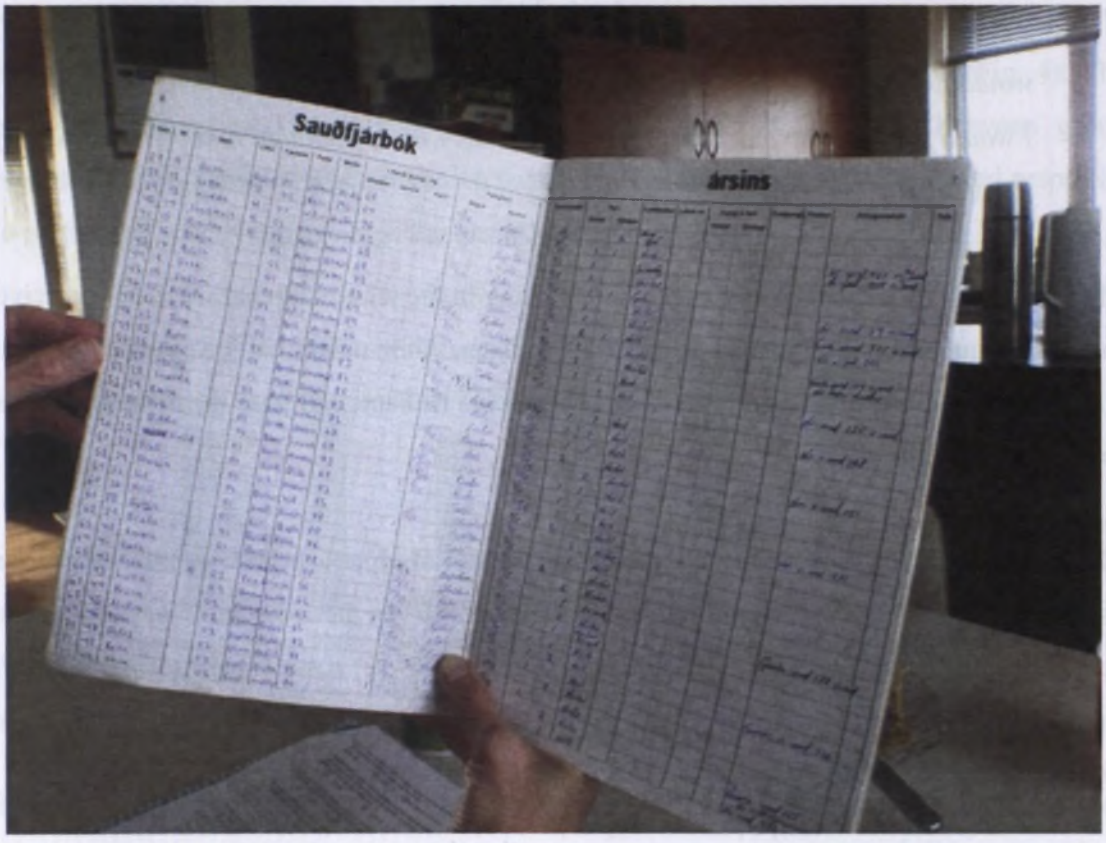

Figure 3. Livestock identification book which lists all 400 sheep, their parents and various other characteristics. One farmer shared this book with us in order to illustrate the strong emotional connection he has with his livestock. In addition to sheep, this farmer cares for 70 cattle, 60 horses and 25 foals, all of which are also named.

The majority of participants from both groups would try to call 112 (Icelandic emergency services), police or a neighbour in the event of an unannounced Katla eruption. However, nearly a quarter of participants chose the option 'other'. Comments included:

- *I would just go* (rural).
- *I wouldn't do anything. I wouldn't dare call anyone because of lightning* (rural).
- *All the communication systems will not work during an eruption-I would probably just take my family to a safe place* (rural).
- *I've never thought about it. I suspect that the people who are monitoring the volcano would see it before I would feel it* (rural).
- *We can never miss it. There would be a lot of noise and then we would just leave* (urban).
- *I would go next door. He's a member of the local rescue team. Here it is such a small area. People look out for each other. It's a very good community spirit* (urban).

- *I would call my friend in Ketlingardalur. It is further east and closer to Katla so I would just call her and ask if she's seen anything* (urban).
- *I would just walk up and see if there is a plume. I have been told that it will come very fast* (urban).

More than half of rural participants (i.e. those living in the jökulhlaup hazard zone) perceived that jökulhlaup will pose the most serious risk to them, while nearly half of urban participants (i.e. those living in the tsunami hazard zone) perceived tsunami will pose the most serious risk to their region (Table 3).

The results show that in addition to jökulhlaup, rural participants perceived lightning hazard as a serious risk. One participant remarked: "*Jökulhlaup* [as the most serious] *but lightning can be very serious. Lightning is greatly feared in this region...Even though tephra was quite small the lightning was so severe that it looked like the middle of the day even though it was night in October* [during the 1918 eruption]."

Table 3. Participants' perception of risk (n=65).

	Rural	Urban
% of participants who believe the following hazard poses the most serious risk if Katla erupts:		
• Jökulhlaup	53	17
• Ice blocks	6	0
• Lightning	39	15
• Tephra	26	20
• Poisonous gases	0	4
• Lava	0	2
• Tsunami	0	49
• Earthquake	0	2
• Don't know	0	4

Tephra was also considered a serious risk by both groups. Participant comments included:

- *Tephra, I'm not so afraid that we are in real danger but it may become completely dark and this would be a huge mental strain to deal with. I know of farmers who were out in the complete dark and they had to use the fence to find their way* [back to the house during the 1918 Katla eruption]. *This would be very difficult to deal with* (rural).
- *I rank tephra as 1, 2 and 3* (urban).

Of those participants who took part in the exercise (see Bird et al., in review for details), 57% of rural and 90% of urban participants were positive about its implementation (Fig. 4). The chi-square test indicates that there is a significant difference (p=0.017) between group responses to this question. The remaining participants in both groups gave a mixed response. No participant stated negative feelings toward the exercise.

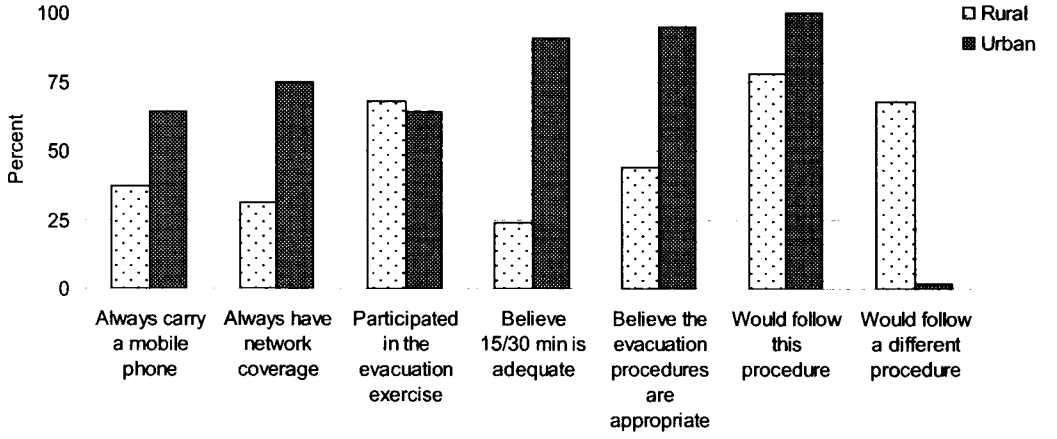

Figure 4. Percent of participants who: always carry a mobile phone, always have network coverage to their mobile phone, took part in the evacuation exercise, think 15 or 30 min is enough time to prepare to evacuate (n=65), think the evacuation procedures are appropriate (n=64), would follow this procedure if there was a real evacuation (n=64) and would follow a different procedure if conditions were not favourable (n=64).

The majority of participants (n=65; rural: 61%; urban: 72%) believe evacuation exercises should be held every two to five years. Many Álftaver residents again stated that they would evacuate to Herjólfsstaðir rather than drive to Kirkjubæjarklaustur. One participant added: "*It's like we are driving right into her* [Katla's] *mouth.*" Other feelings expressed by Álftaver participants in relation to the evacuation exercise include:

- *The local community decided that we should take part even though we didn't agree with the plan.*
- *I would stay. I am not saying that we should ignore everything. It is good to plan. But not with this top-down method.*
- *We had mixed feelings about the exercise because we were supposed to evacuate against the flood. This is a very dangerous area. This feeling has been imbedded in us since 1918. This region to the east of here was badly affected in 1918. It went under very quickly.*

- *It is a good idea to have people come and help but it is ridiculous that they don't involve the real people in the evacuation process. It is ridiculous not to talk to local people who have read the annals and have local knowledge and then to base a model on inaccurate data. I think the plan is ridiculous. Especially for police to come from Kirkjubœjarklaustur to make us leave. We are supposed to have only 30 minutes to evacuate.*
- *We wanted to join in. Even though I thought it was foolish. I hope I will never have to go this way. I would rather stay in Herjólfsstaðir. During the exercise we went against the flood up to Kirkjubœjarklaustur but we didn't want to. We thought that this is odd.*
- *I thought it was so silly that we should go against the flood. I told them that I would go to Herjólfsstaðir or Mýrar* [farmhouses located on higher ground]. *I told them that I would never go to Kirkjubœjarklaustur. The police came and I told them this. It was not a problem because I knew them. It was not good as they didn't communicate with the people about what they wanted us to do, they just told us and expected us to go.*
- *I refused to go. I told them I would take part, I thought it was fine to take part but when it came to the actual plan they didn't take into consideration the real people who live here. There was no communication with us with respect to the development of the plan. I feel safe here in my own home. From that day I learnt that the man in the police costume is in charge. We have become quite good friends since that day.*
- *Some of it is ridiculous. I would not release the animals or collect water. The animals are safer in the house. There will never be enough time. I would never follow the list. One mistake was when they called us they said that we should evacuate to the closest centre but didn't say where it was. Some residents didn't know where that was.*

Sólheimar participants' mixed feelings towards the exercise were due to only one participant receiving the actual evacuation message. These participants were working away from their landline and inadequate reception prevented the sms message reaching their mobile phones. The evacuation message also failed to reach one Meðalland participant while another expressed concern about releasing livestock.

When asked if 15 or 30 minutes was enough time to complete the list of instructions on the evacuation and hazard information sign several participants residing in Sólheimar and Vík revealed that they do not possess this sign. Those participants in Vík had all moved into the area *after* the evacuation exercise in 2006.

A highly significant difference ($p<0.001$) was found between group perceptions of the evacuation plan. Of the rural participants who responded positively toward the plan, only one participant was from Álftaver. Most (74%) rural and nearly all (97%) urban participants would follow the evacuation procedure during a real emergency. Of the rural participants who would not, five were from Álftaver. Only 32% of rural participants stated they would still follow the proposed plan if weather conditions were bad. This included not one participant from Álftaver. In comparison, 93% of urban participants would still follow the plan.

There is a highly significant difference in group responses to each of the closed questions 'would you follow this procedure if there was a real evacuation' ($p=0.006$) and 'would you follow a different procedure if weather conditions were bad' ($p<0.001$). Comments from rural participants in relation to their decision to not follow the proposed emergency plan during unfavourable conditions included:

- *I would follow my forefathers and go to higher ground* (Álftaver).
- *If I could not see anything I would not follow the procedure. And also it depends how much time we have* (Álftaver).
- *It will be dark anyway with tephra and no electricity* (Meðalland).
- *I would stay at home unless I would be arrested* (Meðalland).
- *We would collect all the tourists...then go up to the next farm* (Sólheimar).
- *We have 2 plans. First, if there is time before the eruption we will evacuate to Vik but there is not enough time to release the animals from the yards as it takes 15 minutes just to drive to the sheep house. Second, if the eruption has started we only have 15 minutes before it could flood down Jökulsá. Therefore we will evacuate to our neighbour's house which is much higher up* (Sólheimar).

Rural participants ($n=16$) were asked an additional question regarding their feelings towards leaving their livestock during an evacuation. 81% stated they were very concerned about their livestock, 6% were a little concerned and 13% were not concerned.

Very few participants from either group accessed hazard information from the ICP (rural: 11%; urban: 15%), EWIS (rural: 37%; urban: 36%) or IMO (rural: 37%; urban: 47%) websites. However, 90% of rural and 94% of urban stated they had followed discussions on Katla in the media. The most popular media sources were radio (rural: 94%; urban: 84%) and television (rural: 88%; urban: 80%) (Fig. 5). The chi-square test shows there is a highly significant difference ($p=0.009$) between group use of newspapers. Rural participants are less

likely to rely on newspapers as a source of information because "*we get them so late so the news is old*". Group responses to other media sources did not indicate any significant difference.

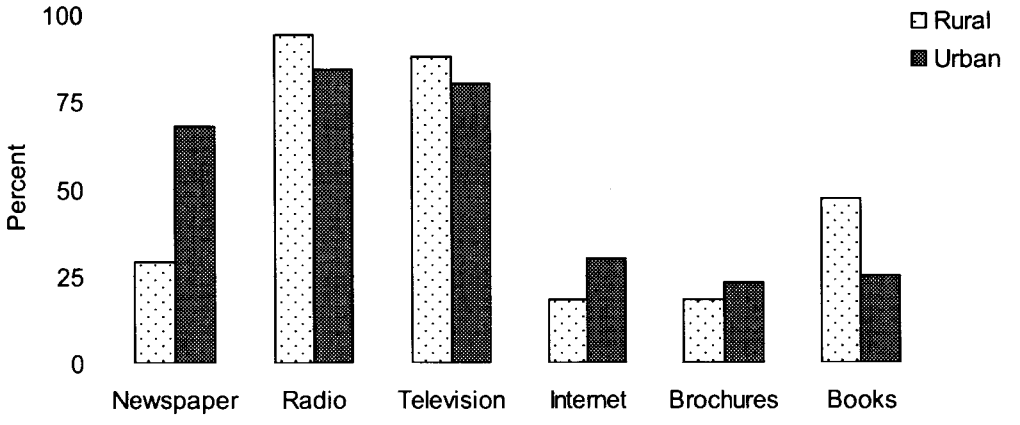

Figure 5. Percent of participants (n=61) who have followed discussions on Katla in the media from various sources.

A five-point response format was used to measure the remaining group of questions and independent samples t-tests were performed on each in *SPSS*. Overall, participants perceived themselves as being less prepared than the ICP and regional public officials for a Katla eruption (Table 4). There is a significant difference between each group's perceptions of personal preparedness. Overall, urban participants rate themselves as more than moderately prepared whereas rural participants rated themselves as less than moderately prepared.

Table 4. Participants' (n=65) perceptions of officials', the ICP's and personal preparedness for a future Katla eruption. Each question is ranked on a scale where 1=not at all, 2=a little, 3=moderately, 4=a great deal and 5=completely.

	mean	p value
How prepared do you think:		
- Officials (e.g. the police, rescue team) in your area are?		
• rural	3.8	0.647
• urban	3.9	
- ICP is?		
• rural	3.4	0.084
• urban	3.9	
- You and your family are?		
• rural	2.7	0.049
• urban	3.5	

Rural comments regarding officials' and the ICP's preparedness included:

- *Preparedness among officials and the ICP is getting lower and lower each year since the exercise. And it will continue to do so until the next practice* (4=a great deal) (Sólheimar).
- *I don't trust the police but I trust the local rescue team a great deal...They* [the rescue team] *would be better prepared if they were more involved in the process with the ICP* (2.5=not at all-moderately) (Álftaver).
- *I rank the police 'moderately'* (3) *and the rescue team 'a great deal'* (4) *but hopefully with the new plan this will change. I rate my opinion of the police from the last exercise when they were threatening to arrest people. It was silly the way they acted, it was not very convincing for the local population* (Álftaver).
- *I have lost faith in the ICP* (3=moderately) (Meðalland).

Rural comments regarding personal preparedness included:

- *I don't talk about it. I never worry therefore I am not prepared.* (Participant response=1)
- *I've never thought about it. They suggested to us during the meeting that we should pack a small suitcase ready to go but we haven't done that.* (Participant response=1)
- *People know about it but don't do anything. They don't keep food and blankets ready for an eruption but they might be stuck here for days due to the jökulhlaup.* (Participant response=3)
- *You need to have things in an emergency kit to protect your ears from the loud noise of the volcano erupting and eyes and breathing from the ash.* (Participant response=3)

Urban comments with respect to officials' and the ICP's preparedness included:

- *Previously the police chief was situated here but now they have moved it to Hella. They should have someone from here in charge.* (Participant response=2)
- *I think the ICP is prepared 'a great deal'* (4). *But not completely due to the communication problems and they don't consider lightning.*

Although many participants perceived that it is unlikely there will be a Katla eruption in the next 10 years there is a highly significant difference between each groups' perception (Table 5). Participants from both groups supported their belief that Katla is unlikely to erupt in the next 10 years by citing "*Krukksspá*". Krukkur was a fortune teller who predicted (in Krukksspá) that Katla would not erupt after certain circumstances had been met (all of which

have occurred). Other residents stated that "*she has released herself*" during either the unconfirmed 1955 Katla eruption or the neighbouring Heimaey eruption in 1973.

Table 5. Participants' (n=65) perceptions about the probability of a future Katla eruption and its possible effects. Each question is ranked on a scale where 1=extremely unlikely, 2=somewhat unlikely, 3=50/50, 4=somewhat likely and 5=extremely likely.

	mean	p value
How likely do you think:		
- There will be a Katla eruption in the next 10 years?		
• Rural	1.7	0.006
• Urban	2.5	
- Your area will be adversely affected?		
• Rural	3.7	0.306
• Urban	3.2	
- You (or your family) will be injured?		
• Rural	1.3	0.433
• Urban	1.4	
- You will suffer damage to your home?		
• Rural	2.2	0.254
• Urban	2.6	

Rural participants' comments included:

- *It is 'extremely unlikely'* (1) *that Katla will erupt due to Krokkspá. But if Katla were to erupt now it wouldn't be as bad as it was in 1918 as there is hardly any glacier.*
- *We will most likely suffer damage to our home from lightning.* (Participant response=2)
- *Totally depends on wind direction. If tephra comes here then it is 'extremely likely'* (5) *that our community will suffer damage.*

Overall, rural participants have the greatest trust in information provided by scientists whereas urban participants have the greatest trust in information provided by the ICP (Table 6). The results show there is a highly significant difference between each group's trust in information from the ICP and a significant difference in each group's trust in information provided by local police and the media. Although not significant, there is a marginal difference between each groups trust in government officials who are responsible for the public's safety during a future Katla eruption.

Table 6. Participants' (n=65) trust in information from various sources and trust in government officials who are responsible for the public's safety. Each question is ranked on a scale where 1=not at all, 2=a little, 3=moderately, 4=a great deal and 5=completely.

	mean	p value
How do you rate your level of trust in:		
- Information provided by ICP?		
• rural	3.6	0.008
• urban	4.3	
- Information provided by scientists?		
• rural	4.0	0.655
• urban	4.1	
- Information provided by local police?		
• rural	3.1	0.014
• urban	4.0	
- Information provided by the media?		
• rural	2.4	0.031
• urban	3.1	
- Government officials who are responsible for the public's safety?		
• rural	3.8	0.071
• urban	4.3	

Rural participants' reasons for lacking trust included:

- *I only trust the ICP 'a little'* (2) *because it's been such a long time since the last eruption. Also, they didn't respond to the flood* [in 1999]. *They didn't send out a message until after the flood had passed.*
- *I was at the meeting at Herjólfsstaðir and a scientist was there. The locals were talking about the 1955 eruption but the scientist wouldn't listen to them. Why would I trust a scientist who is not willing to listen to the locals?* (Participant response=3)
- *I have no trust* (1) *in the police in Hvolsvöllur because I don't know them...Prior to the reorganisation of the police I would have said 'completely'.*
- *The media would probably exaggerate. When there is no other news they sensationalise whatever they can.* (Participant response=1)

While urban participants' sentiment was "*we have to have trust in these people*" some stated that "*nobody is perfect*". One participant echoed the opinion of many by stating: "*I can never expect it completely. We are aware that they are just people and that they will do their best.*" However, comments from urban participants in relation to lacking trust in the scientists and police include:

- *My experience* [with scientists] *has shown me they are ignorant.* (Participant response=3)
- *The police are in Hvolsvöllur and that is quite serious. The only policeman here is often there. If the eruption goes through the Markarfljót* [the western hazard zone] *or Sólheimar then he can't get back here.* (Participant response=2)
- *We hardly know anything about the police anymore.* (Participant response=3)

3.1 Álftaver residents' perception of developments to emergency response procedures since 2006

A meeting was held in spring 2008 between the regional Chief of Police, the police and a member of the ICP. During this meeting residents were told they "*had to go to Kirkjubæjarklaustur*" if an evacuation was ordered. Apparently, some residents questioned this procedure but as one resident stated: "*no Plan B* [alternative plan] *came out of this meeting*". Nevertheless, one resident stated: "*I am happy with the police chief following the recent meeting in spring 2008. He is really thinking of this. He believes in communicating with the locals and the local rescue team.*"

He continued: "*It is obvious that the police chief believes that the rescue team should have a more important role than previously stated. He is more willing to discuss options than the previous police chief.*" According to this resident the current police chief stated: "*the rescue team are more qualified to deal with a Katla eruption here than the police.*"

Another resident commented: "*The police chief is working with us for a Plan B, especially if the weather is bad. It is not official yet but he is in favour. We will go to Mýrar or Herjólfsstaðir.*" These two properties in Álftaver are positioned at a higher elevation than other properties. In relation to the new plans, another resident stated: "*Plan B is in the process of being completed... We are more responsible now. We are able to evaluate the situation and we could make the decision* [to not evacuate to Kirkjubæjarklaustur]. *The police won't come here.*"

A further resident confirmed that the evacuation procedures are now the responsibility of the local rescue team in Álftaver, of which he is a member, and that "*the police are not to come into this area*". He also described changes to the plan for Sólheimar residents: "*there is not enough time for them to evacuate so they are just supposed to go to higher ground*".

