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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 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 tourists 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.

**Keywords:** Hazard knowledge, risk perception, emergency response education, volcanic risk mitigation training, Katla

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 (Burby and Wagner, 1996; Drabek, 1995; Murphy and Bayley, 1989). 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; Johnston et al., 2007; Leonard et al., 2005; 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 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 1,100 years (Larsen, 2000). Despite two smaller, unconfirmed eruptions in 1955 and 1999 (Björnsson et al., 2000; Gudmundsson, 2005; Russell et al., 2000), 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.

Insert Figure 2 here

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
the 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 (Paton et al., 2008;
Siegrist and Cvetkovich, 2000) 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 reduces their acceptance of new hazard information (Gregg et al., 2004a; Haynes et al., 2008a; Johnston et al., 1999; 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 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 organizations, 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 (Gregg et al., 2004a; Lindell and Whitney, 2000; Mulilis and Duval, 1995). 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). And 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 (Carlino et al., 2008; Ronan and Johnston, 2001) 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; Gregg et al., 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; Haynes et al., 2008a; Johnston et al., 2005; McIvor and Paton, 2007; Paton, 2007).

Hazard, risk and emergency response information must be issued through multiple sources (Mileti et al., 2004; Sorensen, 2000) 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 (Chester et al., 2008; Dibben and Chester, 1999; 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
Sleeping bag accommodation and camping facilities are provided at three mountain hut communities. Operators access this area year round while mountain 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).

Fig. 3a. Sleeping bag accommodation and camping facilities are provided at three mountain hut communities. Operators access this area year round while mountain 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).

Insert Figure 3 here

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 two 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 activity in Icelandic, 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 (hereafter 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%) or 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 Þórmörk 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 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 but 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 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.

Insert Table 3 here

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 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.

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.

Insert Table 4 here

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 Þórmörk 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 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) were 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.

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 is 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 (Paton et al., 2008; Siegrist and Cvetkovich, 2000) 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 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 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. And 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. Haynes et al., 2008a; Mileti et al., 2004; Paton et al., 2008; Sorensen, 2000) 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 (Johnston et al., 2007; Leonard et al., 2005; Leonard et al., 2008).
6.4 Behaviour when faced with a natural hazard

Commonsense 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 two 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 Kótluvá” 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 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 activity. 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 hours), 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.

The 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 there will 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 tourists’ 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 busses 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 along side 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.

References


knowledge for volcanic hazard management on Ambae Island, Vanuatu.


Figure Captions

Figure 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).

Figure 2. The Eruption Emergency Guidelines published by the ICP (http://www.almannavarnir.is/displayer.asp?cat_id=245).

Figure 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.
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.

<table>
<thead>
<tr>
<th></th>
<th>18&lt;30 yrs</th>
<th>31&lt;50 yrs</th>
<th>51+ yrs</th>
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<td><strong>Participant age:</strong></td>
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<td>E=35</td>
<td>T=36</td>
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<td>E=48</td>
<td>T=28</td>
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<td><strong>Residency:</strong></td>
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<td>E=87</td>
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<td>International</td>
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<td>E=13</td>
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<td><strong>Main language spoken at home</strong> (tourists only):</td>
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<td></td>
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<td>E=43</td>
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<tr>
<td>Other</td>
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<td>E=48</td>
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</table>
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 |
Table 3. Tourists (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.

<table>
<thead>
<tr>
<th>% of participants who think the Markarfljót could be affected by a jökulhlaup:</th>
<th>Tourists</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>86</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

% 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
<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>tephra</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>poisonous gases</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>lava</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>tsunami</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>earthquake</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>don’t know</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>
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.

| % 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: | | |
| o newspaper | 81 | 74 |
| o radio | 56 | 58 |
| o television | 69 | 68 |
| o internet | 25 | 32 |
| o information brochures | 0 | 16 |
| o 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 |
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.

<table>
<thead>
<tr>
<th>If a jökulhlaup warning is issued, % of participants who would:</th>
<th>Tourists</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>go to the highest point</td>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>escape Þórsmörk</td>
<td>18</td>
<td>30</td>
</tr>
<tr>
<td>report to wardens</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>follow procedures</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>other</td>
<td>14</td>
<td>9</td>
</tr>
</tbody>
</table>

If there was a volcanic eruption at Katla, % of participants who would:

<table>
<thead>
<tr>
<th>If there was a volcanic eruption at Katla, % of participants who would:</th>
<th>Tourists</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>report to wardens or guide</td>
<td>54</td>
<td>13</td>
</tr>
<tr>
<td>call an emergency number (e.g. 112) or friend</td>
<td>19</td>
<td>56</td>
</tr>
<tr>
<td>listen to radio</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>evacuate Þórsmörk</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>other</td>
<td>13</td>
<td>4</td>
</tr>
</tbody>
</table>