Bull Volcanol (2012) 74:1263–1279
DOI 10.1007/s00445-012-0595-z

RESEARCH ARTICLE

Residents' attitudes and behaviour before and after the 2010 Eyjafjallajökull eruptions—a case study from southern Iceland

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Received: 12 September 2011 / Accepted: 6 March 2012 / Published online: 29 April 2012

Abstract While the disruption to international air travel caused by the eruption of Iceland's Eyjafjallajökull volcano in 2010 has been well documented, the significant social impacts on local residents from ash fall to the south and east of the crater are less well-known. These impacts and attitudes of impacted residents and emergency managers are the foci of our present study. Prior to and during the eruption, officials worked to protect the local population from the glacial outburst floods (jökulhlaup) that were of primary concern. The success of these endeavours can in part be attributed to a regional evacuation exercise held in March 2006, an exercise that was carried out with respect to a possible eruption at another volcano, Katla, that is located 25 km to the east of Eyjafjallajökull. Eruptions at either volcano will impact the same communities. Our study here concentrates on Álftaver, a small farming community, located approximately 60 km east-southeast of Eyjafjallajökull and 30 km southeast of Katla. Álftaver has been the subject of longitudinal studies carried out in 2004, 2006, and 2008; these studies highlighted the difficulties that emergency managers face in developing appropriate response strategies acceptable to vulnerable communities. The 2010 Eyjafjallajökull eruptions presented an opportunity to re-assess residents' attitudes and behaviour in relation to volcanic risk management in the wake of their first-hand experiences with volcanic hazards. To achieve this, interviews were conducted with residents and emergency management officials and a questionnaire was distributed to residents. This paper presents the results of this survey and examines changes in attitudes towards volcanic risk management. It was apparent that the experience of ash fall from Eyjafjallajökull provided a better perspective of what could be expected from a Katla eruption and that attitudes towards emergency management had evolved accordingly. Importantly, officials' perceptions of risk are now more aligned with those of residents and both recognise the need for more detailed and concise information regarding the impacts of ash fall during and following volcanic eruptions.

Keywords Risk perception · Volcanic ash · Emergency response · Mixed methods · Katla

Editorial responsibility: C. Oppenheimer

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Introduction

> "Of course we know that we live in a place like this, there are floods, earthquakes and we have these volcanoes"—quote from a health practitioner in southern Iceland following the Eyjafjallajökull eruption in 2010.

The Katla and Eyjafjallajökull volcanoes are located in central southern Iceland and both are overlain by glaciers

(Fig. 1). Since the 10th century, Eyjafjallajökull has erupted only three times: in 1612, from 1821 to 1823, and most recently in 2010. Past eruptions have produced very fine-grained ash deposits typically found within a 10-km radius from the Eyjafjallajökull crater (Larsen et al. 1999) and only small to medium (3,000–30,000 m^3s^{-1}) glacial floods (jökulhlaups) (Guðmundsson and Gylfason 2005). In comparison, Katla has erupted at least 20 times in the same period and is known as one of the most dangerous volcanoes in Iceland due to catastrophic jökulhlaup (>100,000 m^3s^{-1}) (Guðmundsson et al. 2007). The last major Katla eruption and catastrophic jökulhlaup (~300,000 m^3s^{-1}) occurred in 1918 (Tómasson 1996; Björnsson 2002), while small jökulhlaups in 1955 and 1999 are believed to have been the product of minor subglacial activity. Katla eruptions are also characterised by significant ash fall and lightning hazards (Larsen 2000) and some have produced small tsunami which have affected the south coast of Iceland and Vestmannaeyjar (Almannavarnir 2000; Elíasson 2008).

All historic Katla eruptions have produced jökulhlaups which have emanated from the Kötlujökull or Sólheimajökull catchments while only prehistoric jökulhlaups have flooded from the Entujökull catchment (Björnsson et al. 2000). Emergency response plans have therefore traditionally focused on a potential Katla eruption for the southern and eastern hazard zones (see Fig. 1). The initial plans, developed from as early as 1973, did not include the western hazard zone or the possibility of an Eyjafjallajökull eruption. These plans have, however, undergone revision since 2002 due to increased seismicity in Katla and continuing magma intrusions in Eyjafjallajökull (Guðmundsson and Gylfason 2005).