Regardless of some residents' perception and the rescue teams' increased responsibility, they still do not have the authority to determine whether residents will evacuate to Kirkjubæjarklaustur or stay in Álftaver: "*In an evacuation the police chief will be in direct contact with the head of the rescue team. However, there still wasn't a Plan B discussed at the last meeting in spring 2008. This was the first meeting* [for residents] *since the evacuation exercise.*" This resident, who is a member of the Álftaver rescue team, also acknowledged current efforts by the regional police chief: "*I would like to commend the police chief on his work to communicate with the local rescue teams and residents.*"

Apparently, another meeting was planned between the police chief and rescue teams in addition to "*a meeting with residents in each town about the current set up of the police*". However, one resident expressed concern about local involvement in developing new strategies: "*If they are developing any new plans they need to do it in close consultation with the local community and rescue team.*"

During the survey, a town hall meeting was held in Vík on 16 August 2008 to discuss the current state of Katla. Scientific presentations were given by members of the Icelandic Meteorological Office, the University of Iceland and the regional Chief of Police. The meeting was organised in conjunction with the ICP and was attended by members of the local rescue teams, the Red Cross and hut wardens working in the tourist region of Þórsmörk– which is located in the western hazard zone. Unfortunately, due to lack of preparation and other community functions, very few residents attended.

Consequently, one resident, out of the four who were in attendance, criticised the timing of the meeting: "*There were so few residents but then I understand that it was last minute* [organising] *in conjunction with the scientific workshop.*" This resident was very impressed with the meeting but said: "*It was difficult to understand one scientist but her images were good and made it easier to understand. I found the English presentation harder to understand.*"

4 Discussion

Our overall response rate of 77% is very good in comparison with other natural hazard studies (e.g. Johnston et al., 1999) and therefore, we are confident in the results. There is a possibility of non-response error but we believe this to be minimal since only 9% of households declined to participate. We captured a high percentage of the total population living in the hazard zone.

Consequently, we are confident in using these results to develop and apply disaster risk reduction strategies.

All rural and many urban residents described firsthand experience of the jökulhlaup in 1955 and/or 1999 and demonstrated inherited local knowledge of historic Katla eruptions. It is therefore not surprising that all rural and most urban residents accurately described Katla and displayed knowledge of the warning system and emergency response procedures. These results are exceptionally good particularly when compared to other studies. For example, Barberi et al. (2008) assessed hazard knowledge within the Red and Yellow Zones of Vesuvius and found that 45% and 33% correctly identified the year of the last eruption while only 41% and 18% of respondents were familiar with the evacuation plans, respectively.

Our result however, is unexpected since many residents stated '*I don't know anything about Katla*' and '*I never think of Katla*'. Other studies of hazard knowledge have found that residents overestimate their actual knowledge (Johnston et al., 1999) or perceive themselves as more knowledgeable than family or friends (Lindell and Whitney, 2000). In comparison, our survey suggests that residents underestimate their knowledge of Katla. Dibben and Chester (1999) found that many residents deliberately avoided thinking about an eruption (one resident stated 'I never think about it') and lacked general knowledge about volcanic hazards.

On Santorini, Dominey-Howes and Minos-Minopoulos (2004) found that residents had poor understanding with only 7% correctly identifying when Mt Colombo last erupted. They found that despite some residents retaining hazard knowledge from previous experience, this knowledge was not passed on to younger generations. Within our survey, knowledge has been passed down and as such, inherited knowledge has contributed to residents' awareness.

Unsurprisingly, new residents in the urban community lack knowledge of Katla, the warning system and emergency response procedures. Similarly, Lavigne et al. (2008) found that people living in their birth village usually demonstrate better knowledge of their environment whereas new migrants coming from a relatively safe area lack knowledge of volcanic hazards.

Inherited local knowledge not only raises community awareness of Katla and the associated hazards but it also contributes to residents' risk perceptions. For example, many urban residents did not perceive the risk of tsunami in their region *because* people in Vík who

experienced the 1918 eruption did not discuss the threat of tsunami in relation to their experience. Whereas in Álftaver, all residents demonstrated inherited local knowledge and all perceived the risk of jökulhlaup based on historic accounts. However, many rural and urban residents perceived the risk of lightning or tephra as more serious than jökulhlaup or tsunami (Table 3) based on inherited knowledge.

Irrespective of knowledge and perception, rural residents described varied behavioural responses to a hazard warning whereas urban residents stated that they followed the recommended procedure. Justifying their responses, rural residents described their obligation or duty of care to their livestock (livelihood connections) and other issues relating to inherited knowledge. It is apparent that rural residents want to protect their livelihoods for moral reasons as well as to sustain economic resilience. Consequently, if faced with evacuation, rural residents have an emotional dilemma about whether or not to abandon their livestock. Chester et al. (2002) also identified the importance of close links between residents and the land. They discussed how this connection has developed as a result of both active and traditional family-based agricultural ties and how it might affect residents' willingness to evacuate.

Veterinary scientists (e.g. Bryant, 2008; Heath, 1999) have recognised the issue of dealing with livestock during disasters and emergency management agencies such as the Federal Emergency Management Agency in the United States have provided preparedness advice for livestock owners (http://www.fema.gov/plan/prepare/livestock.shtm). These guidelines, and other related literature (Bankoff, 2006; Heath et al., 2001a; Heath et al., 2001b; Irvine, 2006; Sorensen and Sorensen, 2007), discuss the possibility of evacuating animals prior to disaster.

However, livestock evacuation is not always the best option due to the unpredictable nature of volcanic hazards. For example, a Katla jökulhlaup can flood to the eastern, southern or western region and ash fall is dependent on the prevailing wind. Since tephra fall is of great concern during Katla eruptions and adequate shelters exist on all farms (all livestock are housed during the winter) it would be more appropriate to ensure that livestock are sheltered on high ground before residents evacuate their homes. Further, to avoid residents returning to attend their livestock without permission, the ICP should develop strategies together with local residents and the Farmers Association of Iceland to guarantee that certain residents will be able to return for short periods, whenever possible during an evacuation.

Our results and historical reports (Bjarnason, 1985; Jóhannesson, 1919) indicate that residents in Álftaver formulated what they perceived to be the best community response to the 1918 eruption. Evacuating together, residents safely relocated to a building positioned on higher ground which was not vulnerable to jökulhlaup. Many rural participants endorsed and encouraged a similar response by stating that they would evacuate to a neighbouring property on higher ground. Based on Clark (1995), King and MacGregor (2000) described concepts of cooperation and neighbourliness as important aspects of community cohesion and therefore, resilience to natural hazards. Within the rural communities, these values of personal responsibility and community involvement in emergency response procedures, in addition to community cooperation and neighbourliness, might be instrumental in reducing vulnerability and increasing resilience.

Interestingly, residents expressed greater willingness to follow the recommended procedure when asked 'Would you follow this procedure if there was a real evacuation?' It appears that some residents do not want to openly defy officials, particularly when threatened with arrest. Haynes et al. (2008b) found that 60% of participants followed evacuation advice during a volcanic crisis on Montserrat because it was 'the right thing to do' while a further 25% followed due to legal reasons and *not* because they agreed with the advice. Bird et al. (2009; in review) also reported that residents took part in evacuation exercises because it was 'their duty' to do so or 'to obey orders'.

Figure 4 indicates significant differences between rural and urban residents' views of the evacuation. In general, rural residents did not perceive the current plan as appropriate and if conditions are bad (i.e. heavy tephra fallout, blizzard), they would personally assess the situation before deciding on a course of action. Residents' unwillingness to evacuate to Kirkjubæjarklaustur, as revealed by Bird et al. (in review), were summed up by one participant who stated "*It's like we are driving right into her* [Katla's] *mouth*". In comparison, urban residents are more likely to follow recommended actions regardless of whether or not conditions are bad. This could be attributed to the short distance from home to the evacuation centre in the urban community. Urban residents are not expected to leave their community and therefore attachment to place and livelihood connections are not a salient issue.

Initially, most residents would try calling the emergency number 112, the police or a neighbour for further information. This substantiates recommendations made by Bird et al. (2009; in review) in relation to promoting public use of various media during a volcanic

crisis. The evacuation and hazard information sign explicitly states: "Follow all announcements on TV and radio" (see Fig. 2 Bird et al., 2009). It is obvious however, that more needs to be done to encourage residents to first turn to media sources for further information. Considering that nearly all participants followed discussions on Katla on the radio or television, this should not be a challenging task.

The difference between rural residents' perception of officials and the ICP's preparedness could be biased due to our interpretation of 'local officials' (i.e. the police *and* the rescue team). When asked 'how prepared do you think the officials in your area are?' some residents responded separately for each. Although overall, both rural and urban residents perceived the officials and the ICP to be more prepared than them. This perception might be influenced by EMA recommendations which do not obligate residents with personal responsibility. Based on the evacuation and hazard information sign, residents are only obliged to prepare *during* a volcanic crisis. Residents have not been given advice on how to prepare *prior to* an eruption.

Rural residents indicate that they believe possessing an evacuation kit equals personal preparedness. Consequently, they rated themselves as less than moderately prepared. These residents did not consider their knowledge of the recommended emergency response procedures as a form of preparedness, that they actively followed discussions in the media about Katla or that they have a predetermined safe destination, whether it is the designated evacuation centre or a neighbouring house.

Perry and Lindell (2008) described knowledge of local alert systems and emergency response plans, identifying a safe destination, possessing masks for inhalation protection and defensive tools to protect property from tephra as simple measures to effectively anticipate, respond to, and recover from the impacts of an eruption. Consequently, the results suggest that rural residents might have underestimated their level of personal preparedness. In comparison, urban residents rated themselves as more than moderately prepared. This could be attributed to the fact that urban residents are not responsible for the well-being of livestock and the evacuation centre is within a five minute drive of their home.

It is evident however, that residents are not adopting personal safety measures. EMA must therefore inform residents that any mitigation measures they implement are done so to complement rather than replace personal preparation (Paton et al., 2008). Researchers (e.g. Gregg et al., 2004; Lindell and Whitney, 2000) have shown that when residents perceive

officials to be responsible for preparedness they might be less likely to adopt self protective behaviour as compared to those residents who deem themselves responsible. At present it appears that residents have transferred responsibility for personal safety to EMA. A transfer of responsibility was also described by Ballantyne et al. (2000).

This issue can be overcome if EMA engage the community and persuade them to adopt simple, effective measures *prior to* an eruption. These might include possessing masks for inhalation protection and spare air filters for vehicles to ensure transportation during tephra fall out in addition to, having an emergency kit ready. Once the immediate threat of jökulhlaup or tsunami has passed and residents are allowed to return home, tools such as shovels and brooms should be readily available to remove tephra from infrastructure.

Residents acknowledged the importance of organising evacuation exercises every two to five years. However, education campaigns focusing on personal preparedness should be conducted on a more regular basis and through various forms of media especially radio, television and newspaper. Also, the issue of educating new residents must be dealt with. In Iceland, this might easily be achieved through the National Registry Office. All people residing in Iceland must register their new address within seven days. As a government initiative, the ICP could work in conjunction with the National Registry Office to distribute regionally specific hazard, risk and emergency response information kits to residents who have recently moved into a hazardous region. In addition to the Katla region *and* volcanic hazards, this initiative should include all vulnerable regions and all hazards. EMA should aim to develop an all-risks reduction culture by placing volcanic risk mitigation within the context of other risk-related phenomena (e.g. earthquakes, extreme weather, climate change) (Barclay et al., 2008). However, research is needed in order to establish this possibility.

Perceptions varied considerably when asked about the probability of a future eruption and its effects. Rural residents perceived an eruption as less likely to occur in the next 10 years than urban residents and this can be attributed to their belief in the fortune teller and that Katla '*released herself*' in 1955 or 1973. Worryingly, Johannesdottir (2005) reported that some residents believed that Katla was no longer active. However, based on our participants' comments, it appears that this might be a coping strategy rather than a form of denial. Even though rural residents might not perceive an eruption in the next 10 years, they have displayed accurate knowledge and perception of hazard and risk. This cognitive dissonance, a conflict

between perceptions, was also described by Dibben and Chester (1999) and Chester et al. (2002).

Dibben and Chester (1999) found that residents held beliefs that minimised their concern about a future eruption. For example, residents believed that hot springs acted as a release valve ensuring that the volcano does not reach dangerous levels of pressure. In spite of this, it is not pertinent to change residents' perception of the probability of an eruption because it might provoke a feeling of unease about the future and as such produce feelings of extreme discomfort (Dibben and Chester, 1999). Also, researchers (e.g. Gaillard, 2008; Lavigne et al., 2008; Lindell and Whitney, 2000) have shown that preparedness and appropriate response to hazard warnings are not equated to the perception of risk.

Rural residents stated that it is 'somewhat likely' that their community will be adversely affected by the next eruption. However, rural residents affirmed that it is 'somewhat unlikely' that their homes will suffer damage and 'extremely unlikely' that they or their family will be injured by the next eruption. Urban residents shared similar but less extreme views. Again, this is cognitive dissonance, where residents have justified their decision to live where they do in the belief that their homes are not under threat but rather, the threat occurs elsewhere. As a result, residents do not have to deal with the complexity of moving and life can go on as normal (Chester et al., 2002).

Lindell and Whitney (2000) reported comparable results in relation to residents' perceptions of seismic hazards in Los Angeles. They showed that even though the probability of a damaging earthquake in the metropolitan area was judged to be relatively high, the probability of personal property loss or injury was judged to be relatively small. Consequently, residents perceived the risk to their community but they did not adopt personal preparedness measures (Lindell and Whitney, 2000). Similarly, our results show that residents perceived the risk to their community but they did not deem themselves as being prepared. In accordance with our earlier recommendation, it is imperative that EMA focus on increasing residents' responsibility for protecting themselves and their property (Lindell and Whitney, 2000).

The difference between rural and urban residents' trust can be categorised according to Poortinga and Pidgeon (2003). Urban residents demonstrated a high degree of general trust in information provided by all EMA and are therefore more likely to accept decisions and communications from these institutions. In comparison, rural residents expressed a high

degree of general trust in information provided by scientists, critical trust (i.e. general trust with scepticism) in information from the ICP and police and distrust in information from the media.

However, when considering residents' explanations as to why they lack trust in the various agencies, it is apparent that there is little necessity in focusing resources on increasing trust. For example, several rural and urban residents expressed concern regarding the restructuring of the police and how this has affected their levels of trust in them. In this instance, it is not the police *per se* that residents distrust but rather the unknown. In contrast, rural residents were given the opportunity to articulate their risk mitigation concerns but this did not result in meaningful (empowering) responses from officials (Bird et al., in review). Coupled with the threat of arrest if they did not obey the evacuation orders, it is understandable that rural residents stated lower levels of trust in the ICP and the police.

We therefore believe that by establishing a working relationship, where communities and EMA engage in complementary roles in the development of risk mitigation strategies, residents will be empowered and as such trust will evolve. When residents perceive that their concerns have been resolved through their relationship with EMA, it is more likely that they will trust them and the information they provide (Paton, 2007). Not only will this increase trust, but it will also facilitate personal responsibility for adopting preparedness measures, a recommendation previously highlighted. Haynes et al. (2008a) provides further discussion on the importance of developing and maintaining a trusting relationship between EMA and the at-risk community in relation to volcanic hazards.

Interestingly, urban residents' high degree of trust in information provided by the ICP conflicts with the findings of other studies (e.g. Barberi et al., 2008; Carlino et al., 2008; Haynes et al., 2008a) which have shown that residents had greater trust in scientists than government officials. According to Siegrist and Cvetkovich (2000), the public relies on the opinions of experts or authorities, who they consider trustworthy and knowledgeable, when they themselves lack detailed knowledge to make a rational assessment of the risk. Therefore, we believe that urban residents regard the ICP as the most trustworthy agency and will rely on them for risk mitigation advice.

Residents' lack of trust in information provided by the media is in line with other studies (e.g. Haynes et al., 2008a). This however, should not be a major concern to EMA since nearly all

residents followed discussions on Katla in the media. The role of the media before, during and after an event is crucial for disseminating information through all channels (e.g. radio, television, internet) (Scanlon, 2007) because residents rely on multiple sources of information (Sorensen and Sorensen, 2007). Nevertheless, given the trust residents have in the ICP and scientists, it would be wise to use recognised ICP officials and scientific experts as spokespeople to broadcast warnings and response information.

Images portraying those affected by hazards as helpless victims does little to promote personal responsibility for preparedness (Hughes and White, 2005). Instead, it promotes attitudes which lead residents to become increasingly dependent on EMA. Alternatively, the media's role should be to provide an effective channel to communicate information on preparedness measures, warnings and appropriate public response, without confusing, complicating or changing the message (McGuire et al., 2009). Scientists and EMA should work closely with the Icelandic media to ensure a trusting and productive relationship prior to and during any hazardous event. Although focused on small volcanic islands, the advice and recommendations provided by McGuire et al. (2003) to improve communication during volcanic emergencies are invaluable and relevant prior to and during any crisis.

An intriguing point that was noted during both rural and urban interviews was that residents referred to Katla as a woman and not an inanimate landform. This further demonstrates the emotional attachment and cultural connection residents have with their communities and region. According to Icelandic folktales, Katla was a wicked female cook in a monastery located in Álftaver (Guðmundsson, 1996; p. 61-62):

> "She had magic trousers enabling her to run fast and without a break. When she discovered that a shepherd had misused her priceless belongings, she killed him and hid him in a big barrel of whey. When confronted with the revelation of her crime as the whey was slowly being used up, she fled in the trousers up to the mountains and flung herself into a dark crevasse in the ice cap. Ever since, according to tales, she avenges her fate by pouring fire and water onto the nearby regions."

Emotions are undoubtedly important explanatory factors in perceived risk and related views (Sjöberg, 2007). Bird et al. (in review) also noted that residents referred to the volcano as '*their Katla*'. Similarly, Dibben and Chester (1999) reported that residents referred to the natural landscape as '*their land*' and that residents appeared to have an emotional attachment to the volcanic environment. Consequently, Dibben and Chester (1999) argued that the root

causes of vulnerability relate to the history and development of the society. As previously noted however, community vulnerability is dependent on a variety of factors.

Using several of the factors described by King and MacGregor (2000) we can compare rural versus urban vulnerability and resilience according to community behaviour and characteristics. For example, urban residents are more willing to evacuate, they have a greater ability to access warnings, instruction and advice and a greater percentage have no dependant children. These factors reduce vulnerability. On the other hand, urban residents demonstrated lower levels of general and local knowledge, more urban residents live alone and more urban residents are newcomers to the community. These factors increase vulnerability. Additionally, rural residents displayed a greater sense of community and attachment to place, factors which decrease vulnerability and increase resilience. Overall, according to these factors, rural residents should be less vulnerable and more resilient to volcanic hazards.

Our survey clearly demonstrates that EMA need to consider knowledge and risk perceptions in conjunction with social issues inherent in these communities. Learning from local knowledge should begin with respect for the people concerned and requires their trust (Blaikie et al., 1994). The top-down method of risk mitigation which was implemented in 2006 was rejected by residents, particularly by those with inherited local knowledge and emotional and economic connections to their livelihood. Similar findings were identified by Cronin et al. (2004) and as a result, considerable work was done towards adapting and applying a Participatory Rural Appraisal (PRA) approach to volcanic hazard management. This approach, which incorporated scientific with traditional knowledge, enhances communication, respect and understanding between communities and EMA.

It is therefore recommended that EMA work in close consultation with, and with participation from, rural communities to enhance and exploit the abovementioned factors which decrease vulnerability and increase resilience. It is evident that the Chief of Police has made significant progress in negotiating more appropriate risk mitigation strategies in consultation with local residents. However, it is also obvious that in order to open up channels of communication, it must go beyond consultation. Residents must have an active role in planning and preparedness and the local rescue team must be used as an internal resource to help the community resist, absorb, accommodate to and recover from the effects of an eruption.

The regional Chief of Police has begun action to achieve these goals by holding a meeting with residents in Sólheimar (as mentioned by one Álftaver resident). Together with residents, they devised a more acceptable evacuation plan for their community (K. Þorkelsson, personal communication, 2008). During a Katla emergency, residents in Sólheimar are to evacuate to a local farm on higher ground rather than evacuating to Vík. Furthermore, in response to the results of this survey, the Chief of Police has ensured that all Sólheimar residents possess the evacuation and hazard information sign (K. Þorkelsson, personal communication, 2008).

Johannesdottir and Gisladottir (2010) suggested that cooperation, understanding and communication between the scientific community, government authorities and residents is essential to ensure public safety. Since then, much work has been done to improve the community's collective capacity to positively respond during a future Katla eruption. However, our study suggests that more work is needed.

