Tourism, volcanic hazards and education in southern Iceland

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Abstract
Research in 2007 in southern Iceland examined the relationship between volcanic risk and the tourism sector and the complex challenge emergency management agencies face in developing effective volcanic risk mitigation strategies. The popular tourist region of Þórsmörk was the focus of this survey due to its location within the jökulhlaup hazard zone of Katla. The survey, conducted prior to the implementation of education and training campaigns, showed that tourists lacked volcanic hazard knowledge and both tourists and tourism employees lacked knowledge of the early warning system and emergency response procedures they should follow.

These issues of knowledge were reassessed in a follow-up survey conducted in 2009 after education and training campaigns had been implemented. The results of this survey suggest that these efforts have not been successful at increasing tourists and tourism employees' knowledge. Only a quarter of the tourists had seen the Eruption Emergency Guidelines brochure and only 21% of employees had received appropriate emergency response training. One critical point raised by many participants was the inadequacy of the hazard map. The map failed to 'communicate to them' the location of the hazard zone and evacuation routes. Tourists found the map confusing and inappropriately scaled for the region. Also, those who had read the Eruption Emergency Guidelines brochure likened it to a tourist advertisement.

This research shows that critical improvements are essential to ensure the safety of all people in Þórsmörk. This region must have appropriate and detailed hazard, risk and emergency response information readily available to all tourists and tourism employees must receive adequate training prior to the commencement of the 2010 summer tourist season. This work must start immediately given the increased likelihood of a Katla eruption following the recent eruption in Eyjafjallajökull on 20 March 2010.

Introduction
The Þórsmörk region remains an extremely popular tourist destination in Iceland with record numbers travelling through Þórsmörk in 2009 (various hut wardens, pers. comm., 2009) to access the famous Laugavegur hiking trail (NAT, 2010). This region lies in close proximity to the Katla volcano which is covered by the Mýrdalsjökull icecap (Fig. 1). Katla is renowned as Iceland's most hazardous volcano due to catastrophic jökulhlaup, tephra fall and lightning (Björnsson, 2002; Larsen, 2000).

Emergency management agencies have been preparing for a Katla eruption (Sigthorsson et al., 2006) and emergency response procedures have recently been developed for communities located in the western jökulhlaup hazard zone (Almannavarnir, 2006; Bird et al., 2009a; Bird et al., 2009b). Þórsmörk is situated in this hazard zone, which extends from the Entujökull outlet glacier and encompasses the river Markarfljót.

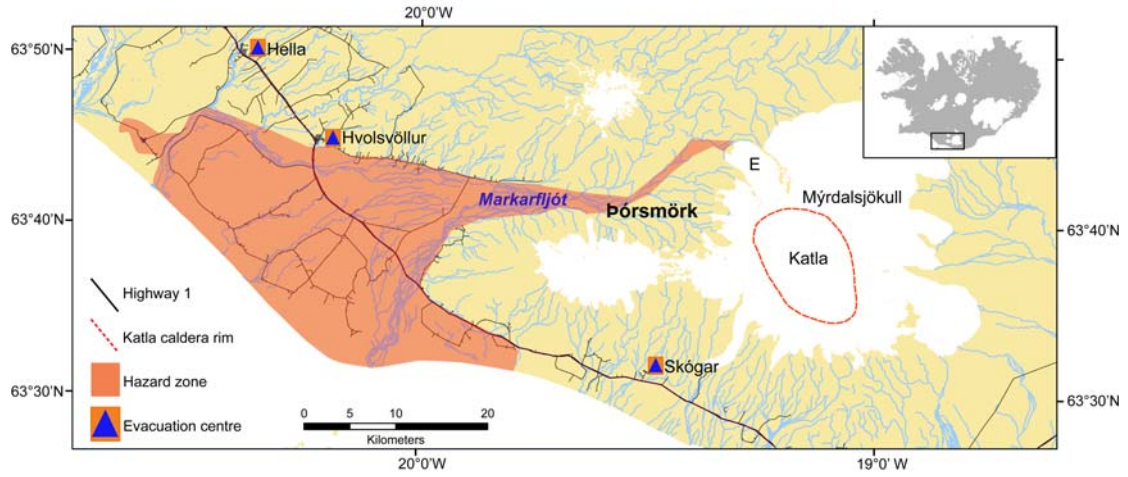

Figure 1. Katla and the Mýrdalsjökull ice cap in southern Iceland (from Bird, 2009). The western jökulhlaup hazard zone extends from the Entujökull (E) outlet glacier and encompasses Þórsmörk and the river Markarfljót.