The Icelandic Civil Protection Office, in conjunction with scientists and local police, held hazard and response information meetings in 2005/06 to discuss a newly devised evacuation plan for a Katla eruption with residents. Attendees were advised to collect evacuation and hazard information posters from their local police station. This poster provides detail on appropriate behavioural responses when faced with various volcanic hazards and instructions on preparing for an evacuation. These include: collecting a first aid kit and valuables, switching off electricity, removing fencing from around the house, unplugging electric fences and releasing livestock from enclosures, among others (for details see Fig. 2 in Bird et al. 2009). Upon evacuation, residents are to hang these posters on their front doors to indicate to officials that the house has been evacuated. Similar plans for an Eyjafjallajökull eruption were not completed until 2010.

The revised evacuation plans for a Katla eruption were tested during a full-scale exercise for communities located in the southern and eastern hazard zones on 25 March 2006 and the western hazard zone on 26 March 2006. In conjunction with these exercises, a mixed methods survey was used to assess officials' and residents' responses to and perceptions of the proposed procedures. The small rural community of Álftaver participated in this research due to its

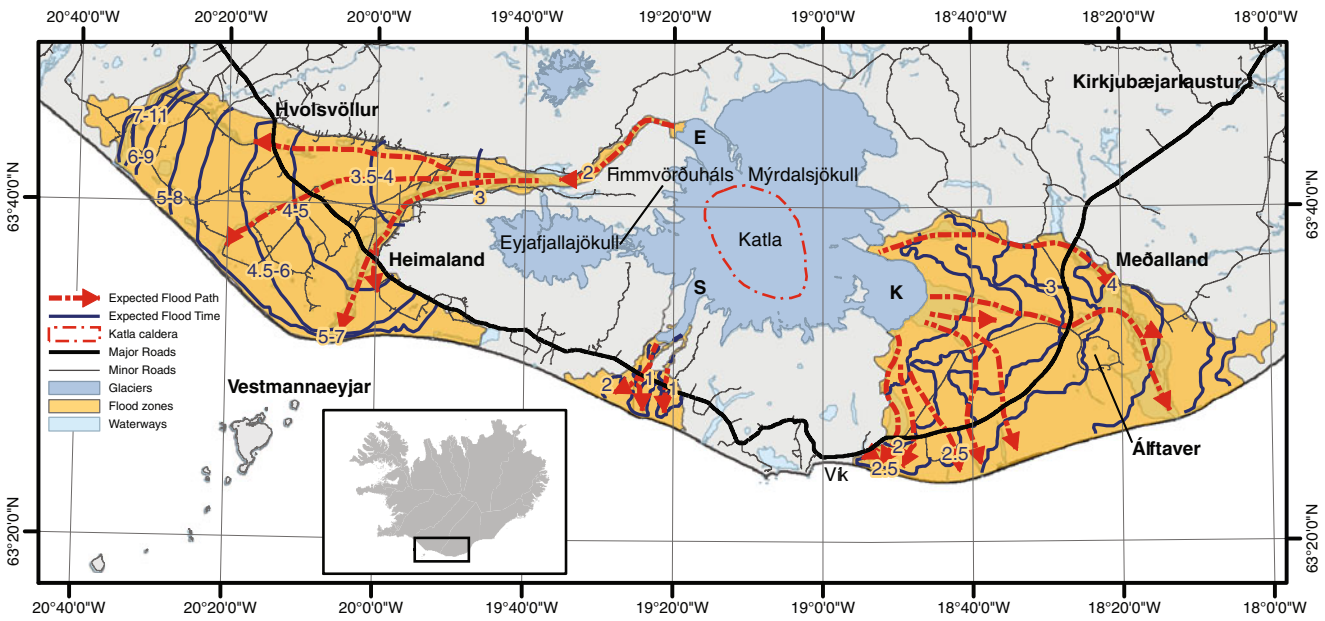

Fig. 1 Jökulhlaup (flood) hazard zones around the Mýrdalsjökull ice-cap showing the Entujökull (E), Kötlujökull (K) and Sólheimajökull (S) catchments, small rural community of Álftaver and their designated evacuation centre in Kirkjubæjarklaustur (from Ríkislögreglustjóri almannavarnadeild 2008a, b). The 'expected flood time' indicates the minimum number of hours (i.e., 3.5–4) before the onset of flooding after an eruption commences. Map produced by James O'Brien at Risk Frontiers