5 Key findings and recommendations

- All rural and most urban residents displayed accurate knowledge of Katla, the warning system and emergency response procedures.
- New urban residents lack knowledge of Katla, the warning system, emergency response procedures and they do not possess the evacuation and hazard information sign.
- Livelihood connections and inherited knowledge will influence rural residents' compliance with evacuation orders.
- Rural residents displayed values of personal responsibility, community involvement in emergency response procedures, community cooperation and neighbourliness.
- Rural residents do not perceive the current plan as appropriate and if conditions are bad they would personally assess the situation before deciding on a course of action
- Rural and urban residents have not adopted personal preparedness measures
- Urban residents trust information provided by all EMA and are therefore more likely to accept decisions and communication from the various agencies.
- Rural residents trust information provided by scientists.

Based on our findings we recommend that EMA:

- Use factors inherent within rural communities, such as personal responsibility, neighbourliness, community involvement and cooperation, to develop and implement more appropriate volcanic risk mitigation strategies.

- Devise strategies for selected rural residents to re-enter evacuated communities so they can tend to livestock.
- Encourage residents to first follow all warning and response announcements on the radio or television.
- Engage the community and persuade them to adopt personal preparedness measures such as possessing masks for inhalation protection, spare air filters for vehicles, defensive tools to protect infrastructure and preparing an emergency kit.
- Distribute regionally specific hazard, risk and emergency response information kits to residents who have recently moved into a hazardous region. This might best be achieved through a cooperative agreement between the ICP and the National Registry Office.
- Consult local communities, learn from their knowledge, have respect for the residents, gain their trust and assist them in developing appropriate disaster risk reduction strategies for their community. It should be noted however, that the regional Chief of Police in southern Iceland is already applying these principles.

6 Conclusions

The contextual issues influencing residents' perceptions and ability to positively respond to emergency information are complex and deeply rooted within their cultural and social setting. These issues include inherited local knowledge, attachment to place, emotional connection to livelihoods (i.e. the obligation to safeguard livestock) and sense of community (e.g. neighbourliness and community cohesion).

Firsthand experience and inherited knowledge have contributed to raising residents' awareness of Katla. This however, has not transferred into residents adopting personal preparedness measures nor does it ensure that residents will positively respond to emergency information. Affecting rural residents' proposed behaviour is an emotional connection that binds them to their livelihood and community. While some aspects of community cohesion also influence rural residents' behaviour, overall values of personal responsibility, community cooperation, community participation and neighbourliness will facilitate disaster risk reduction.

This research demonstrates that while there are some similarities, differences do exist between rural and urban residents' perceptions, proposed behaviour when faced with an eruption, preparedness and trust. It is clear that rural residents have a proactive perspective and want to be involved, not only in consultation, but also in the development of mitigation strategies.

Furthermore, rural residents exhibited personal responsibility for their own safety during an eruption. It is therefore likely that rural residents will take control of the situation. In comparison, urban residents have a reactive perspective towards risk mitigation. Urban residents trust emergency information and will follow evacuation procedures when issued.

This research shows that to develop effective mitigation strategies, emergency management agencies must consider local knowledge and perceptions in addition to the contextual issues effecting community perspectives. In particular, emergency response plans must be developed in consultation and collaboration with rural communities to ensure applicability. Risk mitigation must be placed within the context of the society it aims to protect and within a framework that incorporates both the social and physical aspects of hazards.

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Chapter 7

This chapter consists of:

7 Summary

The collection of papers, presented as chapters within this thesis, form a coherent body of research that investigates stakeholder knowledge and perception of the Katla volcano and emergency response procedures in southern Iceland. The mulitgroup nature of the investigation (i.e. urban and rural residents, tourists and tourism employees, and emergency management officials) provides a robust assessment of some of the social dimensions of hazard, risk and emergency response procedures in relation to Katla. As a result, it identifies various factors that affect people's ability to adopt personal preparedness actions and respond positively to risk communication and hazard warnings, and in doing so, highlights community vulnerability. The research makes a distinct and original contribution to our knowledge and understanding of the social dimensions of hazard, risk and emergency response procedures in southern Iceland.

Previous research (Guðmundsson and Gylfason, 2005; Jóhannesdóttir, 2005) indicated that emergency management plans had been developed without proper consideration of the social context of communities situated around Katla. In order to address this gap in knowledge and gain an understanding of the vulnerability within each community, it was essential to access each stakeholder group at the community level to give them the opportunity to voice their perspectives and concerns. Consequently, I embarked on a journey of discovery while interviewing and observing various stakeholders. Using a mixed methods approach, this research revealed stakeholder characteristics (including demographics, hazard knowledge and risk perceptions) and discovered socio-cultural factors that influence their perspectives.

The mixed methods approach proved to be appropriate for this research because it advocates the use of any methodological tools required to address the issues at hand (Teddlie and Tashakkori, 2009). Consequently, field observations were conducted when opportunities arose and these were combined with semi-structured and structured questionnaire interviews to provide a more comprehensive investigation while reducing the possibility of systematic biases and limitations. To enable comparison between each case study, questionnaires were modelled on the originals used in chapters 2 and 3. However, as the research progressed other issues arose and it became apparent that additional questions should be incorporated. These additions were therefore integrated in the questionnaires used in chapters 5 and 6.

Through the application of the mixed methods approach, the research generated interest in the societal context of hazards and risk associated with Katla. This was achieved through consultation, collaboration and interaction with a range of emergency management officials, rural and urban residents, and tourists and tourism employees. Meetings were held with the Chief of Police and the project manager of the Icelandic Civil Protection Department on a regular basis throughout the research so as to identify and tackle issues of importance. Consequently, these officials gained a more thorough understanding of 'what' the public perceive and 'why'.

As a result, the regional Chief of Police has begun to embrace the public's input and empower communities by incorporating local knowledge in the development of more relevant emergency response strategies. Furthermore, the regional Chief of Police has expressed interest in incorporating social data generated from this research in the ongoing development of regional risk communication and emergency response, and in a proposed Katla museum and information centre in Hvolsvöllur (K. Þorkelsson, personal communication, 2008, 2009).

Of further interest is the tourism case study presented in chapter 3. The Chief of Police has informed us that he is anxious to receive the final results from the Þórsmörk study (K. Þorkelsson, personal communication, 2009). This research has already helped raise awareness in the tourism sector (e.g. Ísland Guide (2008) and Iceland Naturalist (2008) tourist websites) and contributed to the ongoing development of education and training (Fig. 1). In-kind support (see Acknowledgements, p. x) provided by the tourism sector further demonstrates their interest in this research and their commitment to improving volcanic mitigation strategies.

The overall aim of the research, which was to provide a social framework based on an in-depth study of some of the social dimensions of hazard, risk and emergency response, has been achieved. Officials have recognised the practical applications of this research and they have expressed great interest in using this information to develop more appropriate emergency management strategies.

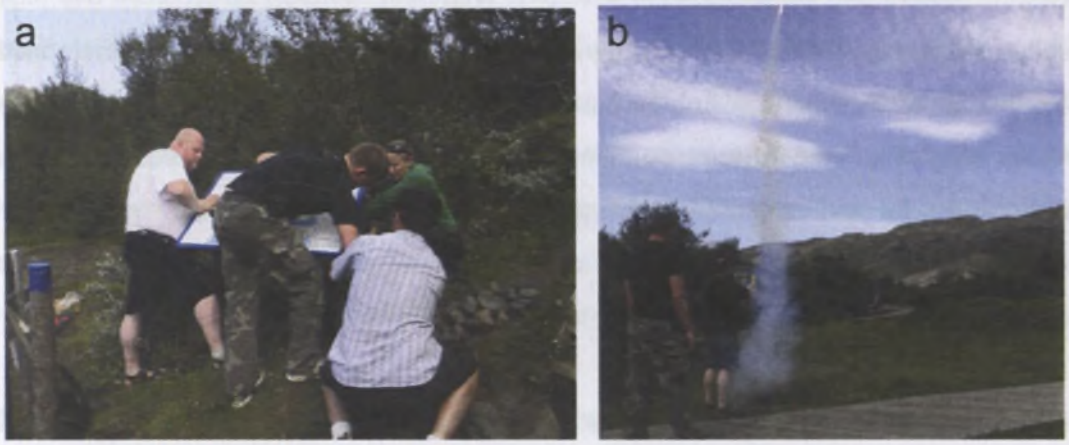

Figure 1. a) Installing hazard and emergency response information signs in Þórsmörk. b) ICP officials training hut wardens to use eruption warning signals in Þórsmörk. Photos taken by Deanne K. Bird and Guðrún Jóhannesdóttir.

7.1 Limitations

Although the limitations inherent within this survey have been addressed in each chapter, when observing the combined chapters as a coherent body of research, it is evident that other limitations exist. Most notably, the Þórsmörk tourism (chapter 3) and resident (chapter 4) case studies in the western jökulhlaup hazard did not apply a random sampling technique. Therefore, extrapolations or generalisations should be undertaken with caution. Conclusions based on the eastern and southern jökulhlaup hazard zone case studies (chapters 5 and 6) may well be more robust since a saturation sampling technique where every household in the hazard zone was given the opportunity to participate (Sarantakos, 2005) was applied. However, using the saturation method can generate other forms of bias in relation to self-selection because some residents will chose not to participate if they know little about or do not care about the issue under investigation.

The possibility of bias generated by face-to-face interviewing has been discussed in chapter 2 with regards to the participant feeling comfortable with the interviewer and in chapter 3 with respect to language barriers. In contrast, chapter 5 discussed positive aspects of face-to-face

interviewing with Álftaver residents since Guðrún Gísladóttir, who conducted interviews in collaboration with me, had an established rapport with the participants. This positive aspect also holds true for chapter 6. However, neither I nor Guðrún had an already established rapport with tourists in Þórsmörk (chapter 3) and residents in the western hazard zone (chapter 4). As such, the power to produce a rich, detailed and thorough assessment was lacking in comparison.

In spite of this, face-to-face interviewing was considered to be the most appropriate method within the context of this research because it reveals complex behaviours and perspectives, provides insights into the differing opinions between groups, reveals consensus on issues, and shows respect for and empowers participants (Dunn, 2005). Furthermore, participants are given the opportunity to reflect on their experiences and discover more about the research topic than if they were simply completing an online or mail-out questionnaire.

Additionally, this research only addresses volcanic hazards from Katla. For example, it does not consider hazards associated with a Hekla or Eyjafjallajökull eruption even though both these active volcanic systems lie in close proximity to communities in southern Iceland. As suggested by Barclay et al. (2008), to develop an all-risks reduction culture, mitigation measures must be placed within the context of other risk-related phenomena.

Although the findings and recommendations from this research should be readily transferable to other volcanic areas in Iceland and internationally, every community is different and the transferability of this research to other less developed regions is limited when considering a vulnerability perspective. Extreme events show that the poor are more vulnerable to hazards than the rich, although poverty and vulnerability are not uniformly or invariably correlated in all cases (Blaikie et al., 1994; Cannon, 1994; Lewis, 1999). Unlike the situation in Iceland, many people and communities, especially in developing countries, are not given the opportunity to participate in evacuation exercises or information meetings, or they lack the resources to adopt protective actions when faced with hazards.

7.2 Key findings

This research incorporates multiple perspectives (residents, tourists, tourism employees and emergency management officials) and approaches giving a comprehensive overview of the situation and location. As such, this study has advanced our understanding of the contextual issues affecting volcanic risk mitigation in southern Iceland and makes a significant

contribution to the international literature on the perception of risk and vulnerability to hazards, and the social processes that influence behaviour.

Most notably, chapter 2 demonstrated that although researchers use questionnaires to generate social data in relation to hazard and risk, very few describe the applied methodologies. As a result, transferability between case studies is compromised. Therefore, drawing from the social and behavioural sciences literature, chapter 2 highlighted the importance of including details on response format, delivery mode, sampling techniques and response rate in addition to providing the survey instrument used in the study. Adhering to these principles will facilitate comparison and reproduction. It will also allow researchers to build on current knowledge, understanding and practice. In order to illustrate these aspects, a questionnaire was developed and piloted for the tourist region of Þórsmörk and recommendations were made to improve this instrument based on this investigation.

Chapter 3 used the questionnaire piloted in chapter 2 to assess tourists' and tourism employees' hazard knowledge, risk perception, adoption of personal preparedness measures, predicted behaviour if faced with a Katla eruption and views on education. This study demonstrated that tourists lacked hazard knowledge and knowledge of emergency response procedures. Likewise, employees lacked knowledge of emergency response procedures. Futhermore, the employees were reluctant to share hazard knowledge with tourists because they believed it would stop tourists from travelling in the region. However, tourists were positive about receiving hazard, risk and emergency response information and the employees were positive about receiving emergency education and training.

Chapter 4 used field observations to discover how emergency management officials and the public responded to the evacuation exercise in the western hazard zone. Also, a questionnaire was developed to assess residents' knowledge and perceptions. This study identified how residents interpreted their situation in relation to Katla, its associated hazards and their potential response during an eruption. This research suggested that although residents participated in the exercise, they might not comply with evacuation orders during a Katla eruption due to concerns for personal safety and livelihood connections (particularly the desire to safeguard livestock). Also highlighted is the fact that residents were frustrated about not being involved in the development of relevant emergency response procedures for their communities.

Through the application of field observations and semi-structured interviews in Álftaver, chapter 5 also identified that livelihood connections and community involvement in emergency response procedures influenced residents' perceptions of and response to mitigation. Additional factors that came into play were inherited local knowledge and attachment to place. During an eruption, residents might not follow evacuation procedures because they do not want to abandon their livestock. Residents also believed that evacuating to their designated centre might place them in a more hazardous situation than if they evacuated to a neighbouring farm. This study revealed that inherited local knowledge must not be underestimated and, in conjunction with residents' perceptions and socio-cultural issues, it must be incorporated in mitigation strategies in order to reduce vulnerability and increase resilience.

Based on the instrument used in chapter 3, the questionnaire in chapter 6 integrated additional questions to assess residents' perceptions of preparedness, trust and the probability of a Katla eruption and its effects. Both livelihood connections and inherited local knowledge were prominent influences affecting residents' ability to comply with evacuation orders. Furthermore, chapter 5 demonstrated that there are differences between rural and urban residents' knowledge and perceptions and as such, emergency management agencies must consider these when developing mitigation strategies.

Recommendations to emergency management agencies that are applicable to all communities include:

- Empower residents through consultation and collaboration and provide support to develop volcanic mitigation at the local level.
- Incorporate stakeholders' knowledge, perceptions and socio-cultural issues in mitigation strategies.
- Develop alternative options (i.e. Plan B) if adverse conditions prevent safe evacuation to designated centres.
- Effectively communicate hazard warning and response information to all communities in the hazard zone.
- Provide additional detailed information on the effects of all volcanic hazards.
- Devise strategies for selected residents to re-enter evacuated communities so they can attend livestock.
- Encourage residents to first follow all warning and response announcements on the radio, television and internet.

- Engage communities and persuade them to adopt personal preparedness measures.
- Provide hazard, risk and emergency response information kits to residents who have recently moved into a hazardous region and all tourists travelling in Þórsmörk (and other tourist regions surrounding Katla).
- Provide feedback on proposed strategy outcomes within a reasonable timeframe (e.g. within 3 months).
- Broadcast hazard warnings and emergency response information using recognised officials and scientific experts as spokespeople.
- Use the film 'Katla og Kötluvá' as an educational tool.

While some similarities are transferable between case studies, differences existed between stakeholder groups and therefore recommendations to improve emergency management strategies varied between each. These differences are highlighted in Figure 2.

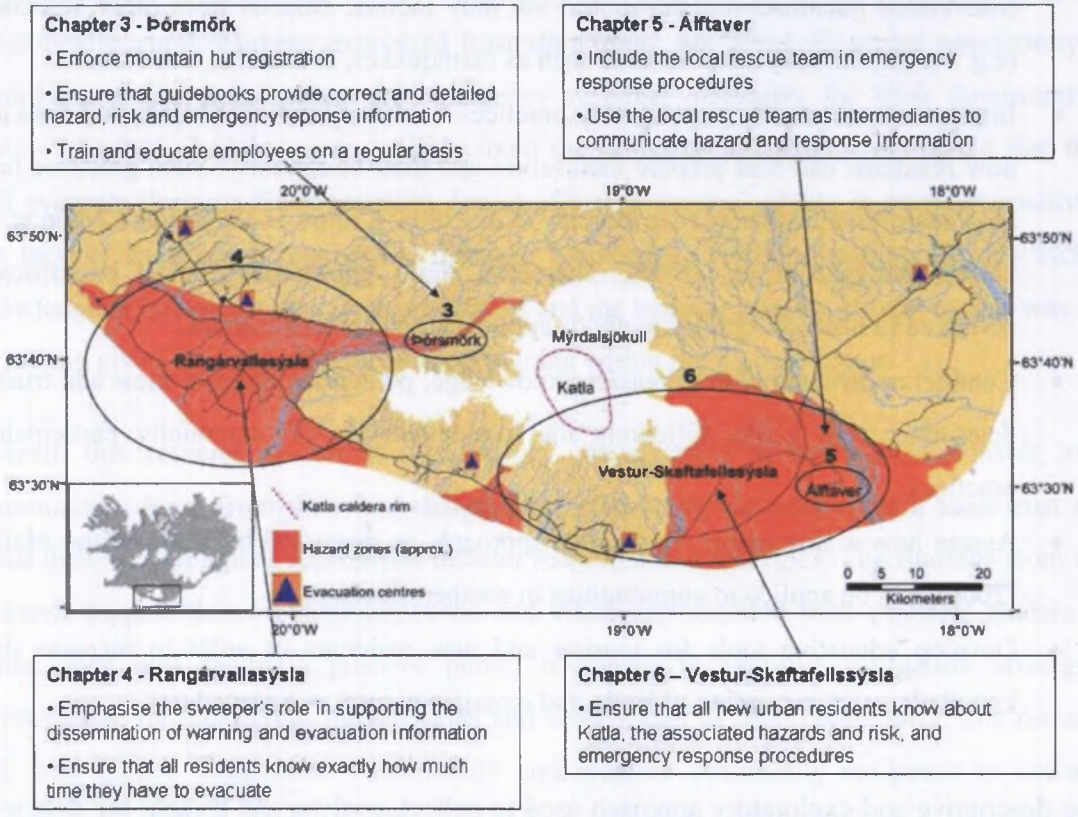

Figure 2. Specific recommendations from each case study to facilitate improvements in emergency management in southern Iceland.

7.3 Future work

Despite the contribution this research makes towards a more thorough approach to volcanic risk mitigation in southern Iceland, it is evident that much more work is needed. Good education and outreach programs must be ongoing and must consider the social context of the situation in order to facilitate an effective response to risk communication, hazard warnings and emergency response procedures (Mileti et al., 2004). By continuing to examine the various components of the Protective Action Decision Model (Lindell and Perry, 2004, described in chapter 1), emergency management agencies will gain a better understanding of whether or not people have the ability to adopt protective action after being exposed to, heeding, and accurately interpreting environmental cues (e.g. precursory activity or imminent threat) and social warnings.

Based on discussions generated through this research, future studies should:

- Investigate how mitigation for a Katla eruption can be placed within context of other risk-related phenomena. This should not only include hazards from other volcanoes (e.g. Hekla) but also other hazards such as earthquakes, avalanches and floods.
- Implement community participatory practices to identify critical hazards and risks and how residents can best prepare themselves and their community. Such practices have been identified elsewhere (e.g. Barclay et al., 2008; Cronin et al., 2004a; Cronin et al., 2004b; Mimaki et al., 2009). Therefore, these approaches should be critically reviewed in order to identify methods applicable to southern Iceland.
- Conduct an investigation to reassess knowledge, perception, preparedness and trust to determine what works following the implementation of community participatory practices.
- Assess how a sustainable livelihoods approach, as discussed by Kelman and Mather (2008), can be applied to communities in southern Iceland.
- Develop educative tools for tourists and new residents in order to increase their knowledge and perception of Katla and emergency response procedures.

The descriptive and exploratory approach used to collect, analyse and present the data were adopted in an attempt to accommodate the cultural isses of the research location. It is hoped that the data generated from this analysis will provide baseline data that could be used to formulate research questions in subsequent studies of risk perceptions and behavioural response in Iceland.

7.4 Conclusions

This research provides a more thorough approach to volcanic risk mitigation by offering a first assessment of the social dimensions of hazard, risk and emergency response procedures for a Katla eruption. While researching emergency management in Iceland it became apparent that emergency response plans were modelled solely on physical investigations of regional volcanic hazards. They did not consider the human element despite it being an integral factor of emergency management. To address this gap in knowledge, this research explored the many factors affecting people's ability to effectively respond to hazard warnings and evacuation orders by investigating public knowledge and perception. A mixed methods approach, using field observations, and face-to-face semi-structured and structured questionnaire interviews, was applied in order to generate social data that will complement physical studies on Katla and its hazards.

Contextual issues affecting residents' ability to respond positively include inherited local knowledge, livelihood connections, concerns for personal safety and attachment to place. Additionally, rural residents expressed frustration about not being given the opportunity to contribute to the development of emergency response strategies for their communities. However, urban residents were positive about the proposed procedures and stated that they will evacuate during a Katla eruption. Issues affecting tourists' ability to respond positively are lack of hazard and emergency response knowledge. Tourism employees also lacked knowledge of emergency response procedures and the warning system. However, this was not surprising given the lack of education and training within the tourism sector.