Resident evacuation centres are located in Hella, Hvolsvöllur and Skógar. However, if an eruption is imminent, emergency management officials will enforce road closures preventing people from evacuating Þórsmörk and the surrounding region (Almannavarnir, 2007). This is considered a necessary precaution because the Þórsmörk access road traverses the Markarfljót floodplain and it often crosses dangerous tributaries. It is estimated that a catastrophic jökulhlaup with a discharge in excess of 100,000 m^3 s^{-1} would produce a flood height across the floodplain in excess of 20 m and it would reach Þórsmörk no more than 2 hours after an eruption commences (Guðmundsson et al., 2005).

Each of the mountain hut communities in Þórsmörk: Húsadalur, Langidalur and Básar are either on, or are situated adjacent to, floodplains. Therefore, during a Katla eruption, people located in the Þórsmörk region will be instructed to go to higher ground and avoid low-lying areas, especially near glacial rivers.

In relation to the recently developed emergency response plans, Bird et al. (2010) conducted a survey to investigate tourists' and tourism employees' knowledge and perception of Katla, volcanic hazards and risk, and emergency response procedures. The survey, conducted prior to the implementation of education and training campaigns, showed that tourists lacked volcanic hazard knowledge and both tourists and tourism employees lacked knowledge of the early warning system and emergency response procedures. Based on the findings, Bird et al. (2010) made recommendations for more direct and specific education campaigns to increase knowledge within the tourism sector.

During the 2008 summer, the Icelandic Civil Protection Office (ICP) together with local police and rescue teams, scheduled hazard education and emergency response training campaigns with the Þórsmörk tourism sector (Bird et al., 2010). These consisted of information meetings with tourism companies, onsite training at each mountain hut community, distribution of the brochures entitled 'Eruption Emergency Guidelines" (available in six languages), and the erection of hazard and emergency response information signs entitled 'Katla-Mýrdalsjökull' in mountain huts and in prominent positions along hiking trails (Fig. 2).

Figure 2. A ‘Katla-Mýrdalsjökull’ sign detailing hazard and emergency response information erected at the southern end of the famous Laugavegur hiking trail (photo taken by Damian Gore).

To assess the effectiveness of these efforts, this study re-examines tourists’ and tourism employees’ knowledge and perception of Katla, volcanic hazards and risk, and emergency response procedures. The following section describes the methods used to conduct the survey.

Methods

The study included two stakeholder groups: tourists and tourism employees (hereafter referred to as employees). Separate questionnaires were used to survey each group and these were based on previous questionnaires developed by Bird (2009) and Bird et al. (2010). Three interviewers administered the questionnaires during face-to-face interviewing from July to September 2009. As with the 2007 survey, interviews were conducted in either English or Icelandic, participants were recruited via a purposive sampling technique, both single and multiple day visitors were targeted and recruiting took place on weekdays and weekends from morning to late evening.

All visible tourist groups and all hut wardens working during the study period were asked to participate in the survey. In total, 105 tourists and 19 employees took part. Only 12 tourists declined to participate giving a response rate of 90% and 100% for each the tourist and employee groups, respectively. Five tourists declined due to language barriers, a further five declined due to lack of time, one tourist was too tired and the other tourist declined due to lack of interest.

Both surveys included open and closed questions to generate information on participant demographics (age, residency, language spoken at home, and highest level of completed education, etc), general knowledge of natural hazards in Iceland and more specifically,

knowledge and perception of Katla, jökulhlaup hazards and emergency response procedures. For a correct response, participants were required to state the approximate recurrence interval of eruptions (1 to 3 times per century, Thordarson and Larsen, 2007) or the year of the last Katla eruption as 1918 (the last major eruption), 1955 or 1999 (two small, confined eruptions that did not break the glacier surface) (Sturkell et al., 2008; Sturkell et al., 2003). If a participant declared that they did not know of Katla or jökulhlaup hazards, the interviewer provided them with a brief description.

Additional questions were included in the 2009 questionnaires in order to assess participants' knowledge and perception of the education and training campaigns. Participants were also asked to rate their perception of preparedness for a future Katla eruption, perception of the possibility of a future Katla eruption and its effects, and their level of trust in hazard information. These questions included closed and five-level Likert-style (e.g. on a scale ranging from 1-not at all prepared, to 5-completely prepared) questions. Electronic copies of both questionnaires are available from the lead author.

Quantitative data was coded and interrogated using frequency and cross-tabulation tables in SPSS® (Statistical Package for Social Science). Data from the 2007 and 2009 surveys were compared and tests for statistically significant differences using p values from chi-square tests and independent samples t-tests were conducted. A p value of <0.01 was considered highly significant and a p value between 0.01 and 0.05 was considered significant.