Fig. 2 Satellite image of Eyjafjallajökull and Mýrdalsjökull showing the location of the farmhouses Herjólfsstaðir and Mýrar in Álftaver, and Meðalland, Kirkjubæjarklaustur and Vík (Image adapted from Google Earth ©2011). Clouds can be seen around Meðalland

isolated location in the middle of the eastern jökulhlaup hazard zone.

Álftaver has been the focus of several studies due to its proximity to the volcanoes and the difficulties that emergency management agencies face in developing response strategies that are appropriate and acceptable to all those involved in a volcanic crisis. Moreover, Álftaver typifies many small remote communities that are vital to the economic and social wellbeing of Iceland.

Longitudinal research carried out in 2004, 2006, and 2008 showed that Álftaver residents were concerned and confused about the plans (see Table 1). Residents were also frustrated by the fact that they had not been involved in developing response plans for their community. More recently, however, residents recognised that emergency managers were making a concerted effort to involve them in future developments to enhance risk reduction (Bird 2010).

The inclusion of local input in the effort to reduce community vulnerability to volcanic hazards in southern Iceland marks an important shift in emergency management. It is, however, a shift indicated as desirable by a significant body of scientific literature (e.g., Cronin et al. 2004; Wisner et al. 2004; Bajek et al. 2008; Barclay et al. 2008; Kelman and Mather 2008; Gaillard et al. 2009; Maceda et al. 2009; Mimaki et al. 2009; Mercer and Kelman 2010; Patterson et al. 2010).

Álftaver was impacted by significant ash fall during the 2010 Eyjafjallajökull eruption, where it had serious consequences on farming. For this reason, we undertook a further study in order to investigate residents' behaviour during the eruption and to document the impacts, if any, the ash had on this farming community. To achieve this, open-ended interviews were carried out and a hard-copy, self-completion questionnaire was distributed. Open-ended interviews were also conducted with several Icelandic officials to provide a

Table 1 Key findings from longitudinal studies in the rural farming community of Álftaver and their occurrence (marked with an X) in either 2004, 2006, or 2008 (from Jóhannesdóttir 2005; Bird et al. 2009; Bird 2010; Jóhannesdóttir and Gísladóttir 2010; Bird et al. 2011). These conclusions are based on a combination of both qualitative and quantitative data and each point was not necessarily investigated in each survey

Finding	2004	2006	2008
Residents displayed inherited and acquired local knowledge, attachment to place, community cooperation and neighbourliness	X	X	X
Residents want community involvement in emergency response procedures and were frustrated because they had not been involved in developing plans		X	X
Residents' risk perceptions differed from emergency management agencies		X	X
Residents perceive that evacuating to Kirkjubæjarklaustur will make them more vulnerable to ash, lightning or jökulhlaup they will adopt a 'Plan B' and evacuate to Herjólfsstaðir or Mýrar		X	X
Connection to livelihood (i.e., concern for livestock) and inherited knowledge were influencing residents ability to comply with evacuation orders		X	X
Residents had not adopted personal preparedness measures			X
Residents trusted information provided by scientists			X

broader understanding of the consequences of the eruption from a management perspective.

In this paper, we present and examine the results of this survey in relation to the findings from longitudinal research in 2004, 2006, and 2008, with an aim to:

a) document people's experience of and reaction to the 2010 Eyjafjallajökull eruptions and emergency response advice;
b) identify changes in residents' attitudes towards volcanic risk management following their experience of the 2010 eruptions; and
c) highlight the lessons learned from the 2010 Eyjafjallajökull eruptions.

Before describing the methods and results of the survey, we first provide background information on Álftaver.