Overall, this research shows that emergency management agencies must consult local communities, learn from their knowledge, have respect for the people, gain their trust and assist them in developing appropriate disaster risk reduction strategies. The findings from this research support these recommendations and when corroborated with physical studies on Katla, they will facilitate positive public responses to volcanic mitigation strategies. Furthermore, by identifying the strengths and weaknesses of each community, this research will help reduce stakeholder vulnerability and increase community resilience to volcanic hazards in southern Iceland. The research demonstrates that emergency management strategies must incorporate community heterogeneity and whenever possible, emergency response procedures must be tailored to meet community objectives. Although specific to southern Iceland, these findings support those identified in other international studies. Therefore, this study illustrates some important principles for disaster risk reduction both on a national and international level.

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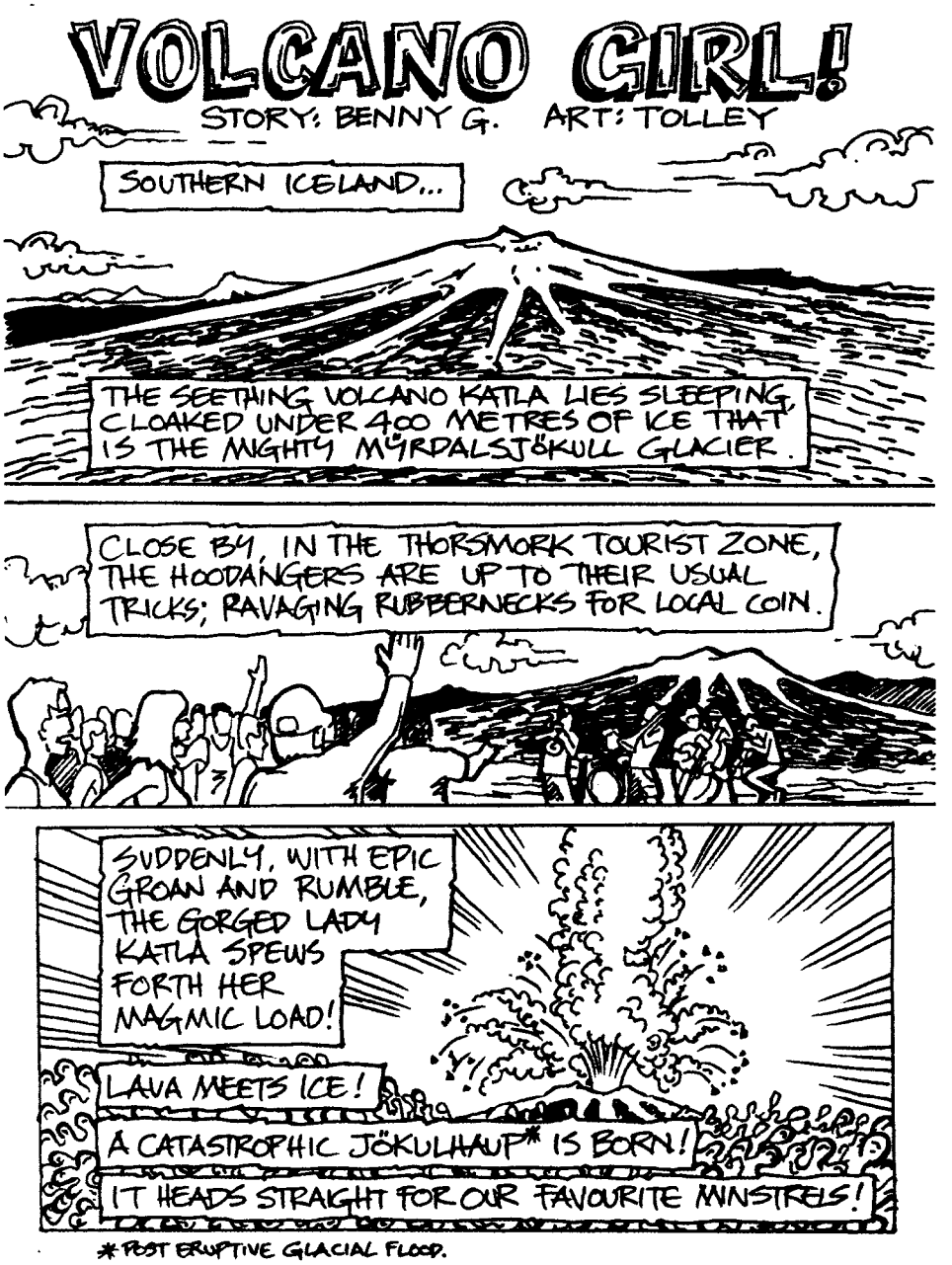
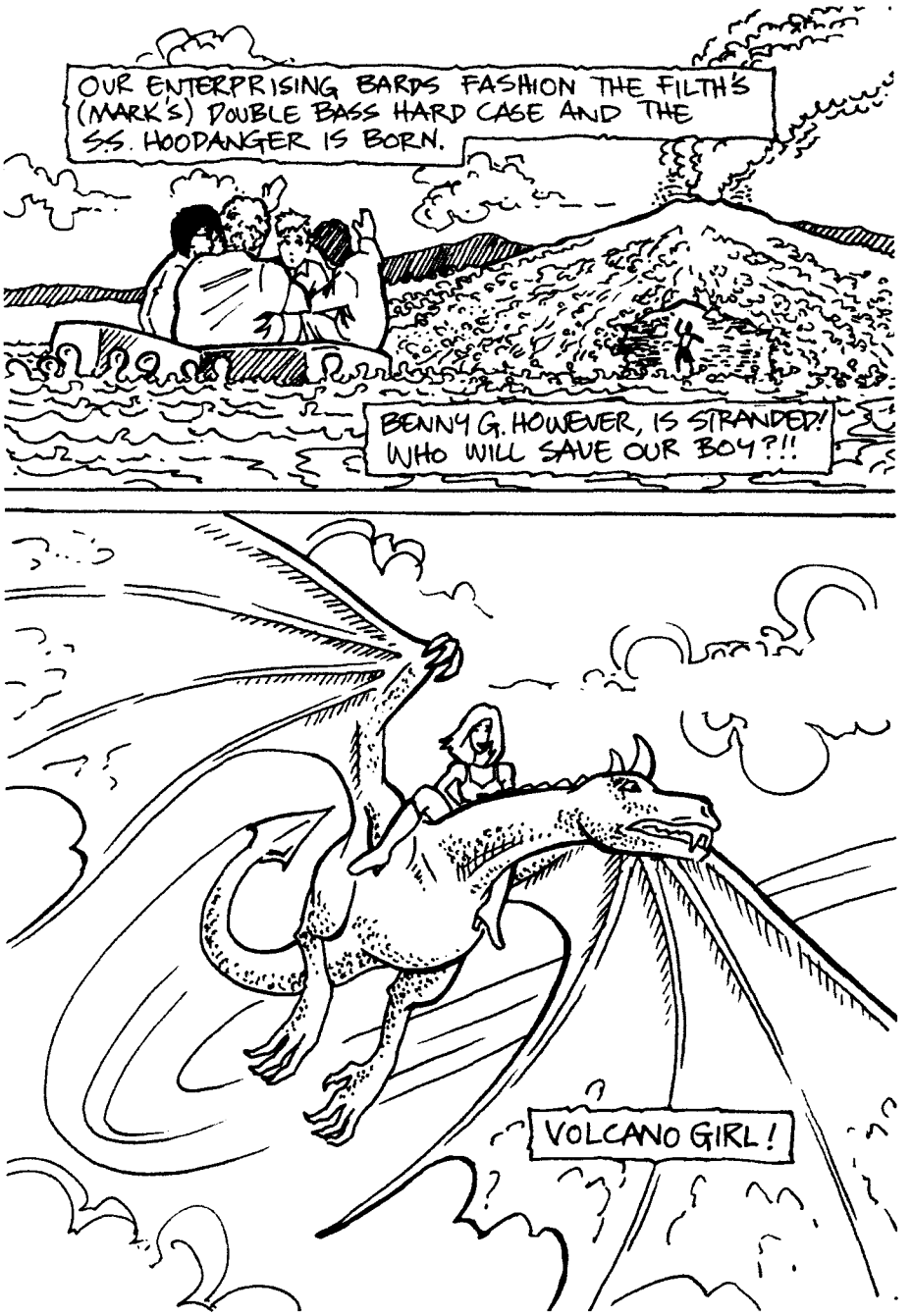
APPENDICES

Appendix A


VOLCANO GIRL!
STORY: BENNY G. ART: TOLLEY
SOUTHERN ICELAND...
THE SEETHING VOLCANO KATLA LIES SLEEPING, CLOAKED UNDER 400 METRES OF ICE THAT IS THE MIGHTY MÝRDALSJÖKULL GLACIER.
CLOSE BY, IN THE THORSMORK TOURIST ZONE, THE HOODANGERS ARE UP TO THEIR USUAL TRICKS; RAVAGING RUBBERNECKS FOR LOCAL COIN.
SUDDENLY, WITH EPIC GROAN AND RUMBLE, THE GORGED LADY KATLA SPEWS FORTH HER MAGMIC LOAD!
LAVA MEETS ICE!
A CATASTROPHIC JÖKULHAUP* IS BORN!
IT HEADS STRAIGHT FOR OUR FAVOURITE MINSTRELS!
* POST ERUPTIVE GLACIAL FLOOD.


OUR ENTERPRISING BARDS FASHION THE FILTH'S (MARK'S) DOUBLE BASS HARD CASE AND THE S.S. HOODANGER IS BORN.
BENNY G. HOWEVER, IS STRANDED! WHO WILL SAVE OUR BOY?!!
VOLCANO GIRL!

Artwork by Tolley

Story by BennyG

Appendix B

2006

Dear

RE: Your participation in the project: ***Public perception of jokulhlaup risk along the Markarfljot River, south Iceland***

You are invited to participate in a study that investigates public perception and knowledge of the risk from jokulhlaup along the Markarfljot River, south Iceland. This investigation has been triggered by recent research on jokulhlaup hazards within this area. The results will be used as a chapter in a Master of Philosophy thesis and may be written up for publication in a journal such as Journal of Volcanology and Geothermal Research.

The study is being conducted by Ms Deanne Bird (Macquarie University) and Gudrun Gisladottir, Department of Geography and Geology, University of Iceland, Askja, Sturlugata 7, 101 Reykjavik, Iceland; Tel: +354 552 4471, Fax. +354 525 4499, email: ggisla@hi.is. Supervising this project is Dr Dale Dominey-Howes, Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, NSW 2109; Tel: +612 9850 9679, Fax: +612 9850 8420, email: ddominey@els.mq.edu.au.

If you decide to participate, you will be asked to complete a detailed questionnaire in the presence of the researchers (Ms Deanne Bird and Gudrun Gisladottir) at a time convenient to yourself and arranged in advance. The questionnaire will include a range of questions that will require tick box responses and a number of open-ended questions that will require written answers. It is expected that the questionnaire will take about 30 minutes to complete. You will only be required to complete this task once. You will be asked to provide information about your knowledge of jokulhlaup and their likely risk to the region along the Markarfljot River. Your responses will be recorded on an audio tape for referral and clarification by the researchers. This tape will be for the sole use of Deanne Bird, Gudrun Gisladottir and Dale Dominey-Howes. It will not be made available to any other staff member of Macquarie University or the University of Iceland. There are no physical risks associated with this research. You will not receive any payment for your participation in this investigation.

Any information or personal details gathered in the course of the study are confidential. No individual will be identified in any publication of the results. Deanne Bird and Dale Dominey-Howes of Macquarie University and Gudrun Gisladottir of the University of Iceland will be the only staff that will have access to the information you provide. Information collected from you will be kept in a secure location not accessible to anyone else. There is a possibility that the results collected during the course of this research may be used in the preparation of a manuscript for publication in an International Scientific journal. Where such publication does occur, again, the publication will not contain any information that would allow readers to identify you and your organisation. Where publication does take place, we will send you a copy of the publication for your information and interest.

If you decide to participate, you are free to withdraw from further participation in the research at any time without having to give a reason and without consequence.

I, *(_____)* have read *(or, where appropriate, have had read to me)* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name:
(block letters)

Participant's Signature: _____Date:

Investigator's Name:
(block letters)

Investigator's Signature: _____ Date:

The ethical aspects of this study have been approved by the Macquarie University Ethics Review Committee (Human Research). If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Ethics Review Committee in Australia through its Secretary (telephone +612 9850 7854; email: ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome. Alternatively, you may contact Persónuvernd in Iceland (telephone +354 510 9600; email: postur@personuvernd.is).

(INVESTIGATOR'S [OR PARTICIPANT'S] COPY) – delete as appropriate

Please sign both copies of this letter and keep one copy for your records. Please return the other signed copy to Ms Deanne Bird at the time of your questionnaire interview.

Thank you.

Appendix C

2006 Tourism Employee Questionnaire:
'Public perception of jökulhlaup risk along the Markarfljót River'

1.Age:
- ❑ 18-30
- ❑ 31-50
- ❑ 50+

2.Where do you live? _____

3.In which country, or region of Iceland, have you lived the longest? _____

4.What language do you usually speak at home? _____

5.What is the highest level of education you have completed?
- ❑ Some schooling
- ❑ Educated from 6 to 16 years
- ❑ High school 16-20 years
- ❑ Special education
- ❑ University Degree
- ❑ Postgraduate Qualification
- ❑ Other, please specify: _____

6.What is your occupation? _____

7.Does your company hold regular emergency training in relation to natural hazards associated with the regions you visit with tourists?

❑Yes ❑No ❑Don't know

8.If yes, how often? _____

9.How often do you take tourists to the region around the Markarfljót?

	Summer	Winter
Everyday	❑	❑
Several times per week	❑	❑
Once a week	❑	❑
Once every two weeks	❑	❑
Once a month	❑	❑
Once every few months	❑	❑
Twice a season	❑	❑
Once a season	❑	❑
Other, please specify	❑	❑

10. What is the average group size that you take into the Markarfljót region? _____

11. When your company takes tours into the Markarfljót region is a guide always with the tourists? ❑Yes (já) ❑No (nei)

12. If not, how long are they left alone? _____

13. Do you inform your tourists that Iceland is volcanically active and is subjected to natural hazards? ❑Yes ❑No

14. If yes, what do you tell them about? _____

_____

_____

_____

15. Do you inform your tourists about natural hazards associated with Katla and Mýrdalsjökull? ❑Yes ❑No

16. If yes, what do you tell them about? _____

_____

_____

_____

17. Can you tell me a brief eruptive history of Katla?

_____

_____

_____

_____

18. How would you define a jökulhlaup?

_____

_____

19. What do you think can generate a jökulhlaup?

_____

_____

20. From the answers given in question 19 which one is the most likely to cause a jökulhlaup along the Markarfljót?

_____

_____

21. Do you think the Markarfljót could be flooded by a jökulhlaup?

❑Yes ❑No ❑Don't know

22. What local and distant geographic areas could generate a jökulhlaup on the Markarfljót?

_____

_____

23. Do you know when the last jökulhlaup affected the Markarfljót?

❑Yes ❑No

24. If yes, when? _____

25. Do you think if a jökulhlaup flooded the Markarfljót region it would cause any of the following? (You may choose as many as you like).

Human Impacts:

- ❑ Death and injury of people
- ❑ Damage and destruction to homes and businesses
- ❑ Damage and destruction to critical lifelines e.g. water, electricity
- ❑ Damage and destruction to communication networks and infrastructure
- ❑ Damage and destruction to transport networks and infrastructure
- ❑ Impacts on agriculture
- ❑ Impacts on tourism
- ❑ Other, please specify:

_____

_____

Biophysical Impacts:

- ❑ Impacts on river systems
- ❑ Impacts on beaches
- ❑ Impact on agricultural land
- ❑ Impacts on submarine plants and animals
- ❑ Impacts on natural plants and animals
- ❑ Other, please specify):

_____

_____

26. Which of the above do you think will have the greatest impact on the Markarfljót region and why?

_____

_____

27. Do you know whether a jökulhlaup warning system exists for the Markarfljót region?

❑Yes ❑No ❑Don't know

28. If you answered yes to question 27 did you know prior to the evacuation exercise organised in March 2006? ❑ Yes ❑ No

29. If you answered no or don't know to question 27 do you think the Markarfljót region needs an early warning system?

❑ Yes ❑ No

30. Are you aware of the emergency procedures you need to follow if a jökulhlaup warning is issued (Veistu hvaða neyðaráætlun þú þarft að fylgja ef viðvörun er gefin út)?

❑ Yes ❑ No

31. If you answered yes to question 30 did you know prior to this evacuation exercise?

❑ Yes ❑ No

32. Please describe what you would do if a jökulhlaup warning is issued.

_____

_____

_____

_____

33. What would you do if there was a volcanic eruption in Katla i.e. how would you find out if you need to evacuate?

_____

_____

_____

_____

34. Who do you think is responsible for issuing a jökulhlaup warning for the Markarfljót region?

_____

_____

35. Who do you think is responsible for evacuation procedures if a jökulhlaup warning is given?

_____

_____

36. Does your company inform any authorities (i.e. police, Almannavarnir etc.) that you are taking a tourist group into Þórsmörk? ❑Yes ❑No

37. If yes, who do they tell and what sort of information do they provide them with?

_____

_____

_____

38. What would you define as the most serious hazard if Katla erupted? You can mention more than one, and if so please rank in order with 1 being the most serious.

- ❑ Jökulhlaup
- ❑ Ice blocks
- ❑ Lightning
- ❑ Tephra
- ❑ Poisonous gases
- ❑ Lava
- ❑ Tsunami
- ❑ Earthquake

39. Do you always carry your GSM with you when you are in the Markarfljót region?

❑Yes ❑No

40. Do you always have GSM coverage in the Markarfljót region?

❑Yes ❑No

41. Do you always carry a satellite phone with you when you are in the Markarfljót region? ❑Yes ❑No

42. Do you have any suggestions for the warning and evacuation of Þórsmörk?

_____

_____

_____

_____

43. Do you think it is necessary to have another evacuation exercise which involves the tourist operators working in this region?

❑Yes ❑No ❑Don't know

44. How often do you think they should practice evacuations in this region?

- ❑ Once every 6 months
- ❑ Once every year
- ❑ Once every two years
- ❑ Once every five years
- ❑ Other, please specify: _____

45. Have you looked up the emergency services website (Almannavarnir) and familiarised yourself with information on the possible natural hazards connected to a Katla eruption?

❑Yes ❑No

46. Have you ever used the Skjálftavefsjá website for hazard information?

❑Yes, how often? _____ ❑No

47. Have you ever used the Veðurstofa website for hazard information?

❑Yes, how often? _____ ❑No

48. Have you followed discussions in the media about natural hazards connected to a Katla eruption?

❑Yes ❑No

49. From what forms of media do you access this information?

❑Newspaper ❑Radio ❑Television

❑Internet ❑Information Brochures ❑ Books

Appendix D

2006 Tourist Questionnaire:
'Public perception of jökulhlaup risk along the Markarfljót River'

1. Age:
   - ❑ 18-30
   - ❑ 31-50
   - ❑ 50+

2. Where do you live? _____

3. In which country, or region of Iceland, have you lived the longest?
   _____

4. What language do you usually speak at home? _____

5. What is the highest level of education you have completed?
   - ❑ Some schooling
   - ❑ Educated from 6 to 16 years
   - ❑ High school 16-20 years
   - ❑ Special education
   - ❑ University Degree
   - ❑ Postgraduate Qualification
   - ❑ Other, please specify: _____

6. What is your occupation? _____

7. How long will you be spending in the region around the Markarfljót? _____

8. What is your main purpose of visiting this area?
   - ❑ Hiking
   - ❑ Camping
   - ❑ Relaxing
   - ❑ Partying
   - ❑ 4WDriving
   - ❑ Other, please explain: _____

9. Are you travelling with a guide whilst in this region? ❑Yes ❑No

10. Is the guide with you at all times? ❑Yes ❑No

11. Has your guide informed you of any natural hazards that may affect this region?
    ❑Yes ❑No

12. If you are travelling in a group, how many people are in your group? _____

13. Do you have your GSM with you whilst travelling in the Markarfljót region?
❑Yes ❑No

14. If yes, do you always have GSM coverage in the Markarfljót region?
❑Yes ❑No

15. Do you carry a satellite phone with you when travelling in the Markarfljót region?
❑Yes ❑No

16. Are family/friends (or anyone else) aware of your exact location whilst you are travelling?
❑Yes ❑No

17. What precautions did you take to ensure your own safety whilst travelling in this region?

_____

_____

_____

18. Prior to travelling in this region, did you look up the emergency services website (Almannavarnir) and familiarised yourself with information on the possible natural hazards that may affect this region? ❑Yes ❑No

19. Have you ever used the Skjálftavefsjá website for hazard information?
❑Yes, how often? _____ ❑No

20. Have you ever used the Veðurstofa website for hazard information?
❑Yes, how often? _____ ❑No

21. Have you followed discussions in the media about natural hazards connected to a Katla eruption? ❑Yes ❑No

22. From what forms of media do you access this information?
❑Newspaper
❑Radio
❑Television
❑Internet
❑Information Brochures
❑ Books

23. Did you know that Iceland is a volcanically active island? ❑Yes ❑No

24. If yes, can you briefly describe what you know?

_____

_____

_____

25. Are you aware of the natural hazards that occur in Iceland? ❑Yes ❑No

26. If yes, can you tell me what they are?

_____

_____

27. Have you heard of Katla? ❑Yes ❑No

28. If yes, can you briefly describe what you know?

_____

_____

_____

29. Have you heard of the Icelandic term jökulhlaup? ❑Yes ❑No

30. If yes, can you briefly describe what you know?

_____

_____

_____

If no, tell them what it is and then ask them question 31.