QSR NVivo® was used for qualitative data analysis. All qualitative data was coded for interrogation to facilitate comparisons, identify patterning of responses and enable the establishment of linkages between the 2007 and 2009 surveys. The results from this analysis are presented and discussed in the following section.

Results and discussion

Preliminary results of the questionnaire are presented in Tables 1 to 4.

Table 1. Classification questions identifying participant demographics. All data are given as a percentage. Some sections do not equal 100% due to rounding.

	Tourists	Employees
Participant age		
▪ 18<30 yrs	41	32
▪ 31<50 yrs	42	32
▪ 51+ yrs	17	37
Residency		
▪ Iceland	18	84
▪ International	82	16
Main language spoken at home		
▪ Icelandic	18	74
▪ English	18	11
▪ Danish	3	-
▪ French	15	-
▪ German	18	-
▪ Spanish	3	-
▪ Other	25	16
Highest level of education		
▪ Up to high school	14	21
▪ University degree or higher	78	32
▪ Other	8	47

The main purpose for participants visiting Þórsmörk was for hiking (59%) and nature/sightseeing (26%) and many (77%) had travelled in the surrounding region. Only 20% of participants had previously visited Þórsmörk and very few (11%) were travelling with a guide.

37% of employees were working as hiking/tourist guides, 21% were employed as drivers and 42% were hut wardens working in Húsadalur, Langidalur or Básar. Very few (11%) employees stated that their companies held *regular* emergency response training exercises and the vast majority (79%) stated that they had not received emergency training prior to or during their work in Þórsmörk.

Table 2. Tourists' knowledge of Iceland, Katla and jökulhlaup. All data are given as a percentage.

% of participants who are aware of the natural hazards occurring in Iceland:	91
% of participants who have heard of Katla:	73
→ % of these participants who correctly described Katla:	37
% of participants who have heard of jökulhlaup:	31
→ % of these participants who correctly described jökulhlaup:	98

Table 3. Participants' 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	39	47
▪ escape Þórsmörk	21	21
▪ report to wardens	23	5
▪ follow procedures	7	21
▪ other	10	5
If there was a volcanic eruption at Katla, % of participants who would:		
▪ report to wardens or guide	32	5
▪ call an emergency number (e.g. 112) or friend	7	58
▪ listen to radio	2	0
▪ evacuate Þórsmörk	20	21
▪ go to higher ground	28	11
▪ other	10	5

Table 4. Percent of participants who had seen the current education strategies.

	Tourists	Employees
% of participants who have seen an "Eruption Emergency Guidelines" brochure:	26	63
% of participants who read the "Eruption Emergency Guidelines" brochure:	17	58
% of participants who have seen a "Katla-Mýrdalsjökull" information sign:	44	58
% of participants who read the "Katla-Mýrdalsjökull" information sign:	42	53

Alarmingly, very few tourists had read the 'Emergency Eruption Guidelines' brochure and many were critical of its content. Information within the brochure continually refers to 'Mt. Katla' but 'Mt Katla' is not marked on the map (Fig. 3). The first instruction in the brochure states:

> Examine the map to see where glacial floods have flowed in the past. If an eruption warning signal is given, keep to the upper slopes. The main escape routes are shown by red arrows on the map. No entry signs indicate road closures.

However, many participants commented that it is very difficult for tourists to determine their location, the extent of previous floods or designated escape routes on the map.