Álftaver—the community, volcanic hazards, and emergency plans

The area of Álftaver has been occupied since the settlement of Iceland in the late 9th century (Landnáma 1968). Today, there are nine permanent households out of which six rely on agriculture as their main source of income. Each of these household families has resided in Álftaver for several generations and most consist of two or three adults (Bird et al. 2011). Sheep farming (~2,200 sheep) for wool and meat production is a predominant activity (Farmers Association of Iceland 2010b) although farmers also maintain 230 cattle and 192 horses (ibid). In recent years, however, one farmer has diversified into tourism by providing farmstay accommodation.

Álftaver has been repeatedly impacted by volcanic hazards since settlement. During the 934–938 AD Eldgjá flood lava eruption, residents were forced to flee Álftaver (Landnáma 1968; Larsen 2000; Thordarson and Larsen 2007). Beyond Álftaver, this eruption destroyed more than 780 km^2 of extensively vegetated land (Larsen 2000). Nevertheless, Álftaver remained settled even though repeated Katla eruptions have impacted the area with jökulhlaup and ash fall destroying vegetation. The community now live in a cluster around the most viable agricultural land (Safn til sögu Íslands IV 1907–1915; Gísladóttir 1980; Gísladóttir and Margrétardóttir 2004; Oddsdóttir 2008).

During the 1918 eruption, residents from the northern properties safely evacuated to the farmhouse of Herjólfsstaðir (Fig. 2), and residents from the southern properties evacuated to nearby sheep sheds standing on higher ground (Bjarnason 1985). Although Álftaver did not flood, the sound of water and ice flooding the surrounding region prompted residents to evacuate. The maximum discharge of that jökulhlaup has been estimated to be 300,000 m^3s^{-1}; historical resident descriptions suggest that the jökulhlaup produced during the 1755 eruption was likely even larger (Guðmundsson and Högnadóttir 2006).

Despite the fact that some farms were abandoned during past eruptions, there is no indication that farmhouses on the properties of Herjólfsstaðir and Mýrar, which are positioned on topographical highs and established prior to 1500 AD, have been affected by jökulhlaups (Jóhannesson 1919; Loftsson 1930; Gísladóttir 1980). Flood simulation modelling, however, on which the 2006 emergency response strategies are based indicates that all households are vulnerable to jökulhlaup hazards (Guðmundsson and Gylfason 2005). The model predicts that a jökulhlaup can flood the main highway, bridges and electric power lines and reach the community of Álftaver within 3 h of a Katla eruption. All residents are therefore considered to be at risk and are required to evacuate.

In the likelihood of a future Katla eruption, residents in Álftaver will be instructed that they have 30 min to prepare before evacuating to their designated centre in Kirkjubæjarklaustur, a town located approximately 45 min drive to the north east of Álftaver. Residents will be notified of an eruption via a short messaging service (SMS) text message sent to their mobile phone or a recorded message called through to their landline.

Naturally, residents are concerned about jökulhlaup, but they are also very worried about ash fall and lightning (Bird et al. 2011). Guðmundsson et al. (2008) report that large Katla eruptions (Volcanic Explosivity Index 4) have produced heavy ash fall up to 20 cm thick at distances of 30 km from the crater. Similarly, lightning affects areas in a 30 km radius and has resulted in significant loss of livestock in addition to two deaths during the 1755 eruption (Safn til sögu Íslands IV. Kaupmannahöfn og Reykjavík, 1907–1915 in Guðmundsson et al. 2008).

In the next section, we describe the survey methods used in 2010. We then discuss the emergency management response to the Eyjafjallajökull eruptions in 2010 based on media reports and interviews with key government officials. Following this, we present and discuss the key factors that emerged from the interviews conducted with residents in Álftaver and officials.

Methods

A mixed methods approach was applied whereby different qualitative methods (i.e., open-ended interviews and questionnaires) contributed to different aspects of the study. A mixed methods approach not only provides a

comprehensive view of the social issues that may affect the success of emergency response strategies (Horlick-Jones et al. 2003; Haynes et al. 2007) but also reduces the possibility of systematic biases or limitations compared with a single data source or method (Maxwell 2005).