31. What do you think can generate a jökulhlaup?

_____

_____

32. From the answers given in question 31 which one is the most likely to cause a jökulhlaup along the Markarfljót?

_____

_____

33. Do you think the Markarfljót could be affected by a jökulhlaup?

❑Yes ❑No ❑Don't know

34. What local and distant geographic areas could generate a jökulhlaup along the Markarfljót?

_____

_____

35. Do you know when the last jökulhlaup flooded the Markarfljót?

❑Yes ❑No

36. If yes, when? _____

37. Do you think if a jökulhlaup flooded the Markarfljót region it would cause any of the following? (You may choose as many as you like).

Human Impacts:

- ❑ Death and injury of people
- ❑ Damage and destruction to homes and businesses
- ❑ Damage and destruction to critical lifelines e.g. water, electricity
- ❑ Damage and destruction to communication networks and infrastructure

- ❑ Damage and destruction to transport networks and infrastructure
- ❑ Impacts on agriculture
- ❑ Impacts on tourism
- ❑ Other, please specify:

Biophysical Impacts:

- ❑ Impacts on river systems
- ❑ Impacts on beaches
- ❑ Impact on agricultural land
- ❑ Impacts on submarine plants and animals
- ❑ Impacts on natural plants and animals
- ❑ Other, please specify):

38. Which of the above do you think will have the greatest impact on the Markarfljót region and why?

39. Do you know whether a jökulhlaup warning system exists for the Markarfljót region?

❑Yes ❑No ❑Don't know

40. If you answered no or don't know to question 39 do you think the Markarfljót region needs an early warning system?

❑ Yes ❑ No

41. Are you aware of the emergency procedures you need to follow if a jökulhlaup warning is issued?

❑ Yes ❑ No

42. Please describe what you would do if a jökulhlaup warning is issued.

43. What would you do if there was a volcanic eruption in Katla i.e. how would you find out if you need to evacuate?

44. Who do you think is responsible for issuing a jökulhlaup warning for the Markarfljót region?

45. Who do you think is responsible for evacuation procedures if a jökulhlaup warning is given?

_____

_____

46. What would you define as the most serious hazard if Katla erupted? You can mention more than one, and if so please rank in order with 1 being the most serious.

- ❑ Jökulhlaup
- ❑ Ice blocks
- ❑ Lightning
- ❑ Tephra
- ❑ Poisonous gases
- ❑ Lava
- ❑ Tsunami
- ❑ Earthquake

47. Do you think they should practice evacuations in this region?

❑Yes ❑No

48. If yes, how often?

- ❑ Once every 6 months
- ❑ Once every year
- ❑ Once every two years
- ❑ Once every five years
- ❑ Other, please specify: _____

49. Do you think they should include tourists in these evacuation exercises?

❑Yes ❑No

50. Would you take part if there was an evacuation exercise whilst you were travelling in this region? ❑Yes ❑No

Appendix E

2007

Dear

RE: Your participation in the project: ***Public perception of jokulhlaup risk along the Markarfljot River, south Iceland***

You are invited to participate in a study that investigates public perception and knowledge of the risk from jokulhlaup along the Markarfljot River, south Iceland. This investigation has been triggered by recent research on jokulhlaup hazards within this area. The results will be used as a chapter in a Doctor of Philosophy thesis and may be written up for publication in a journal such as Journal of Volcanology and Geothermal Research.

The study is being conducted by Ms Deanne Bird (Macquarie University and the University of Iceland) and Gudrun Gisladottir, Department of Geography and Geology, University of Iceland, Askja, Sturlugata 7, 101 Reykjavik, Iceland; Tel: +354 552 4471, Fax. +354 525 4499, email: ggisla@hi.is. The principal supervisors for this research are Gudrun Gisladottir and Dale Dominey-Howes, Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, NSW 2109; Tel: +612 9850 9679, Fax: +612 9850 8420, email: ddominey@els.mq.edu.au.

If you decide to participate, you will be asked to complete a detailed questionnaire in the presence of the researchers (Ms Deanne Bird and Gudrun Gisladottir) at a time convenient to yourself and arranged in advance. The questionnaire will include a range of questions that will require tick box responses and a number of open-ended questions that will require written answers. It is expected that the questionnaire will take about 30 minutes to complete. You will only be required to complete this task once. You will be asked to provide information about your knowledge of jokulhlaup and their likely risk to the region along the Markarfljot River. There are no physical risks associated with this research. You will not receive any payment for your participation in this investigation.

Any information or personal details gathered in the course of the study are confidential. No individual will be identified in any publication of the results. Deanne Bird and Dale Dominey-Howes of Macquarie University and Gudrun Gisladottir of the University of Iceland will be the only staff that will have access to the information you provide. Information collected from you will be kept in a secure location not accessible to anyone else. There is a possibility that the results collected during the course of this research may be used in the preparation of a manuscript for publication in an International Scientific journal. Where such publication does occur, again, the publication will not contain any information that would allow readers to identify you and your organisation. Where publication does take place, we will send you a copy of the publication for your information and interest.

If you decide to participate, you are free to withdraw from further participation in the research at any time without having to give a reason and without consequence.

I, *(_____)* have read *(or, where appropriate, have had read to me)* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name:
(block letters)

Participant's Signature: _____Date:

Investigator's Name:
(block letters)

Investigator's Signature: _____ Date:

The ethical aspects of this study have been approved by the Macquarie University Ethics Review Committee (Human Research). If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Ethics Review Committee in Australia through its Secretary (telephone +612 9850 7854; email: ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome. Alternatively, you may contact Persónuvernd in Iceland (telephone +354 510 9600; email: postur@personuvernd.is).

(INVESTIGATOR'S [OR PARTICIPANT'S] COPY) – delete as appropriate

Please sign both copies of this letter and keep one copy for your records. Please return the other signed copy to Ms Deanne Bird at the time of your questionnaire interview.

Thank you.

Appendix F

2007

Kæri/kæra:

EFNI: ÞÁTTTAKA ÞÍN Í VERKEFNINU: VIÐHORF FÓLKS TIL VÁR VEGNA JÖKULHLAUPS Í NÁGRENNI MARKARFLJÓTS.

Ég, Deanne Bird, óska eftir þátttöku þinni í rannsókn á viðhorfi og þekkingu fólks á hættu vegna jökulhlaups í Markarfljóti. Nýleg rannsókn á náttúrvá vegna eldgosa og hlaupa frá vestanverðum Mýrdalsjökli og Eyjafjallajökli var hvatinn að þessu verkefni. Niðurstöður rannsóknarinnar verða notaðar í kafla í doktorsritgerð minni við Háskóla Íslands og háskólann í Macquarie í Sydney í Ástralíu en einnig sem grein í vísindatímarit s.s. Journal of Volcanology and Geothermal Research.

Rannsóknin er framkvæmd af Deanne Bird (Macquarie University) og Guðrúnu Gísladóttur, prófessor við land- og ferðamálafræðiskor Háskóla Íslands,og jarðvísindastofnun Háskólans Öskju, Sturlugötu 7, 101 Reykjavik, sími 552 4471, fax. 525 4499, netfang: ggisla@hi.is. Leiðbeinandi af hálfu Hákóla Íslands er Guðrún Gísladóttir og af hálfu Macquarie háskólans er Dr. Dale Dominey-Howes, Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, NSW 2109; Tel: +612 9850 9679, Fax: +612 9850 8420, netfang: ddominey@els.mq.edu.au.

Ef þú ákveður að taka þátt í rannsókninni verður þú beðinn/beðin um að svara nokkuð ítarlegum spurningalista, í viðveru Deanne og Guðrúnar, eftir samkomulagi við þig. Mörgum spurningunum er fljótsvarað, og merkt í þar til gert box við spurningar á listanum. Aðrar bjóða upp á að þú segir frá eða tjáir viðhorf þitt til viðkomandi spurningar. Reiknað er með að það taki um 30 mínútum að svara spurningunum. Við munum ekki trufla þig nema í þetta eina skipti. Við munum biðja þig að segja okkur frá þekkingu þinni á jökulhlaupum og hugsanlegri hættu af þeim í nágrenni Markarfljóts.

Farið verður með öll persónuleg svör sem trúnaðarmál og þegar rannsóknin verður birt verður ekki hægt að rekja nein svör til einstaklinga. Deanne Bird, Guðrún Gísladóttir við Háskóla Ísland og Dale Dominey-Howes við Macquarie háskólann verða þau einu sem hafa aðgang að gögnunum. Þau verða geymd á öruggum stað óaðgengilegt öðrum en þeim þremur. Hugsanlegt er að niðurstöður rannsóknarinnar verði birtar í alþjóðlegu vísindatímariti, en þá verður, eins og áður hefur verið bent á, ekki hægt að rekja svör eða viðhorf til einstaklinga. Þegar búið verður að gefa niðurstöður rannsóknarinnar út verður þér sent eintak ef þú óskar þess.

Ef þú ákveður að taka þátt í könnuninni en snýst hugur, getur þú hætt við án þess að gefa okkur nokkra skýringu á því og án óþæginda.

Ég, *(_____)* hef lesið og *(eða ef við á, ofangreindur texti hefur verið lesinn fyrir mig og ég hef)* skilið ofangreindar upplýsingar og fengið fullnægjandi svör við spurningum sem ég spurt. Ég hef samþykkt að taka þátt í rannsókninni vitandi að ég get hætt við þátttöku hvenær sem er án nokkurs eftirmála. Mér hefur verið fengið afrit af þessu skjali.

Nafn þátttakanda:
(prenstafir).

Undirskrift þátttakanda: _____Dagsetning:

Nafn spyrjanda:
(prentstafir)

Undirskrift spyrjanda: _____ Dagsetning:

Siðferðisnefnd Macquarie háskólans (Macquarie University Ethics Review Committee) hefur samþykkt fyrir sitt leyti að rannsóknin fari fram. Ef þú vilt koma kvörtunum á framfæri eða hefur efasemdir um réttmæti/siðferðisleg sjónarmið rannsóknarinnar getur þú haft samband við skrifstofuna Ethics Review Committee í Ástralíu, (sími +612 9850 7854; netfang: ethics@mq.edu.au). Farið verður með kvartanir sem trúnaðarmál, en þær kannaðar og þú verður látinn vita um niðurstöður hennar. Einnig getur þú hringt í Persónuvernd á Íslandi (sími 510 9600; netfangl: postur@personuvernd.is).

(Afrit spyrjanda [eða þátttakanda]) – strikið yfir það sem ekki á við.

Vinsamlega undirritaðu bæði skjölin, og haltu öðru en Deanne Bird mun halda hinu.

Kærar þakkir.

Appendix G

2007 Tourism Employee Questionnaire:
'Public perception of jökulhlaup risk along the Markarfljót River'
Viðhorf fólks til hættu vegan jökulhlaups í Markarfljóti.

1. Within which age group were you on your last birthday (Vinsamlega merktu við þann reit sem endurspeglar aldur þinn þegar þú áttir afmæli síðast)?
   - ❑ 18-30
   - ❑ 31-50
   - ❑ 50+

2. Where do you live (Hvar býrð þú)? _____

3. In which country, or region of Iceland, have you lived the longest (Í hvaða landi hefur þú búið lengst af)? _____

4. What language do you usually speak at home (Hvaða mál talar þú oftast heima fyrir)?

❑ Icelandic (íslensku) ❑ English (ensku) ❑ German (þýsku)
❑ Spanish (spænsku) ❑ French (frönsku) ❑ Italian (ítölsku)
❑ Other, please specify (annað, vinsamlega tilgreindu hvaða): _____

5. What is the highest level of education you have completed (Hvaða menntun átt þú að baki)?
   - ❑ Some schooling (Nokkra skólagöngu)
   - ❑ Educated from 6 to 16 years (Grunnskóla)
   - ❑ High school 16-20 years (Menntaskóla)
   - ❑ Special education (Sérnám, t.d. iðnnám, verslunarnám)
   - ❑ Undergraduate (Grunnám í Háskóla)
   - ❑ University Degree (Háskólamenntun)
   - ❑ Postgraduate Qualification (Framhaldsnám í háskóla t.d. meistara- eða doktorsnám)
   - ❑ Other, please specify (Annað, vinsamlegast tilgreindu): _____

6. What is your occupation (Við hvað starfar þú)?

❑ Guide (leiðsögumaður) ❑ Driver (bílstjóri) ❑ Hut Warden (skálavörður)
❑ Other, please specify (annað, visamlega skýrðu): _____

7. Does your company hold regular emergency training in relation to natural hazards associated with the regions you visit with tourists (Heldur fyrirtækið þitt reglulegar æfingar í tengslum við náttúrvá á þeim svæðum sem þú ferð með ferðamenn)?
   ❑ Yes (já) ❑ No (nei) ❑ Don't know (veit ekki)

8. If yes, how often (Ef já, hversu oft)? _____

9. How often do you take tourists to the region around the Markarfljót (Hversu oft ferð þú með ferðamenn um svæðið í nágrenni Markarfljóts)?

	Summer (Sumar)	Winter Vetur)
Everyday (Daglega)	❑	❑
Several times per week (Nokkru sinnum í viku)	❑	❑
Once a week (Einu sinni í viku)	❑	❑
Once every two weeks weeks (Aðra hverja viku)	❑	❑
Once a month (Einu sinni í mánuði)	❑	❑
Once every few months (Einu sinni á nokkurra mánaða fresti)	❑	❑
Twice a season (Tvisvar á ferðamannatímanum)	❑	❑
Once a season (einu sinni á ferðamannatímanum)	❑	❑
Other, please specify (Annað, vinsamlega tilgreindu)	❑	❑

10. Does your company inform any authorities (i.e. police, Almannavarnir etc.) that you are taking a tourist group into Þórsmörk (Tilkynnir fyrirtækið þitt það til yfirvalda (lögreglu, Almannavarna eða annarra) að þú sért með ferðamenn í Þórsmörk)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

11. If yes, who do they tell (Ef já, hvað segja þeir)? _____

What sort of information do they provide them with (Hvers konar upplýsingar láta þeir þeim í té)?

_____

_____

_____

_____

12. Do you always carry your GSM with you when you are in the Þórsmörk region (Ert þú alltaf með GSM síma á meðan þú ert í Þórsmörk)?

❑Yes (já) ❑No (nei)

13. Do you always have GSM coverage in the Þórsmörk region (Nærðu alltaf GSM sambandi á Þórsmerkursvæðinu)?

❑Yes (já) ❑No (nei)

14. Do you always carry a satellite phone with you when you are in the Þórsmörk region (Ertu alltaf með gervihnattasíma meðan á ferð þinni í Þórsmörk stendur)?

❑Yes (já) ❑No (nei)

15. What is the average size of the groups you take into the Þórsmörk region (Hver er meðalstærð hópa sem þú ferð með á Þórsmerkursvæðið)? _____

16. When your company takes tours into the Þórsmörk region is a guide always with the tourists (Er leiðsögumaður alltaf með ferðamönnunum þegar fyrritækið þitt er með ferðir í Þórsmörk)?

❑Yes (já) ❑No (nei)

17. If not, how long are they left alone (Ef ekki, hve lengi eru ferðamenn án leiðsögumanns)? _____

18. Do you inform your tourists that Iceland is volcanically active and is subjected to natural hazards (Upplýsir þú ferðamenn um að Íslands sé virkt eldfjallaland og að hætt sé á náttúruvá)? ❑Yes (já) ❑No (nei)

19. If yes, what do you tell them about (Ef já, hvað segir þú þeim)?

_____

_____

_____

20. Do you inform your tourists about natural hazards associated with Katla and Mýrdalsjökull (Upplýsir þú ferðamennina um náttúrvá sem tengist Kötlu og Mýrdalsjökli)? ❑Yes (já) ❑No (nei)

21. If yes, what do you tell them about (Ef já hvað segir þú þeim)?

_____

_____

_____

22. Please tell me a brief eruptive history of Katla i.e. last eruption and frequency of eruptions (Getur þú sagt mér frá gossögu Kötlu í grófum dráttum)?

_____

_____

_____

23. What would you define as the most serious hazard if Katla erupted? You can mention more than one, and if so please rank in order with 1 being the most serious. (Hverja teldir þú mesta hættu í kjölfar Kötlugoss? Þú mátt telja meira en eina hættu, vinsamlegast raðaðu í hætturöð, 1 er mest hætta, o.s.frv.)

- ❑ Jökulhlaup
- ❑ Ice blocks (Jakaburður)
- ❑ Lightning (Eldingar)
- ❑ Tephra(Gjóskufall)
- ❑ Poisonous gases (Gaseitrun)
- ❑ Lava (Hraunrennsli)
- ❑ Tsunami (Flóðbylgja af hafi)
- ❑ Earthquake (Jarðskjálfti)

24. How would you define a jökulhlaup (Hvernig skilgreinir þú jökulhlaup)?

_____

_____

25. What do you think can generate a jökulhlaup (Hvað telur þú að orsaki jökulhlaup)?

❑Volcanic eruption (Eldgos) ❑Geothermal activity (Jarðhitavirkni)

❑Glacial Lake outburst (Hlaup úr jökullóni) ❑Don't know (Veit ekki)

❑Other, please specify (Annað, vinsamlega tilgreindu): _____

26. Do you think the Markarfljót could be affected by a jökulhlaup (Telur þú að jöklulhlaup geti farið í Markarfljót)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

27. From the answers given in question 25 which one is the most likely to cause a jökulhlaup along the Markarfljót (Út frá svarinu sem þú gafst í spurningu 25 hver telur þú að sé líklegasti orsakavaldur jökulhlaups í Markarfljóti)?

❑Volcanic eruption (Eldgos) ❑Geothermal activity (Jarðhitavirkni)

❑Glacial Lake outburst (Hlaup úr jökullóni) ❑Don't know (Veit ekki)

❑Other, please specify (Annað, vinsamlega tilgreindu): _____

28. What local and distant geographic areas could generate a jökulhlaup along the Markarfljót (Hvaða landfræðilegu svæði nær og fjær gætu orsakað jökulhlaup í Markarfljóti)?

❑Katla ❑Mýrdalsjökull ❑Eyjafjallajökull ❑Tindfjallajökull

❑Don't know ❑Other, please specify: _____

29. Do you know when the last jökulhlaup flooded the Markarfljót (Veistu hvenær síðasta jökulhlaup var í Markarfljóti)? ❑Yes(já) ❑No(nei)

30. If yes to question 29, when (ef já, hvenær)? _____

31. Which of the following do you think will occur if a jökulhlaup flooded the Markarfljót? (You may choose as many as you like). Hvert eftirtalinna atriða telur þú að jökulhlaup í Markarfljóti gæti haft í för með sér? (Þú mátt velja eins mörg og þú vilt).

Human Impacts (Áhrif á fólk):

- ❑ Death and injury of people (Slys og dauða fólks)
- ❑ Damage and destruction to homes and businesses (Skemmdir og eyðileggingu á heimilum og fyrirtækjum)
- ❑ Damage and destruction to critical lifelines e.g. water, electricity (Skemmdir og eyðileggingu á mikilvægum veitukerfum, t.d. flutningi vatns og/eða rafmagns)
- ❑ Damage and destruction to communication networks and infrastructure (Skemmdir eða eyðileggingu á samskiptaneti t.d. fjarskiptaneti - símalínum, gsm sendum, símstöðvum)
- ❑ Damage and destruction to transport networks and infrastructure (Skemmdir eða eyðileggingu á samgönguneti, s.s. vegum og brúarmannvirkjum)
- ❑ Impacts on agriculture (Áhrif á landbúnað)
- ❑ Impacts on tourism (Áhrif á ferðaþjónustu og ferðmannastraum)
- ❑ Other, please specify (Annað, vinsamlega gerðu grein fyrir svari þínu):

Biophysical Impacts (Áhrif á umhverfið):

- ❑ Impacts on river systems (Áhrif á ár og árfarvegi)
- ❑ Impacts on beaches (Áhrif á strönd)
- ❑ Impact on agricultural land (Áhrif á landbúnaðarland)
- ❑ Impacts on submarine plants and animals (Áhrif á neðansjávargróður og sjávardýr)
- ❑ Impacts on natural plants and animals (Áhrif á náttúrlegan gróður og dýralíf)
- ❑ Other, please specify (Annað, vinsamlegast gerðu grein fyrir):

32. Which of the above do you think will have the greatest impact on the Þórsmörk region and why (Hvað af ofangreindu telur þú að muni hafa mest áhrif á svæðið kringum Þórsmörk og af hverju)?

33. Does a jökulhlaup early warning system exist for the Þórsmörk region (Er viðvörunarkerfi (vöktun) í gangi vegna jökulhlaups fyrir Þórsmerkursvæðið)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

34. If you answered no or don't know to question 33 do you think the Þórsmörk region needs an early warning system (Ef þú svaraðir nei eða veit ekki við spurningu 33 finnst þér að að Þórsmerkursvæðið þarfnist viðvörunarkerfis)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

35. Are you aware of the emergency procedures you need to follow if a jökulhlaup warning is issued (Veistu hvaða neyðaráætlun þú þarft að fylgja ef viðvörun um jökulhlaup er gefin út)?

❑ Yes (já) ❑ No (nei)

36. Please describe what you would do if a jökulhlaup warning is issued (Lýstu því sem þú myndir gera ef viðvörun vegna jökuhlaups væri gefin út).

37. What would you do if there was a volcanic eruption in Katla i.e. how would you find out if you need to evacuate (Hvað myndir þú gera ef gos væri hafið í Kötlu, þ.e. hvernig myndir þú komast að því hvort þú þyrftir að yfirgefa staðinn sem þú ert á)?