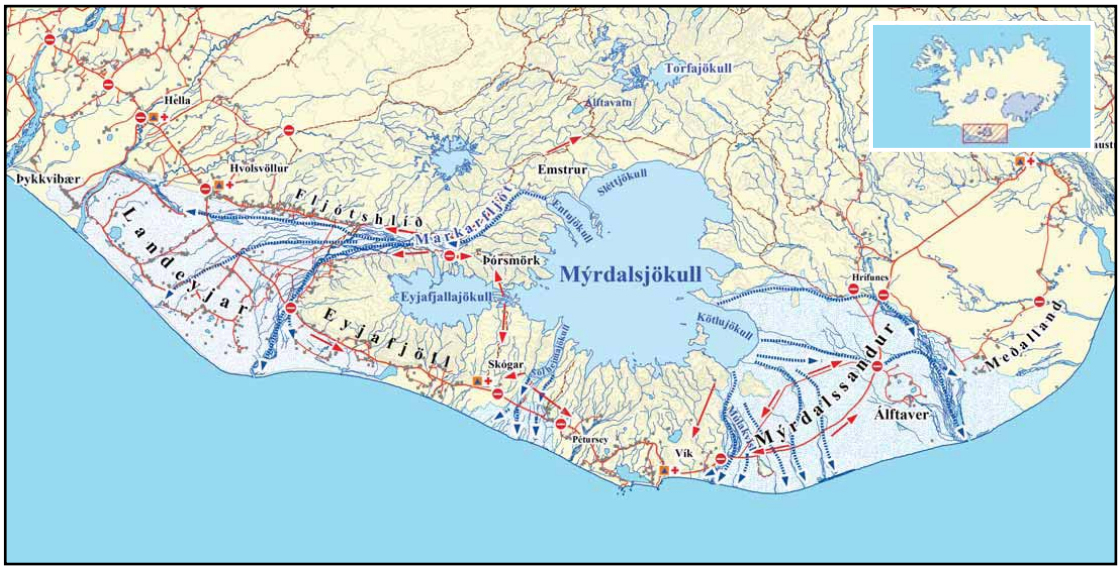

Figure 3. The jökulhlaup hazard map from the 'Emergency Eruption Guidelines' brochure which has been distributed to tourists in the Þórsmörk region (from Almannavarnir, 2007).

Further, the only instruction for tephra is: 'It is advisable not to drive where tephra is falling, as it can damage the engine.' The section on tephra goes on to state that it can be harmful to the eyes and respiratory system but critically, it provides no advice on how to mitigate the effects of tephra. In comparison, the sections entitled 'Risk of lightning' and 'Toxic gases' provides detailed information about the hazard and how to reduce personal vulnerability.

On 20 March 2010 the neighbouring volcano Eyjafjallajökull erupted. Considering that Eyjafjallajökull eruptions have preceded, or occurred simultaneously with, Katla eruptions on several historic occasions (Sturkell et al., 2008), critical improvements to hazard, risk and emergency response education in southern Iceland are essential in the immediate future.

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References

Almannavarnir, 2006. Bergrisinn 2006: http://www.almannavarnir.is/upload/files/Bergrisinn%20lokask%C3%BDrsla%200%204%20%282%29.pdf, accessed: 18 February 2008.

Almannavarnir, 2007. Eruption Emergency Guidelines: http://www.almannavarnir.is/upload/files/almv_baekl_EN_vef.pdf, accessed: 14 January 2008.

Bird, D., Gisladottir, G. and Dominey-Howes, D., 2009a. Public perception of jökulhlaup hazard and risk in Iceland: implications for community education. International Journal of Management and Decision Making, 10(3/4): 164-175.

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. Nat. Hazards Earth Syst. Sci., 9(4): 1307-1325.

Bird, D.K., Gisladottir, G. and Dominey-Howes, D., 2009b. Resident perception of volcanic hazards and evacuation procedures. Nat. Hazards Earth Syst. Sci., 9(1): 251-266.

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.

Björnsson, H., 2002. Subglacial lakes and jökulhlaups in Iceland. Global and Planetary Change, 35(3-4): 255-271.

Guðmundsson, M.T., Elíasson, J., Larsen, G., Gylfason, Á.G., Einarsson, P., Jóhanesson, T., Hákonardóttir, K.M. and Torfason, H., 2005. Yfirlit um hættu vegna eldgosa og hlaupa frá vesturhluta Mýrdalsjökuls og Eyjafjallajökli. In: M.T. Guðmundsson and Á.G. Gylfason (Editors), Hættumat vegan eldgosa og hlaupa frá vestanverðum Mýrdalsjökli og Eyjafjallajökli. Ríkislögreglustjórinn, Reykjavík, pp. 11-44.

Larsen, G., 2000. Holocene eruptions within the Katla volcanic system, south Iceland: Characteristics and environmental impact. Jökull, 49: 1-28.

NAT, 2010. Hiking trail, Landmannalaugar - Thorsmork: http://www.nat.is/travelguideeng/hiking_laugavegur.htm, accessed: 20 March 2010.

Sigthorsson, I.H., Gudmundsson, A.T., Marteinsdottir, F. and Nielsen, T., 2006. Evacuation plan for volcanic eruptions in the Katla caldera in Iceland. Geophysical Research Abstracts, 8(05254).

Sturkell, E., Einarsson, P., Roberts, M.J., Geirsson, H., Gudmundsson, M.T., Sigmundsson, F., Pinel, V., Guðmundsson, G.B., Ólafsson, H. and Stefánsson, R., 2008. Seismic and geodetic insights into magma accumulation at Katla subglacial volcano, Iceland: 1999 to 2005. J. Geophys. Res., 113.

Sturkell, E., Sigmundsson, F. and Einarsson, P., 2003. Recent unrest and magma movements at Eyjafjallajökull and Katla volcanoes, Iceland. Journal of Geophysical Research, 108(B8): 2369.

Thordarson, T. and Larsen, G., 2007. Volcanism in Iceland in historical time: Volcano types, eruption styles and eruptive history. Journal of Geodynamics, 43(1): 118–152.