The research presented here utilised open-ended interviews with officials and residents. Interviews, lasting between 30 min and 3 h, were carried out throughout August 2010. While most were undertaken in Icelandic and translated to English (by Gísladóttir) during the interview process, three were carried out in English with those who felt comfortable doing so. Discussions focused on officials' and residents' experience of the eruptions in addition to their perceptions of the emergency response during these events.

During the interview period, questionnaires were delivered to seven of the nine permanent households in Álftaver. Residents were instructed to return the questionnaires by post after self-completion, which all seven households did. The two households not included were unavailable during the survey period. The questionnaire was developed from the instrument used by Bird et al. (2011) with the assistance of various key volcanologists and Icelandic officials. While all questionnaires were administered in Icelandic, an English copy of the questionnaire is available from the lead author on request. Section topics within the questionnaire include:

1. Demographic data
2. Experience prior to and during the eruption that began on 20th March in Fimmvörðuháls
3. Experience prior to and during the eruption that began on 14th April from under the glacier
4. The effects of the eruptions on residents, family, and property
5. Impacts on agricultural-based businesses
6. Impacts on tourism-based businesses (if applicable)
7. Use of various media sources for acquiring information about the possibility of a future Katla/Eyjafjallajökull eruption
8. Preparedness for a Katla eruption
9. The possibility of a Katla eruption and its effects
10. Trust in information from various sources about a Katla eruption

Since it is beyond the scope of this paper to present all the results from the questionnaire, responses to a few select questions were chosen on the basis that they relate to the aims of this paper and/or issues raised during the interviews. These questions were selected from sections 1–6 and 8–10, as listed above.

In total, seven public officials and ten residents participated in the research—three people from one household, two from another household and five from separate households altogether representing the seven available households. The residents' surveyed included one respondent who was 18–30 years of age, two people 31–50 years of age while the remaining were 51+ years. Importantly, all respondents had resided in Iceland for all of their lives, Icelandic was their main language, and all respondent families had lived in the region for many generations.

Written notes from our observations and interviews were transcribed and imported into *QSR NVivo*® for coding to enable interrogation of the data. All qualitative data were coded by tagging sections of text that related to specific issues. These issues are presented in the following sections as the prominent factors that emerged during the events in 2010.

Emergency management prior to and during the 2010 Eyjafjallajökull eruptions

In February 2010, the regional Chief of Police and the Icelandic Civil Protection Office organised emergency management meetings with scientists, local police and rescue teams in response to increased seismicity in Eyjafjallajökull during 2009 and 2010. In addition, ten community information meetings were held over 4 days with residents living around Eyjafjallajökull and Katla. These occurred up to 1 week prior to the 20 March 2010 eruption and evacuation plans for an Eyjafjallajökull eruption were finalised during this period (Bird et al. 2011). The overall attendance rate at the meetings was approximately 50–60 % of the general population. The residents of Álftaver were included in a group community meeting in Skaftártunga (see Fig. 2). Other meetings were held in Hvolsvöllur, Heimaland, Vík, and Kirkjubæjarklaustur.

Despite the comprehensive seismic and geodetic monitoring system in southern Iceland (see Sturkell et al. 2006, 2009), the 20 March 2010 eruption was first announced by local farmers who observed “a fire on top of the mountain”. After residents reported these sightings to the police and emergency services number 112, the Chief of Police, the Icelandic Civil Protection Office and scientists worked collaboratively to implement an emergency response plan (RÚV 2010).

Approximately 600 residents were evacuated from communities around Eyjafjallajökull on the morning of 21 March 2010. Of these, 440 residents registered at the evacuation centre in Hvolsvöllur and the remaining

residents were housed in five separate centres from Heimaland to Vík (Vísir 2010). Later the same day, however, most residents were advised that they could return to their homes as scientists identified the location of the eruption at Fimmvörðuháls (on the flank of the volcano) and determined that there was no risk of jökulhlaup. The police were reported as stating that the evacuation went very well (Mbl 2010), mostly due to the evacuation exercise for a Katla eruption in March 2006 and the information meetings held prior to the eruption.

The eruption emergency was reduced to a 'hazard phase' on 13 April 2010. However, the Icelandic Meteorological Office recorded an increase in seismicity under the Eyjafjallajökull icecap that evening. Emergency response plans were enacted on the morning of 14 April 2010 with evacuations commencing at 01:02 GMT (local time) for residents living directly south of Eyjafjallajökull. The evacuation involved approximately 800 residents (Gudmundsson et al. 2010a) and was completed by 03:58 (ICP 2010).