38. Who do you think is responsible for issuing a jökulhlaup warning for the Þórsmörk region (Hver telur þú að beri ábyrgð á því að gefa út viðvörun við jökulhlaupi á Þórsmerkursvæðinu)?

_____

_____

39. Who do you think is responsible for evacuation procedures if a jökulhlaup warning is given (Hver telur þú að beri ábyrgð á rýmingu svæðisins ef viðvörun um jökulhlaup er gefin út)?

_____

_____

40. Do you think it is necessary to have another evacuation exercise which involves the tourist operators working in this region (Finnst þér að það ætti að hafa æfingu um rýmingu þar sem ferðaþjónustuaðilar á svæðinu eru þátttakendur)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

41. How often do you think they should practice evacuations in this region (Hversu oft finnst þér að ætti að æfa rýmingu á þessu svæði)?

- ❑ Once every 6 months (Á 6 mánaða fresti)
- ❑ Once every year (Árlega)
- ❑ Once every two years (Annað hvert árti)
- ❑ Once every five years (Á fimm ára fresti)
- ❑ Other, please specify (Annað, gerið grein fyrir): _____

42. Have you looked up the emergency services website (ICP) and familiarised yourself with information on the possible natural hazards connected to a Katla eruption (Hefur þú skoðað heimasíðu Almannavarna og kynnt þér mögulega nátturuvá sem getur hlotist af Kötlugosi)? ❑Yes (já) ❑No (nei)

43. Have you ever used the Veðurstofa website for hazard information (Hefur þú notað heimasíðu Veðurstofunnar fyrir upplýsingar um náttúruvá)?

❑Yes (já) ❑No (nei)

If yes, how often (Ef já hversu oft)?_____

44. If yes, do you use it to access regional information prior to travelling in Þórsmör (Ef já, gerðirðu það til að afla þér svæðisbundinna upplýsinga áður en þú fórst í Þórsmörk)? ❑Yes (já) ❑No (nei)

45. Have you ever used the Skjálftavefsjá website for hazard information (Hefur þú notað Skjálftavefsjá til að afla upplýsinga um jarðskjálfta)?

❑Yes (já) ❑No (nei)

If yes, how often (Ef já, hversu oft)?_____

46. If yes, do you use it to access regional information prior to travelling in Þórsmörk (Ef já, gerðirðu það til að afla þér svæðisbundinna upplýsinga áður en þú fórst í Þórsmörk)? ❑Yes (já) ❑No (nei)

47. Have you followed discussions in the media about natural hazards connected to a Katla eruption? If yes, how often (Hefur þú fylgst með umræðu í fjölmiðlum um náttúruvá tengda Kötlugosi)?

❑Yes (já) ❑No (nei)

48. From what forms of media do you access this information (Úr hvaða miðli sækir þú þessar upplýsingar)?

❑Newspaper (Dagblaði)
❑Radio (Útvarpi)
❑Television (Sjónvarpi)
❑Internet (Netinu)
❑Information Brochures (Upplýsingabæklingum)
❑ Books (Bækur)
❑ Other, please specify (Annað, vinsamlega tilgreindu): _____

Appendix H

2007 Tourist Questionnaire:
'Public perception of jökulhlaup risk along the Markarfljót River'
Viðhorf fólks til náttúruvár tengda jökulhlaupi í Markarfljóti.

1. Within which age group were you on your last birthday (Vinsamlega merktu við þann reit sem endurspeglar aldur þinn þegar þú áttir afmæli síðast)?
   - ❑ 18-30
   - ❑ 31-50
   - ❑ 50+

2. Where do you live (Hvar býrð þú)? _____

3. In which country, or region of Iceland, have you lived the longest (Í hvaða landi hefur þú búið lengst af)? _____

4. What language do you usually speak at home (Hvaða tungumál talar þú oftast heima fyrir)?

❑ Icelandic (íslensku) ❑ English (ensku) ❑ German (þýsku)
❑ Spanish (spænsku) ❑ French (frönsku) ❑ Italian (ítölsku)
❑ Other, please specify (annað, vinsamlega tilgreindu hvaða): _____

5. What is the highest level of education you have completed (Hvaða menntun átt þú að baki)?
   - ❑ Some schooling (Nokkra skólagöngu)
   - ❑ Educated from 6 to 16 years (Grunnskóla)
   - ❑ High school 16-20 years (Menntaskóla)
   - ❑ Special education (Sérnám, t.d. iðnnám, verslunarnám
   - ❑ Undergraduate (Grunnám í háskóla)
   - ❑ University Degree (Háskólamenntun)
   - ❑ Postgraduate Qualification (Framhaldsnám í háskóla t.d. meistara- eða doktorsnám)
   - ❑ Other, please specify (Annað, vinsamlegast tilgreindu):_____

6. What is your occupation (Við hvað starfar þú)? _____

7. How long will you be spending in the Þórsmörk region? (Hversu lengi munt þú dvelja í Þórsmörk?)_____

8. What is your main purpose for visiting this area (Hvert er meginmarkmið þitt með ferðinni?)
   - ❑ Hiking (Göngur)
   - ❑ Camping (Tjaldferð)
   - ❑ Relaxing (Afslöppun)
   - ❑ Partying (Skemmtun)

- ❑ 4WDriving (Jeppaferð eða akstur annarra farartækja með fjórhjóladrifi)
- ❑ Nature/Sightseeing (Náttúran/skoðunarferð)
- ❑ Family (Fjölskyldan)
- ❑ Other, please specify (Annað, vinsamlega tilgreindu): _____

9. Are you travelling with a guide while in this region (Ertu í ferð með leiðsögumanni)?
   ❑Yes (já) ❑No (nei)

10. If yes to question 9, is the guide with you at all times (Ef já við spurningu 9, er leiðsögumaður með þér allan tímann)? ❑Yes (já) ❑No (nei)

11. Has your guide informed you of any natural hazards that may occur in this region (Hefur leiðsögumaðurinn upplýst þig um einhverja náttúruvá sem gæti átt sér stað á þessu svæði)? ❑Yes (já) ❑No (nei)

12. If you are travelling in a group, how many people are in your group (Ef þú ert í hópferð, hversu mörg eruð þið)? _____

13. Do you have your GSM with you while travelling in the Þórsmörk region (Ert þú með GSM síma á meðan þú ert í Þórsmörk)? ❑Yes (já) ❑No (nei)

14. If yes to question 13, do you always have GSM coverage in the Þórsmörk region (Ef já við spurningu 13, nærðu alltaf GSM sambandi á Þórsmerkursvæðinu)?
    ❑Yes (já) ❑No (nei)

15. Do you carry a satellite phone with you when travelling in the Þórsmörk region (Ertu með gervihnattasíma meðan á ferð þinni í Þórsmörk stendur)?
    ❑Yes (já) ❑No (nei)

16. Are family/friends (or anyone else) aware of your exact location while you are travelling (Vita fjölskylda/vinir (eða einhverjir aðrir) nákvæmlega hvar þú ert meðan á dvöl þinni stendur)? ❑Yes (já) ❑No (nei)

17. What precautions did you take to ensure your own safety whilst travelling in this region (Hvaða varúðarráðstafanir gerðir þú til að tryggja öryggi þitt meðan á ferð þinni stendur)?

_____
_____
_____
_____
_____

18. Prior to travelling in this region, did you look up the emergency services website (Almannavarnir or ICP) and familiarise yourself with information on the possible natural hazards that may affect this region (Fórstu inn á vefsíðu Almannavarna eða björgunarsveita áður en þú komst hingað til að kynna þér hugsanlega náttúruvá sem gæti haft áhrif á þetta svæði)? ❑Yes (já) ❑No (nei)

19. Have you ever used the Veðurstofa website for hazard information (Hefur þú einhvern tíman notað heimasíðu Veðurstofunnar fyrir upplýsingar um náttúruvá)?

❑Yes (já) ❑No (nei)

If yes, how often (Ef já, hversu oft)? _____

20. If yes to question 19, did you use it to access regional information prior to travelling in Þórsmörk (Ef já við spurningu 19, notaðirðu hana til að afla þér upplýsinga um svæðið áður en þú fórst í Þórsmörk)? ❑Yes (já) ❑No (nei)

21. Have you ever used the Skjálftavefsjá website for hazard information (Hefur þú einhvern tíman notað Skjálftavefsjá til að afla upplýsinga um jarðskjálfta)?

❑Yes (já) ❑No (nei)

If yes, how often (Ef já, hversu oft)? _____

22. If yes to question 21, did you use it to access regional information prior to travelling in Þórsmörk (Ef já við spurningu 21, notaðirðu hana til að afla þér upplýsinga um svæðið áður en þú fórst í Þórsmörk)? ❑Yes (já) ❑No (nei)

23. Did you know that Iceland is a volcanically active island (Vissir þú að Ísland er virkt eldfjallaland)? ❑Yes (já) ❑No (nei)

24. If yes to question 23, can you please describe what you know (Ef já við spurningu 23, geturðu sagt mér í grófum dráttum hvað þú veist?

_____

_____

_____

_____

25. Are you aware of the natural hazards that occur in Iceland (Ertu meðvitaður/uð um náttúruvá sem geta átt sér stað á Íslandi)? ❑Yes (já) ❑No (nei)

26. If yes, can you tell me what they are (Ef já geturðu sagt mér hverjar þær eru)?

_____

_____

_____

27. Have you heard of Katla (hefur þú heyrt um Kötlu)? ❑Yes (já) ❑No (nei)

28. If yes, can you briefly describe what you know (Ef já, getur þú sagt mér það helsta sem þú veist um hana)?

_____

_____

_____

29. If yes to question 27, have you followed discussions in the media about natural hazards connected to a Katla eruption (Ef já við spurningu 27, Hefur þú fylgst með umræðu í fjölmiðlum um náttúruvá tengda Kötlugosi)?

❑Yes (já) ❑No (nei)

30. From what forms of media do you access this information (Úr hvaða miðli sækir þú þessar upplýsingar)?

- ❑ Newspaper (Dagblaði)
- ❑ Radio (Útvarpi)
- ❑ Television (Sjónvarpi)
- ❑ Internet (Netinu)
- ❑ Information Brochures (Upplýsingabæklingum)
- ❑ Books (Bókum)
- ❑ Other, please specify (Annað, vinsamlega tilgreindu): _____

31. What would you define as the most serious hazard if Katla erupted? You can mention more than one, and if so please rank in order with 1 being the most serious. (Hverja teldir þú alvarlgustu hættu i kjölfar Kötlugoss á þessu svæði? Þú mátt telja meira en eina hættu, vinsamlegast raðaðu i hætturöð, 1 er mest hætta, o.s.frv.)

- ❑ Jökulhlaup
- ❑ Ice blocks (Jakaburður)
- ❑ Lightning (Eldingar)
- ❑ Tephra(Gjóskufall)
- ❑ Poisonous gases (Gaseitrun)
- ❑ Lava (Hraunrennsli)
- ❑ Tsunami (Flóðbylgja af hafi)
- ❑ Earthquake (Jarðskjálfti)

32. Have you heard of the Icelandic term jökulhlaup (Hefur þú heyrt um hugtakið jökulhlaup)? ❑ Yes (já) ❑ No (nei)

33. If yes, can you briefly describe what you know (Ef já, getur þú lýst því í grófum dráttum)?

_____

_____

34. What do you think can generate a jökulhlaup (Hvað telur þú að orsaki jökulhlaup)?

❑ Volcanic eruption (Eldgos) ❑ Geothermal activity (Jarðhitavirkni)
❑ Glacial Lake outburst (Hlaup úr jökullóni) ❑ Don't know (Veit ekki)
❑ Other, please specify (Annað, vinsamlega tilgreindu): _____

35. Do you think the Markarfljót could be flooded by a jökulhlaup (Telur þú að jöklulhlaup geti farið í Markarfljót)?

❑ Yes (já) ❑ No (nei) ❑ Don't know (veit ekki)

36. From the answers given in question 34 which one is the most likely to cause a jökulhlaup on the Markarfljót (Út frá svarinu sem þú gafst í spurningu 34 hvað telur þú að sé líklegasti orsakavaldur jökulhlaups í Markarfljóti)?

❑ Volcanic eruption (Eldgos) ❑ Geothermal activity (Jarðhitavirkni)
❑ Glacial Lake outburst (Hlaup úr jökullóni) ❑ Don't know (Veit ekki)
❑ Other, please specify (Annað, vinsamlega tilgreindu): _____

37. What local and distant geographic areas could generate a jökulhlaup on the Markarfljót (Hvaða svæði nær eða fjær gæti valdið jökulhlaupi í Markarfljóti)?

❑Katla ❑Mýrdalsjökull ❑Eyjafjallajökull ❑Tindfjallajökull

❑Don't know (Veit ekki) ❑Other, please specify (Annað, vinsamlega tilgreindu):_____

38. Do you know when the last jökulhlaup flooded the Markarfljót (Veistu hvenær síðasta jökulhlaup var í Markarfljóti)? ❑Yes (já) ❑No (nei)

39. If yes, when (ef já, hvenær)? _____

49. Which of the following do you think will occur if a jökulhlaup flooded the Markarfljót? (You may choose as many as you like). Hvert eftirtalinna atriða telur þú að jökulhlaup í Markarfljóti gæti haft í för með sér? (Þú mátt velja eins mörg og þú vilt).

Human Impacts: Áhrif á fólk

- ❑ Death and injury of people (Slys og dauða fólks)
- ❑ Damage and destruction to homes and businesses (Skemmdir og eyðileggingu á heimilum og fyrirtækjum)
- ❑ Damage and destruction to critical lifelines e.g. water, electricity (Skemmdir og eyðileggingu á mikilvægum veitukerfum, t.d. flutningi vatns og/eða rafmagns)
- ❑ Damage and destruction to communication networks and infrastructure (Skemmdir eða eyðileggingu á samskiptaneti t.d. fjarskiptaneti - símalínum, gsm sendum, símstöðvum)
- ❑ Damage and destruction to transport networks and infrastructure (Skemmdir eða eyðileggingu á samgönguneti, s.s. vegum og brúarmannvirkjum)
- ❑ Impacts on agriculture (Áhrif á landbúnað)
- ❑ Impacts on tourism (Áhrif á ferðaþjónustu og ferðamannastraum)
- ❑ Other, please specify (Annað, vinsamlega gerðu grein fyrir svari þínu):

_____

_____

Biophysical Impacts (Áhrif á umhverfið):

- ❑ Impacts on river systems (Áhrif á ár og árfarvegi)
- ❑ Impacts on beaches (Áhrif á strönd)
- ❑ Impact on agricultural land (Áhrif á landbúnaðarland)
- ❑ Impacts on submarine plants and animals (Áhrif á neðansjávargróður og sjávardýr)
- ❑ Impacts on natural plants and animals (Áhrif á náttúrlegan gróður og dýralíf)
- ❑ Other, please specify (Annað, vinsamlegast gerðu grein fyrir):

_____

_____

40. Which of the above do you think will have the greatest impact on the Þórsmörk region and why (Hvað af ofangreindu telur þú að muni hafa mest áhrif á svæðið kringum Þórsmörk og af hverju)?

_____

_____

41. Does a jökulhlaup early warning system exist for the Þórsmörk region (Veistu hvort viðvörunarkerfi (vöktun) sé í gangi vegna jökulhlaups fyrir Þórsmerkurssvæðið)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

42. If you answered no or don't know to question 41, do you think the Þórsmörk region needs an early warning system (Ef þú svaraðir nei eða veit ekki við spurningu 41 finnst þér að Þórsmerkursvæðið þarfnist viðvörunarkerfis)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

43. Are you aware of the emergency procedures you need to follow if a jökulhlaup warning is issued (Veistu hvaða neyðaráætlun þú þarft að fylgja ef viðvörun um jökulhlaup er gefin út)? ❑ Yes (já) ❑ No (nei)

44. Please describe what you would do if a jökulhlaup warning is issued (Lýstu því sem þú myndir gera ef viðvörun vegna jökuhlaups væri gefin út).

_____

_____

_____

45. What would you do if there was a volcanic eruption in Katla i.e. how would you find out if you need to evacuate (Hvað myndir þú gera ef gos væri hafið í Kötlu, þ.e. hvernig myndir þú komast að því hvort þú þyrftir að yfirgefa staðinn sem þú ert á)?

_____

_____

_____

46. Who do you think is responsible for issuing a jökulhlaup warning for the Þórsmörk region (Hver telur þú að beri ábyrgð á því að gefa út viðvörun við jökulhlaupi á Þórsmerkursvæðinu)?

_____

_____

47. Who do you think is responsible for evacuation procedures if a jökulhlaup warning is given (Hver telur þú að beri ábyrgð á rýmingu svæðisins ef viðvörun er gefin út)?

_____

_____

48. Do you think they should practice evacuations in this region (Finnst þér að það ætti að æfa rýmingu á þessu svæði)? ❑Yes (já) ❑No (nei)

49. How often do you think they should practice evacuations in this region (Hversu oft finnst þér að ætti að æfa rýmingu á þessu svæði)?

❑ Once every 6 months (Á 6 mánaða fresti)

- ❑ Once every year (Á hverju ári)
- ❑ Once every two years (Á tveggja ára fresti)
- ❑ Once every five years (Á fimm ára fresti)
- ❑ Other, please specify (Annað, gerið grein fyrir): _____

50. Do you think they should include tourists in these evacuation exercises (Finnst þér að ferðamenn ættu að taka þátt í þeim æfingum)?

❑Yes (já) ❑No (nei)

51. Would you take part if there was an evacuation exercise whilst you were travelling in this region (Myndir þú taka þátt í rýmingaráætluninni ef þú værir að ferðast á svæðinu meðan á henni stæði)? ❑Yes (já) ❑No (nei)

Appendix I

2006 - Questions for Emergency Management Officials
'Public perception of jökulhlaup risk along the Markarfljót River'

1. What department are you with? _____

2. What is your department's role during a volcanic eruption in Katla?

_____

_____

3. Who informs you that an eruption and jökulhlaup is likely to occur?

_____

4. What was your role the day of the evacuation on the 26th March 2006?

_____

_____

5. If you dealt with the evacuees directly were they positive or negative about the exercise?

❑ Positive ❑ Negative ❑ Mixed

6. Please describe any negative situation or comments?

_____

_____

_____

_____

7. Do you think the exercise on the 26th March was a success?

❑Yes ❑No ❑Don't know

8. Can you suggest any improvements?

_____

_____

_____

_____

Appendix J

2006

Kæri/kæra:

EFNI: ÞÁTTTAKA ÞÍN Í VERKEFNINU: VIÐHORF FÓLKS TIL VÁR VEGNA JÖKULHLAUPS Í NÁGRENNI MARKARFLJÓTS.

Ég, Deanne Bird, óska eftir þátttöku þinni í rannsókn á viðhorfi og þekkingu fólks á hættu vegna jökulhlaups í Markarfljóti. Nýleg rannsókn á náttúrvá vegan eldgosa og hlaupa frá vestanverðum Mýrdalsjökli og Eyjafjallajökli var hvatinn að þessu verkefni. Niðurstöður rannsóknarinnar verða notaðar í kafla í Meistaraprófsritgerð minni við háskólann í Macquarie í Sydney í Ástralíu en einnig sem grein í vísindatímarit s.s. Journal of Volcanology and Geothermal Research.

Rannsóknin er framkvæmd af Deanne Bird (Macquarie University) og Dr. Guðrúnu Gísladóttur, jarð- og landfræðiskor, Háskóla Íslands, Öskju, Sturlugötu 7, 101 Reykjavík, sími 552 4471, fax. 525 4499, netfang: ggisla@hi.is. Leiðbeinandi af hálfu Macquarie háskólans er Dr. Dale Dominey-Howes, Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, NSW 2109; Tel: +612 9850 9679, Fax: +612 9850 8420, netfang: ddominey@els.mq.edu.au.

Ef þú ákveður að taka þátt í rannsókninni verður þú beðinn/beðin um að svara nokkuð ítarlegum spurningalista, í viðveru Deanne og Guðrúnar, eftir samkomulagi við þig. Mörgum spurningunum er fljótsvarað, og merkt í þar til gert box við spurningar á listanum. Aðrar bjóða upp á að þú segir frá eða tjáir viðhorf þitt til viðkomandi spurningar. Reiknað er með að það taki um 30 mínútum að svara spurningunum. Við munum ekki trufla þig nema í þetta eina skipti. Við munum biðja þig að segja okkur frá þekkingu þinni á jökulhlaupum og hugsanlegri hættu af þeim í nágrenni Markarfljóts. Svörin verða tekin upp á hljóðupptökutæki, svo öruggt sé að rétt sé eftir þér haft. Upptakan verður einungis notuð í tengslum við verkefnið og Deanne Bird, Guðrún Gísladóttir og Dale Dominey-Howes verða þau einu sem munu nota upptökuna og þá í tengslum við rannsóknina.

Farið verður með öll persónuleg svör sem trúnaðarmál og þegar rannsóknin verður birt verður ekki hægt að rekja nein svör til einstaklinga. Deanne Bird, Dale Dominey-Howes við Macquarie Háskólann og Guðrún Gísladóttir við Háskóla Ísland verða þau einu sem hafa aðgang að gögnunum. Þau verða geymd á öruggum stað óaðgengilegt öðrum en þeim þremur. Hugsanlegt er að niðurstöður rannsóknarinnar verði birtar í alþjóðlegu vísindatímariti, en þá verður, eins og áður hefur verið bent á, ekki hægt að rekja svör eða viðhorf til einstaklinga. Þegar búið verður að gefa niðurstöður rannsóknarinnar út verður þér sent eintak.

Ef þú ákveður að taka þátt í könnuninni en snýst hugur, getur þú hætt við án þess að gefa okkur nokkra skýringu á því og án óþæginda.

Ég, *(_____)* hef lesið og *(eða ef við á, ofangreindur texti hefur verið lesinn fyrir mig og ég hef)* skilið ofangreindar upplýsingar og fengið fullnægjandi svör við spurningum sem ég spurt. Ég hef samþykkt að taka þátt í rannsókninni vitandi að ég get hætt við þátttöku hvenær sem er án nokkurs eftirmála. Mér hefur verið fengið afrit af þessu skjali.

Nafn þátttakanda:
(prenstafir).

Undirskrift þátttakanda: _____Dagsetning:

Nafn spyrjanda:
(prentstafir)

Undirskrift spyrjanda: _____ Dagsetning:

Siðferðisnefnd Macquarie háskólans (Macquarie University Ethics Review Committee) hefur samþykkt fyrir sitt leyti að rannsóknin fari fram. Ef þú vilt koma kvörtunum á framfæri eða hefur efasemdir um réttmæti/siðferðisleg sjónarmið rannsóknarinnar getur þú haft samband við skrifstofuna Ethics Review Committee í Ástralíu, (sími +612 9850 7854; netfang: ethics@mq.edu.au). Farið verður með kvartanir sem trúnaðarmál, en þær kannaðar og þú verður látinn vita um niðurstöður hennar. Einnig getur þú hringt í Persónuvernd á Íslandi (sími 510 9600; netfangl: postur@personuvernd.is).

(Afrit spyrjanda [eða þátttakanda]) – strikið yfir það sem ekki á við.

Vinsamlega undirritaðu bæði skjölin, og haltu öðru en Deanne Bird mun halda hinu.

Kærar þakkir.

Appendix K

Resident 2006 Survey:
'Public perception of jökulhlaup risk along the Markarfljót River'
Viðhorf fólks til náttúruvár tengda jökulhlaupi í Markarfljóti.

Region:_____

1. Age: (Aldur)
   - ☐ 18-30
   - ☐ 31-50
   - ☐ 50+

2. How far from the river do you live (Hversu langt frá Markarfljóti/Þverá/ánni/fljótinu býrðu)?
   - ☐ 0-2 km
   - ☐ 2-5 km
   - ☐ 5-10 km
   - ☐ 10+ km

3. How long have you lived at this address (Hversu lengi hefur þú búið hér)? _____

4. For how many generations has your family lived in this region (Hversu margar kynslóðir fjölskyldunnar hafa búið á svæðinu)? _____

5. How many people live/stay at this address (Hversu margir búa/gista hér)?
   Adults (Fullorðnir):_____ Children (Börn):_____

6. In which country have you lived the longest (Í hvaða landi hefur þú búið lengst af)?

_____

7. What language do you usually speak at home (Hvaða tungumál talar þú oftast heima fyrir)? _____

8. What is the highest level of education you have completed (Hvaða menntun átt þú að baki)?
   - ☐ Some schooling (Nokkra skólagöngu)
   - ☐ Educated from 6 to 16 years (Grunnskóla)
   - ☐ High school 16-20 years (Menntaskóla)
   - ☐ Special education (Sérnám, t.d. iðnnám, verslunarnám
   - ☐ University Degree (Háskólamenntun)
   - ☐ Postgraduate Qualification (Framhaldsnám í háskóla t.d. meistara- eða doktorsnám)
   - ☐ Other, please specify (Annað, vinsamlegast tilgreindu):_____

9. What is your occupation (Við hvað starfar þú)? _____

10. Can you tell me a brief eruptive history of Katla (Getur þú sagt mér frá gossögu Kötlu í grófum dráttum)?

_____

_____

_____

11. How would you define a jökulhlaup (Hvernig skilgreinir þú jökulhlaup)?

_____

_____

12. What do you think can generate a jökulhlaup (Hvað telur þú að orsaki jökulhlaup)?

_____

_____

13. From the answers given in question 13 which one is the most likely to cause a jökulhlaup along the Markarfljót (Út frá svarinu sem þú gafst í spurningu 13 hvað telur þú að sé líklegasti orsakavaldur jökulhlaups í Markarfljóti)?

_____

_____

14. Do you think the region where you live could be affected by a jökulhlaup (Telur þú að svæðið sem þú býrð á gæti orðið fyrir áhrifum jökulhlaups)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

15. What local and distant geographic areas could generate a jökulhlaup along the Markarfljót (Hvaða svæði nærliggjandi og fjarlæg gætu orsakað jökulhlaup í Markarfljóti)?

_____

_____

16. Do you know when the last jökulhlaup affected the Markarfljót (Veistu hvenær síðasta jökulhlaup var í Markarfljóti)?

❑Yes(já) ❑No(nei)

If yes, when (ef já, hvenær)? _____

17. Do you think if a jökulhlaup flooded the Markarfljót region that it could cause any of the following? (You may choose as many as you like). (Telur þú að jökulhlaup í Markarfljóti geti hafi einhver meðfylgjandi áhrif? Þú mátt velja eins mörg og þú vilt).
Human Impacts: Áhrif á fólk

- ❑ Death and injury of people (Slys og dauða fólks)
- ❑ Damage and destruction to homes and businesses (Skemmdir og eyðileggingu á heimilum og fyrirtækjum)
- ❑ Damage and destruction to critical lifelines e.g. water, electricity (Skemmdir og eyðileggingu á mikilvægum veitukerfum, t.d. flutningi vatns og/eða rafmagns)
- ❑ Damage and destruction to communication networks and infrastructure (Skemmdir eða eyðileggingu á samskiptaneti t.d. fjarskiptaneti - símalínum, gsm sendum, símstöðvum)
- ❑ Damage and destruction to transport networks and infrastructure

(Skemmdir eða eyðileggingu á samgönguneti, s.s. vegum og brúarmannvirkjum)

- ❑ Impacts on agriculture (Áhrif á landbúnað)
- ❑ Impacts on tourism (Áhrif á ferðaþjónustu og ferðmannastraum)
- ❑ Other, please specify (Annað, vinsamlega gerðu grein fyrir svari þínu):

Biophysical Impacts (Áhrif á umhverfið):

- ❑ Impacts on river systems (Áhrif á ár og árfarvegi)
- ❑ Impacts on beaches (Áhrif á strönd)
- ❑ Impact on agricultural land (Áhrif á landbúnaðarland)
- ❑ Impacts on submarine plants and animals (Áhrif á neðansjávargróður og sjávardýr)
- ❑ Impacts on natural plants and animals (Áhrif á náttúrlegan gróður og dýralíf)
- ❑ Other, please specify (Annað, vinsamlegast gerðu grein fyrir):

---

18. Which of the above do you think will have the greatest impact on the Markarfljót region and why (Hvað af ofangreindu telur þú að muni hafa mest áhrif á svæðið kringum Markarfljót og af hverju)?

---

19. Do you know whether a jökulhlaup warning system exists for the Markarfljót region? Veistu hvort viðvörunarkerfi (vöktun) sé í gangi vegna jökulhlaups fyrir Markarfljótssvæðið?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

20. If you answered yes to question 19 did you know prior to this evacuation exercise (Ef þú svaraðir já við spurningu 22 vissir þú af því fyrir þessa æfingu)?

❑ Yes (já) ❑ No (nei)

21. If you answered no or don't know to question 19 do you think the Markarfljót region needs an early warning system (Ef þú svaraðir nei eða veit ekki við spurningu 19 finnst þér að Makarfljótssvæðið þarfnist viðvörunarkerfis)?

❑ Yes (já) ❑ No (nei)

22. Are you aware of the emergency procedures you need to follow if a jökulhlaup warning is issued (Veistu hvaða neyðaráætlun þú þarft að fylgja ef viðvörun er gefin út um jökulhlaup)?

❑ Yes (já) ❑ No (nei)

23. If you answered yes to question 22 did you know prior to this evacuation exercise (Ef þú svaraðir já við spurningu 22, vissir þú af henni fyrir þessa æfingu)?

❑ Yes (já) ❑ No (nei)

24. Please describe what you would do if a jökulhlaup warning is issued (Lýstu því sem þú myndir gera ef viðvörun vegna jökuhlaups væri gefin út).

_____

_____

_____

25. What would you do if there was a volcanic eruption in Katla i.e. how would you find out if you need to evacuate (Hvað myndir þú gera ef gos væri hafið í Kötlu, þ.e. hvernig myndir þú komast að því hvort þú þyrftir að yfirgefa staðinn sem þú ert á?

_____

_____

_____

26. Who do you think is responsible for issuing a jökulhlaup warning for the Markarfljót region (Hver telur þú að beri ábyrgð á því að gefa út viðvörun við jökulhlaupi á Markarfljótssvæðinu)?

_____

_____

27. Who do you think is responsible for evacuation procedures if a jökulhlaup warning is given (Hver telur þú að beri ábyrgð á rýmingu svæðisins ef viðvörun um jökulhlaup er gefin út)?

_____

_____

28. What would you define as the most serious risk in your area if Katla would erupt? You can mention more than one risk, and if so please rank in order with 1 being the most serious. (Hverja teldir þú mesta hættu í kjölfar Kötlugoss á þessu svæði? Þú mátt telja meira en eina hættu, vinsamlegast raðaðu í hætturöð, 1 er mest hætta, o.s.frv.)

- ❑ Jökulhlaup
- ❑ Ice blocks (Jakaburður)
- ❑ Lightning (Eldingar)
- ❑ Tephra(Gjóskufall)
- ❑ Poisonous gases (Gaseitrun)
- ❑ Lava (Hraunrennsli)
- ❑ Tsunami (Flóðbylgja af hafi)
- ❑ Earthquake (Jarðskjálfti)

Extra questions about the evacuation exercise
Viðbótarspurningar tengdar rýmingaræfingunni:

29. In relation to the town meetings that were held on the possibility of another Katla eruption and the proposed evacuation plan, how many did you attend? (Hversu marga fundi sóttir þú af þeim sem haldnir voru í tengslum við hugsanlegt Kötlugos og áætlaða rýmingaráætlun)?

❑None (engan) ❑One (einn) ❑Two (tvo) ❑Three (þrjá) ❑Four (fjóra)

30. How informative were the meetings to you? (Hversu upplýsandi fannst þér fundurinn)? Please explain. (Vinsamlega útskýrðu)

❑Very informative (mjög upplýsandi) ❑Informative (upplýsandi) ❑Not informative (ekki upplýsandi)

_____

_____

31. How many evacuation messages did you receive on the 26 March 2006 (Hversu mörg skilaboð fékkst þú þann 26. mars 2006)?

❑Red (rautt) ❑Yellow (gult) ❑Green (grænt)

❑No colour (ekkert) ❑Phone Call (símhringingu)

32. Do you always carry your GSM with you (Ertu alltaf með farsíma á þér)?

❑Yes (já) ❑No (nei)

If yes, is it so you can be warned about a possible eruption in Katla (Ef já, tengist það goshættu í Kötlu)?

❑Yes (já) ❑No (nei)

33. Do you always have GSM coverage around your area (Er alltaf farsímasamband á þínu svæði)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

34. Have you registered your phone with the authorities (Hefur þú tilkynnt gsm númer þitt til lögreglustjóra)?

❑Yes (já) ❑No (nei)

35. Did you take part in the evacuation exercise (Tókstu þátt í Amannavarnaræfingunni)? Why/why not (Hvers vegna/hvers vegna ekki)?

❑Yes (já) ❑No (nei)

_____

_____

_____

36. Were you, or anyone else you know, reluctant to take part in the exercise (Var þér eða einhver sem þú þekkir illa við að taka þátt í æfingunni)? Why (Hvers vegna)?

❑Yes (já) ❑No (nei)

_____

_____

37. If you did take part in the evacuation exercise on Sunday 26 March how did you feel about it? Please explain your answer. (Ef þú tókst þátt í æfingunni sunnudaginn 26. mars, hvert var viðhorf þitt til hennar? Vinsamlega útskýrðu).

❑Positive (jákvætt) ❑Negative (neikvætt) ❑Mixed (blendið)

_____

_____

_____

38. How long did it take you to evacuate (Hversu langan tíma tók það þig að yfirgefa svæðið)?

❑ < 30 minutes ❑ 30 < 60 minutes ❑ 60 < 90 minutes ❑ > 90 minutes

39. Do you think 30 minutes is enough time to complete the list and evacuate (Telur þú 30 mínútur nægja til þess að ljúka öllu því sem talið er upp á gátlistanum áður en þú þarft að yfirgefa staðinn)?

❑Yes (já) ❑No (nei)

40. Would you prefer to have a pre-warning (e.g. the green or yellow warning) even if they are not sure whether an eruption and jökulhlaup are imminent (Myndir þú óska eftir því að fá tilkynningu um viðbúnaðarstig (grænt) jafnvel þótt ekki væri víst hvort gos yrði)?

❑Yes (já) ❑No (nei)

41. Do you think the evacuation procedure is appropriate (Telur þú viðbragðsáætlunina vera viðeigandi)?

❑Yes (já) ❑No (nei)

42. Would you follow this procedure if there was a real evacuation (Myndir þú fylgja viðbragðsáætlun ef kæmi til goss)? Please explain (Vinsamlegast útskýrðu).

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

_____

_____

_____

43. Would you follow a different procedure if it was night/day, winter/summer or good/bad weather conditions (Myndir þú fylgja annarri áætlun ef það væri nótt/ dagur, vetur/sumar, eða gott /lélegt skyggni)? Please explain (Vinsamlegast útskýrðu).

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

_____

_____

_____

44. How do you feel about leaving your animals (Hvað finnst þér um að skilja skepnurnar eftir)?

❑ Very concerned (mjög erfitt)
❑ A little concerned (nokkuð erfitt)
❑ Not concerned (ekki erfitt)
❑ Not Applicable (ekki viðeigandi)

45. Do you think it is necessary to have another evacuation exercise following any changes to the evacuation plan (Telur þú nauðsyn á því að hafa aðra æfingu ef breytingar verða á rýmingaráætlun)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

46. How often do you think they should practice evacuations in this region (Hversu oft finnst þér að eigi að æfa rýmingu á þessu svæði)?

- ❑ Once every 6 months (Tvisvar á ár)
- ❑ Once every year (Einu sinni á ári)
- ❑ Once every two years (Annað hvert ár)
- ❑ Once every five years (Á fimm ára fresti)
- ❑ Other, please specify (Annað, vinsamlega tilgreindu): _____

47. Have you looked up the emergency services website (Almannavarnir) and familiarised yourself with information on the possible natural hazards connected to a Katla eruption (Hefur þú skoðað heimasíðu Almannavarna og kynnt þér mögulega náttúruvá sem getur hlotist af Kötlugosi)?

❑Yes (já) ❑No (nei)

48. Have you ever used the Skjálftavefsjá website for hazard information? If yes, how often (Hefur þú einhvern tíman notað Skjálftavefsjá fyrir upplýsingar um jarðskjálfta? Ef já, hversu oft)?

❑Yes (já) ❑No (nei)

---

49. Have you ever used the Veðurstofa website for hazard information? If yes, how often (Hefur þú einhvern tíman notað heimasíðu Veðurstofunnar fyrir upplýsingar um náttúruvá)?

❑Yes (já) ❑No (nei)

---

50. Have you followed discussions in the media about natural hazards connected to a Katla eruption (Hefur þú fylgst með umræðu í fjölmiðlum um náttúruvá tengda Kötlugosi)?

❑Yes (já) ❑No (nei)

51. From what forms of media do you access this information (Úr hvaða miðli sækir þú þessar upplýsingar)?

- ❑Newspaper (Dagblaði)
- ❑Radio (Útvarpi)
- ❑Television (Sjónvarpi)
- ❑Internet (Netinu)
- ❑Information Brochures (Upplýsingabæklingum)
- ❑ Books (Bókum)

Appendix L

2006 - Questions for Álftaver residents
'Public perception of jökulhlaup risk in Álftaver'
Viðhorf fólks til náttúruvár tengda jökulhlaupi í Álftaveri.

1. Age: (Aldur)
   - ❑ 18-30
   - ❑ 31-50
   - ❑ 50+

2. How long have you lived at this address (Hversu lengi hefur þú búið hér)? _____

3. For how many generations has your family lived in this region (Hversu margar kynslóðir fjölskyldunnar hafa búið á svæðinu)? _____

4. Do you think the region where you live could be affected by a jökulhlaup (Telur þú að svæðið sem þú býrð á gæti orðið fyrir áhrifum jökulhlaups)?
   ❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

5. Please describe what you would do if a jökulhlaup warning is issued (Lýstu því sem þú myndir gera ef viðvörun vegna jökuhlaups væri gefin út).

_____
_____
_____

6. In relation to the town meetings that were held on the possibility of another Katla eruption and the proposed evacuation plan, how many did you attend? (Hversu marga fundi sóttir þú af þeim sem haldnir voru í tengslum við hugsanlegt Kötlugos og áætlaða rýmingaráætlun)?
   ❑None (engan) ❑One (einn) ❑Two (tvo) ❑Three (þrjá) ❑Four (fjóra)

7. How informative were the meetings to you? (Hversu upplýsandi fannst þér fundurinn)? Please explain. (Vinsamlega útskýrðu)
   - ❑Very informative (mjög upplýsandi)
   - ❑Informative (upplýsandi)
   - ❑Not informative (ekki upplýsandi)

_____
_____
_____

8. Did you take part in the evacuation exercise (Tókstu þátt í Amannavarnaæfingunni)? Why/why not (Hvers vegna/hvers vegna ekki)?
   ❑Yes (já) ❑No (nei)

_____
_____
_____

9. If you did take part in the evacuation exercise on Saturday 25 March 2006 how did you feel about it? Please explain your answer. (Ef þú tókst þátt í æfingunni sunnudaginn 25. mars, hvert var viðhorf þitt til hennar? Vinsamlega útskýrðu).

❑Positive (jákvætt) ❑Negative (neikvætt) ❑Mixed (blendið)

10. Do you think the evacuation procedure is appropriate (Telur þú viðbragðsáætlunina vera viðeigandi)?

❑Yes (já) ❑No (nei)

11. Would you follow this procedure if there was a real evacuation (Myndir þú fylgja viðbragðsáætlun ef kæmi til goss)? Please explain (Vinsamlegast útskýrðu).

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

Appendix M

2008

Dear

RE: Your participation in the project: ***Public perception of Katla and jökulhlaup risk, south Iceland***

You are invited to participate in a study that investigates public perception and knowledge of the risk from Katla and jökulhlaup, south Iceland. This investigation has been triggered by recent research on jökulhlaup hazards within this area. The results will be used as a chapter in a Doctor of Philosophy thesis and may be written up for publication in a journal such as Journal of Volcanology and Geothermal Research.

The study is being conducted by Ms Deanne Bird (Macquarie University and the University of Iceland) and Guðrún Gísladóttir, Department of Geography and Tourism, Earth Science Institute, University of Iceland, Askja, Sturlugata 7, 101 Reykjavik, Iceland; Tel: +354 552 4471, Fax. +354 525 4499, email: ggisla@hi.is. The principal supervisors for this research are Guðrún Gísladóttir and Damian Gore, Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, NSW 2109; Tel: +612 9850 8391, Fax: +612 9850 8420, email: damian.gore@mq.edu.au. The associate investigator is Dale Dominey-Howes, Natural Hazards Research Laboratory, School of Risk and Safety Sciences, Faculty of Science, University of New South Wales, Sydney 2052; Tel: +612 9385 4830, Fax: +612 9385 6190, email: dale.dh@unsw.edu.au.

If you decide to participate, you will be asked to complete a detailed questionnaire in the presence of the researchers (Ms Deanne Bird, Guðrún Gísladóttir and/or Dale Dominey-Howes) at a time convenient to yourself and arranged in advance. The questionnaire will include a range of questions that will require tick box responses and a number of open-ended questions that will require written answers. It is expected that the questionnaire will take about 30 minutes to complete. You will only be required to complete this task once. You will be asked to provide information about your knowledge of Katla and jökulhlaup hazards and their likely risk to your region. There are no physical risks associated with this research. You will not receive any payment for your participation in this investigation.

Any information or personal details gathered in the course of the study are confidential. No individual will be identified in any publication of the results. Deanne Bird and Damian Gore of Macquarie University, Guðrún Gísladóttir of the University of Iceland and Dale Dominey-Howes of the University of New South Wales will be the only staff that will have access to the information you provide. Information collected from you will be kept in a secure location not accessible to anyone else. There is a possibility that the results collected during the course of this research may be used in the preparation of a manuscript for publication in an International Scientific journal. Where such publication does occur, again, the publication will not contain any information that would allow readers to identify you and your organisation.

If you decide to participate, you are free to withdraw from further participation in the research at any time without having to give a reason and without consequence.

I, *(_____)* have read *(or, where appropriate, have had read to me)* and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name:
(block letters)

Participant's Signature: _____Date:

Investigator's Name:
(block letters)

Investigator's Signature: _____ Date:

The ethical aspects of this study have been approved by the Macquarie University Ethics Review Committee (Human Research). If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Ethics Review Committee in Australia through its Secretary (telephone +612 9850 7854; email: ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome. Alternatively, you may contact Persónuvernd in Iceland (telephone +354 510 9600; email: postur@personuvernd.is).

(INVESTIGATOR'S [OR PARTICIPANT'S] COPY) – delete as appropriate

Please sign both copies of this letter and keep one copy for your records. Please return the other signed copy to Ms Deanne Bird at the time of your questionnaire interview.

Thank you.

Appendix N

2008

Kæri/kæra:

EFNI: ÞÁTTTAKA ÞÍN Í VERKEFNINU: VIÐHORF FÓLKS TIL VÁR VEGNA JÖKULHLAUPS Á HÆTTUSVÆÐI KÖTLU.

Ég, Deanne Bird, óska eftir þátttöku þinni í rannsókn á viðhorfi og þekkingu fólks á hættu vegna jökulhlaups á hættusvæði Kötlu. Nýleg rannsókn á náttúrvá vegna eldgosa og hlaupa frá vestanverðum Mýrdalsjökli og Eyjafjallajökli var hvatinn að þessu verkefni. Niðurstöður rannsóknarinnar verða notaðar í kafla í doktorsritgerð minni við Háskóla Íslands og háskólann í Macquarie í Sydney í Ástralíu en einnig sem grein í vísindatímarit s.s. Journal of Volcanology and Geothermal Research.

Rannsóknin er framkvæmd af Deanne Bird (Macquarie University) og dr. Guðrúnu Gísladóttur, prófessor í landfræði við líf- og umhverfisvísindadeild Háskóla Íslands og jarðvísindastofnun Háskólans, Öskju, Sturlugötu 7, 101 Reykjavík, sími 552 4471, fax. 525 4499, netfang: ggisla@hi.is. Leiðbeinandi af hálfu Háskóla Íslands er Guðrún Gísladóttir prófessor og af hálfu Macquarie háskólans Damian Gore prófessor og Dale Dominey-Howes dósent. Damian Gore er við Department of Physical Geography, Division of Environmental and Life Sciences, Macquarie University, NSW 2109; sími: +612 9850 8391, fax: +612 9850 8420, netfang: damian.gore@mq.edu.au. Dale Dominey-Howes er við Natural Hazards Research Laboratory, School of Risk and Safety Sciences, Faculty of Science, University of New South Wales, Sydney 2052; sími: +612 9385 4830, fax: +612 9385 6190, netfang: dale.dh@unsw.edu.au.

Ef þú ákveður að taka þátt í rannsókninni verður þú beðinn/beðin um að svara nokkuð ítarlegum spurningalista, í viðveru Deanne og Guðrúnar, eftir samkomulagi við þig. Mörgum spurningunum er fljótsvarað, og merkt í þar til gert box við spurningar á listanum. Aðrar bjóða upp á að þú segir frá eða tjáir viðhorf þitt til viðkomandi spurningar. Reiknað er með að það taki um 30 mínútum að svara spurningunum. Við munum ekki trufla þig nema í þetta eina skipti. Við munum biðja þig að segja okkur frá þekkingu þinni á Kötlu og jökulhlaupum og hugsanlegri hættu af þeim í nágrenni þínu. Þátttaka þín mun ekki hafa í för með sér líkamleg óþægindi eða hættu og ekki er greitt fyrir þátttökuna.

Farið verður með öll persónuleg svör sem trúnaðarmál og þegar rannsóknin verður birt verður ekki hægt að rekja nein svör til einstaklinga. Deanne Bird, Guðrún Gísladóttir við Háskóla Íslands, Damian Gore við Macquarie háskólann og Dale Dominey-Howes við háskólann í New South Wales verða þau einu sem hafa aðgang að gögnunum. Þau verða geymd á öruggum stað óaðgengileg öðrum en þeim fjórum. Hugsanlegt er að niðurstöður rannsóknarinnar verði birtar í alþjóðlegu vísindatímariti, en þá verður, eins og áður hefur verið bent á, ekki hægt að rekja svör eða viðhorf til einstaklinga.

Ef þú ákveður að taka þátt í könnuninni en snýst hugur, getur þú hætt við án þess að gefa okkur nokkra skýringu á því og án óþæginda.

Ég, *(_____)* hef lesið og *(eða ef við á, ofangreindur texti hefur verið lesinn fyrir mig og ég hef)* skilið ofangreindar upplýsingar og fengið fullnægjandi svör við spurningum sem ég spurt. Ég hef samþykkt að taka þátt í rannsókninni en get hætt við þátttöku hvenær sem er án nokkurs eftirmála. Mér hefur verið fengið afrit af þessu skjali.

Nafn þátttakanda:
(prenstafir).

Undirskrift þátttakanda: _____Dagsetning:

Nafn spyrjanda:
(prentstafir)

Undirskrift spyrjanda: _____ Dagsetning:

Siðferðisnefnd Macquarie háskólans (Macquarie University Ethics Review Committee) hefur samþykkt fyrir sitt leyti að rannsóknin fari fram. Ef þú vilt koma kvörtunum á framfæri eða hefur efasemdir um réttmæti/siðferðisleg sjónarmið rannsóknarinnar getur þú haft samband við skrifstofuna Ethics Review Committee í Ástralíu, (sími +612 9850 7854; netfang: ethics@mq.edu.au). Farið verður með kvartanir sem trúnaðarmál, en þær kannaðar og þú verður látinn/látin vita um niðurstöður hennar. Einnig getur þú hringt í Persónuvernd á Íslandi (sími 510 9600; netfang: postur@personuvernd.is).

(Afrit spyrjanda [eða þátttakanda]) – strikið yfir það sem ekki á við.

Vinsamlega undirritaðu bæði skjölin, og haltu öðru en Deanne Bird mun halda hinu.

Kærar þakkir.

Appendix O

2008 Resident Questionnaire:

'Knowledge and perception of jökulhlaup/tsunami in relation to a Katla eruption'

Þekking á og viðhorf fólks til náttúruvár vegna jökulhlaups/flóðbylgju af hafi í tengslum við gos í Kötlu

Region: _____

Section 1. To start the interview we are going to ask you some questions to gather classification data about you. In the course of writing up the results no one will be able to identify you from this information (Í byrjun munum við spyrja nokkurra spurninga um sjálfa/sjálfan þig. Svörin verða ekki rekjanleg).

1. Within which age group were you on your last birthday? (Vinsamlega merktu við þann reit sem endurspeglar aldur þinn þegar þú áttir afmæli síðast)
   ❑ 18≤30 ❑ 31≤50 ❑ 50+

2. How far from the coast/river do you live (Hversu langt frá ánni/fljótinu/strönd býrðu)?
   ❑ 0≤2 km ❑ 2≤5 km ❑ 5≤10 km ❑ 10+ km

3. How long have you lived at this address (Hversu lengi hefur þú búið hér)? _____

4. For how many generations has your family lived in this region (Hversu margar kynslóðir fjölskyldunnar hafa búið á svæðinu)?_____

5. How many people live at this address (Hversu margir búa hér)?
   Adults (Fullorðnir):_____ Children (Börn):_____

6. In which country have you lived the longest (Í hvaða landi hefur þú búið lengst af)?

_____

7. What language do you usually speak at home (Hvaða tungumál talar þú oftast heima fyrir)?

_____

8. What is the highest level of education you have completed (Hvaða menntun átt þú að baki)?
   - ❑ Some schooling (Nokkra skólagöngu)
   - ❑ Educated from 6 to 16 years (Grunnskóla)
   - ❑ High school 16-20 years (Menntaskóla)
   - ❑ Special education (Sérnám, t.d. iðnnám, verslunarnám
   - ❑ University Degree (Háskólamenntun)
   - ❑ Postgraduate Qualification (Framhaldsnám í háskóla t.d. meistara- eða doktorsnám)
   - ❑ Other, please specify (Annað, vinsamlegast tilgreindu): _____

9. What is your occupation (Við hvað starfar þú)? _____

Section 2. The next section contains questions about Katla and tsunami/jökulhlaup (Í þessum hluta spyrjum við spurninga um Kötlu og flóðbylgju af hafi/jökulhlaup):

10. Can you tell me a brief eruptive history of Katla (Getur þú sagt mér frá gossögu Kötlu í grófum dráttum)?

_____

_____

_____

_____

11. How would you describe jökulhlaup/tsunami (Hvernig lýsir þú jökulhlaupi/flóðbylgju)?

_____

_____

_____

12. Do you think the region where you live could be affected by a jökulhlaup/tsunami (Telur þú að svæðið sem þú býrð á gæti orðið fyrir áhrifum jökulhlaups/flóðbylgju af hafi)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

13. Do you know when the last jökulhlaup/tsunami affected this region (Veistu hvenær þetta svæði varð síðast fyrir áhrifum jökulhlaups/flóðbylgju af hafi)?

❑Yes(já), when (ef já, hvenær)? _____ ❑No(nei)

14. If a Katla eruption affected the region where you live, do you think it would cause any of the following (You may choose as many as you like)? Please indicate if the effects are positive or negative. Ef Katla myndi gjósa í náinni framtíð og hafa áhrif á það svæði sem þú býrð á, telur þú að gosið hefði einhver eftirtalin áhrif? (Þú mátt velja eins mörg atriði og þú vilt). Vinsamlega tilgreindu hvort á hrifin séu jákvæð eða neikvæð.

Human Impacts: Áhrif á fólk

- ❑ Death and injury of people (Dauða og slys á fólki)
- ❑ Damage and destruction to homes and businesses (Skemmdir og eyðileggingu á heimilum og fyrirtækjum)
- ❑ Damage and destruction to critical lifelines e.g. water, electricity (Skemmdir og eyðileggingu á mikilvægum veitukerfum, t.d. flutningi vatns og/eða rafmagns
- ❑ Damage and destruction to communication networks and infrastructure (Skemmdir eða eyðileggingu á samskiptaneti t.d. fjarskiptaneti - símalínum, gsm sendum, símstöðvum)
- ❑ Damage and destruction to transport networks and infrastructure (Skemmdir eða eyðileggingu á samgönguneti, s.s. vegum og brúarmannvirkjum)
- ❑ Impacts on agriculture (Áhrif á landbúnað)
- ❑ Impacts on tourism (Áhrif á ferðaþjónustu og ferðamannastraum)
- ❑ Other, please specify (Annað, vinsamlega gerðu grein fyrir svari þínu):

_____

Biophysical Impacts (Áhrif á umhverfið):

- ❑ Impacts on river systems (Áhrif á ár og árfarvegi)
- ❑ Impacts on beaches (Áhrif á strönd)
- ❑ Impact on agricultural land (Áhrif á landbúnaðarland)
- ❑ Impacts on submarine plants and animals (Áhrif á neðansjávargróður og sjávardýr)
- ❑ Impacts on natural plants and animals (Áhrif á náttúrlegan gróður og dýr)
- ❑ Other, please specify (Annað, vinsamlegast gerðu grein fyrir):

---

15. Which of the above do you think will have the greatest impact on your region and why (Hvað af ofangreindu telur þú að muni hafa mest áhrif á það svæði sem þú býrð á og hvers vegna)?

---

16. Do you know whether an eruption warning system exists for the Katla region? Veistu hvort viðvörunarkerfi (vöktun) sé í gangi í nágrenni Kötlu?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

17. If you answered no or don't know to question 16 do you think the Katla region needs an early warning system (Ef þú svaraðir nei eða veit ekki við spurningu 16 finnst þér nauðsyn á viðvörunarkerfi á Kötlusvæðinu)?

❑ Yes (já) ❑ No (nei)

18. Are you aware of the emergency procedures you need to follow if an eruption warning is issued (Veistu hvaða neyðaráætlun þú þarft að fylgja ef viðvörun um eldgos er gefin út)?

❑ Yes (já) ❑ No (nei)

19. Please describe what you would do if an eruption warning is issued (Lýstu því sem þú myndir gera ef viðvörun um eldgos væri gefin út).

---

20. What would you do if there was a volcanic eruption in Katla i.e. how would you find out if you need to evacuate (Hvað myndir þú gera ef gos væri hafið í Kötlu, þ.e. hvernig myndir þú komast að því hvort þú þyrftir að yfirgefa staðinn sem þú ert á?

---

21. Who do you think is responsible for issuing an eruption warning for your area (Hver telur þú að beri ábyrgð á því að gefa út viðvörun um eldgos á þínu svæði)?

---

22. Who do you think is responsible for evacuation procedures if an eruption warning is given (Hver telur þú að beri ábyrgð á rýmingu svæðisins ef viðvörun um eldgos er gefin út)?

_____

_____

23. What would you define as the most serious hazard in your area if Katla were to erupt? You can mention more than one, and if so please rank in order with 1 being the most serious. (Hverja myndir þú skilgreina sem mesta hættu í kjölfar Kötlugoss á þessu svæði? Þú mátt merkja við meira en eina hættu. Vinsamlegast raðaðu í mikilvægisröð, 1 alvarlegust hætta, o.s.frv.)

- ❑ Jökulhlaup
- ❑ Ice blocks (Jakaburður)
- ❑ Lightning (Eldingar)
- ❑ Tephra (Gjóskufall)
- ❑ Poisonous gases (Gaseitrun)
- ❑ Lava (Hraunrennsli)
- ❑ Tsunami (Flóðbylgja af hafi)
- ❑ Earthquake (Jarðskjálfti)

Section 3. The next section contains questions about communication and how you feel about the evacuation plan (Í þessum hluta verður þú spurð/spurður um farsímanotkun og hvað þér finnst um rýmingaráætlunina):

24. Do you always carry your GSM with you (Ertu alltaf með farsíma á þér)?

❑Yes (já) ❑No (nei)

25. If yes to question 24, is it so you can be warned about a possible eruption in Katla (Ef já, tengist það goshættu í Kötlu)?

❑Yes (já) ❑No (nei)

26. Do you always have GSM coverage around your area (Er alltaf farsímasamband á þínu svæði)?

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

27. Did you take part in the evacuation exercise in March 2006 (Tókstu þátt í Amannavarnaræfingunni í mars 2006)? Why/why not (Hvers vegna/hvers vegna ekki)?

❑Yes (já) ❑No (nei)

_____

_____

_____

28. If you did take part in the evacuation exercise in March 2006 how did you feel about it? Please explain your answer. (Ef þú tókst þátt í æfingunni mars 2006, hvert var viðhorf þitt til hennar? Vinsamlega útskýrðu).

❑Positive (jákvætt) ❑Negative (neikvætt) ❑Mixed (blendið)

_____

_____

29. Do you think 15/30 minutes is enough time to complete the list and evacuate (Telur þú 15/30 mínútur nægja til þess að ljúka öllu því sem talið er upp á gátlistanum og yfirgefa staðinn)?

❑Yes (já) ❑No (nei)

30. Would you prefer to have a pre-warning even if they are not sure whether an eruption and jökulhlaup/tsunami are imminent (Myndir þú óska eftir því að fá tilkynningu um viðbúnaðarstig, jafnvel þótt ekki væri víst hvort gos yrði)?

❑Yes (já) ❑No (nei)

31. Do you think the evacuation procedure is appropriate (Telur þú viðbragðsáætlunina vera viðeigandi)?

❑Yes (já) ❑No (nei)

32. Would you follow this procedure if there was a real evacuation (Myndir þú fylgja henni ef kæmi til goss)? Please explain (Vinsamlegast útskýrðu).

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

_____

_____

_____

33. Would you follow a different procedure if it was night/day, winter/summer or good/bad weather conditions (Myndir þú fylgja annarri áætlun ef það væri nótt/ dagur, vetur/sumar, eða góð /slæm veðurskilyrði)? Please explain (Vinsamlegast útskýrðu).

❑Yes (já) ❑No (nei) ❑Don't know (veit ekki)

_____

_____

_____

34. How do you feel about leaving your animals (Hvað finnst þér um að skilja skepnurnar eftir)?

❑ Very concerned (mjög erfitt)
❑ A little concerned (nokkuð erfitt)
❑ Not concerned (ekki erfitt)
❑ Not Applicable (ekki viðeigandi)

35. How often do you think they should practice evacuations in this region (Hversu oft finnst þér að eigi að æfa rýmingu á þessu svæði)?

❑ Once every 6 months (Tvisvar á ár)
❑ Once every year (Einu sinni á ári)
❑ Once every two years (Annað hvert ár)
❑ Once every five years (Á fimm ára fresti)
❑ Other, please specify (Annað, vinsamlega tilgreindu): _____

Section 4. The next 5 questions are about your use of various media sources for acquiring information about the possibility of a future Katla eruption (Næstu 5 spurningar eru um það hvort þú nýtir þér ýmsa miðla til að afla upplýsinga um möguleika á Kötlugosi).

36. Have you looked up the emergency services website (Almannavarnir) and familiarised yourself with information on the possible natural hazards connected to a Katla eruption (Hefur þú skoðað heimasíðu Almannavarna og kynnt þér mögulega náttúruvá sem geta hlotist af Kötlugosi)?

❑Yes (já) ❑No (nei)

37. Have you ever used the Skjálftavefsjá website for hazard information (Hefur þú einhvern tíman notað Skjálftavefsjá til að afla upplýsinga um náttúrvá)?

❑Yes (já) ❑No (nei)

If yes, how often (Ef já, hversu oft)?_____

38. Have you ever used the Veðurstofa website for hazard information (Hefur þú einhvern tíman notað heimasíðu Veðurstofunnar til að afla upplýsinga um náttúruvá)?

❑Yes (já) ❑No (nei)

If yes, how often (Ef já, hversu oft)?_____

39. Have you followed discussions in the media about natural hazards connected to a Katla eruption (Hefur þú fylgst með umræðu í fjölmiðlum um náttúruvá tengdar Kötlugosi)?

❑Yes (já) ❑No (nei)

40. From what forms of media do you access this information (Úr hvaða miðli sækir þú þessar upplýsingar)?

❑Newspaper (Dagblaði)
❑Radio (Útvarpi)
❑Television (Sjónvarpi)
❑Internet (Netinu)
❑Information Brochures (Upplýsingabæklingum)
❑ Books (Bókum)

Section 5. The next sections contains questions about preparedness for a future Katla eruption - for each question, please answer on a scale ranging from 1 (not at all prepared) to 5 (completely prepared) (Í þessum hluta ert þú spurð/spurður um undirbúning vegna hugsanlegs Kötlugoss. Vinsamlega merktu við hverja spurningu og raðaðu frá 1-5, þar sem 1 merkir alls ekki undirbúin/undirbúinn, og 5 mjög vel undirbúin/undirbúinn).

How prepared do you think (Hversu vel undirbúna telur þú):	Not at all Alls ekki	A little Nokkuð	Moderately Í meðallagi	A great deal Vel	Completely Fullkomlega
41. officials in your area (e.g., the police, rescue team) are to deal with a future Katla eruption (opinbera aðila á þínu svæði vera (t.d. lögregla, björgunarsveitir) til að takast á við Kötlugos)?	1	2	3	4	5
42. Almannavarnir are to deal with a future Katla eruption (Alamannavarnir vera til að takast á við Kötlugos)?	1	2	3	4	5
43. You or your family are to deal with a future Katla eruption (þig eða fjölskyldu þína vera til að takast á við Kötlugos)?	1	2	3	4	5

Section 6. The next section contains questions about the possibility of a future Katla eruption and its effects - for each question, please answer on a scale ranging from 1 (extremely unlikely) to 5 (extremely likely) (Í þessum hluta verður þú spurð/spurður spurninga um möguleika á Kötlugosi og áhrif þess. Vinsamlega merktu við hverja spurningu og raðaðu frá 1-5, þar sem 1 merkir mjög ólíklegt og 5 mjög líklegt).

How likely do you think (Hversu líklegt finnst þér):	extremely unlikely mjög ólíklegt	somewhat unlikely einhverjar líkur	50/50 50/50	somewhat likely nokkuð líklegt	extremely likel mjög líklegt
44. There will be a Katla eruption in the next 10 years (Að Katla gjósi innan næstu 10 ára)?	1	2	3	4	5
45. Your area will be adversely affected by the next eruption (Að þitt svæði verði fyrir áhrifum af næsta gosi)?	1	2	3	4	5
46. You (or your family) will be injured by the next eruption (Að þú (eða fjölskylda þín) verði fyrir slysi i næsta gosi)?	1	2	3	4	5
47. You will suffer damage to your home by the next eruption (Að heimili þitt muni verða fyrir skemmdum í næsta gosi)?	1	2	3	4	5
48. You will suffer damage to your property by the next eruption (Að jörðin verði fyrir skemmdum í næsta gosi)?	1	2	3	4	5

Section 7. This last section contains questions about your trust in information from various sources about a future Katla eruption - for each question, please answer on a scale ranging from 1 (do not trust at all) to 5 (completely trust) (Þessi síðasti hluti snýr að því hversu mikið traust þú berð til mismunandi aðila/stofnana varðandi upplýsingar um hugsanlegt Kötlugos. Vinsamlega svaraði hverri spurningu og raðaðu frá 1-5, þar sem 1 merkir alls ekkert traust og 5 fullkomið traust)

How do you rate your level of trust in (Hversu mikið traust berð þú til):	Not at all Alls ekkert	A little Nokkuð	Moderately Í meðallagi	A great deal Verulegt	Completely Fullkomið
49. Information provided by Almannavarnir (Upplýsinga sem Almannavarnir gefa)?	1	2	3	4	5
50. Information provided by scientists (Upplýsinga sem vísindamenn gefa)?	1	2	3	4	5
51. Information provided by the local police (Upplýsinga frá lögreglu)?	1	2	3	4	5
52. Information provided by the media (Upplýsinga úr fjölmiðlum)?	1	2	3	4	5
53. Government officials who are responsible for the public's safety during a Katla eruption (Opinberra starfsmanna sem eru ábyrgir fyrir öryggi íbúa meðan á Kötlugosi stendur)?	1	2	3	4	5