The first sign of a jökulhlaup was recorded to the north of the volcano at 06:50 on 14 April 2010 (Gudmundsson et al. 2010a). This flood reached a peak discharge of <3,000 m^3s^{-1} at a gauging station on the river Markarfljót (Sigurðsson et al. 2011) and was not sufficient to cause widespread damage (Gudmundsson et al. 2010b). However, officials considered it necessary to remove sections of the national highway in order to save the bridge that crosses the river Markarfljót. A second jökulhlaup flooded to the south of the crater also on the 14 April and a third to the north on the 15 April (Pagneux et al. 2010; Sigurðsson et al. 2011). Both of these were smaller than the first but all three caused localised damage to infrastructure and agricultural land.

Other hazards produced during the Eyjafjallajökull eruption included 790 lightning strikes detected within or immediately due south of the central crater (Bennett et al. 2010), loud volcanic sound blasts audible to the south and east of the crater, and lava flows within close proximity of the crater (IMO 2010). Volcanic ash, however, was the main hazard. Gudmundsson et al. (2010a) estimate that the eruption produced 0.1–0.2 km^3 (dense rock equivalent) of tephra which caused considerable ash fall (<2 mm size fraction component of tephra) to the east and east-southeast of the crater (Davies et al. 2010). The eruption plume attained a height of over 9 km and the fine-gained ash component was dispersed throughout European airspace after entering the jet stream (Gislason et al. 2011).

As with other regions in southern Iceland, the ash had serious consequences on farming in Álftaver. An increase in short- and long-term livestock mortality can be expected when animals ingest fine ash particles either through inhalation or digestion (Lebon 2009; Wilson 2009; Wilson et al. 2011). Farmers were therefore advised to house livestock during ash fall periods (Farmers Association of Iceland 2010a). This proved to be a difficult task for many since the eruption coincided with the lambing period when livestock numbers can triple due to sheep producing twins. Moreover, this advice contradicted that given during the evacuation exercise and listed on the evacuation and hazard information posters, which was to release all livestock from enclosures.

Factors that emerged from the 2010 Eyjafjallajökull eruptions

Community interest in emergency management efforts

Very few residents from Álftaver attended the hazard and response information meetings regarding Eyjafjallajökull, which were held prior to the eruption, despite knowing about them in advance. Some respondents reported, however, that residents in the nearby community of Meðalland were not informed of the meetings. In comparison, there was a strong representation of residents that live closer to Eyjafjallajökull.

Adequacy of (in)formal communication and information during the event

Residents heard about the Fimmvörðuháls eruption from family and friends in Reykjavík and via radio and television warnings. Following this, many residents proactively accessed information from the Icelandic Meteorological Office website—an official site that provides near-real time earthquake and volcanic hazard information (see Bird et al. 2008 for details). Residents monitoring this site realised that another eruption was likely to occur after officials announced that the Fimmvörðuháls eruption had passed from an 'eruptive phase' into a 'hazard phase' on 13 April 2010. "[I] saw it [an earthquake] on the computer; we were of course watching… I was sure there was something more happening. Then it turned out the earthquake was a magma intrusion and was sending magma over to the west… I was sure about that. Then it turned out on the 14th [April 2010] it started erupting." During these eruptive stages, officials quickly communicated hazard and response information to residents and it was reported that people responded positively. A key emergency management

official described residents as understanding and willing to cooperate (see Text box 1).

Text box 1. An official's report on giving residents information about the third evacuation

All the farmers were quite positive. When we evacuated for the 3rd time, it was about 7pm... Around 9-9:30pm we knew the flood was over so we decided to cancel the evacuation and a lot of them were here in the school. I decided to go in, in person to tell them that. I was very nervous to do that... [I thought] *they were probably quite angry. I went into the school and they were watching the 10pm news and I started to explain to them what happened, why we evacuated in such a hurry... And I said the flood is over and you can all go to your homes. And I waited to see the response and get the anger but it was quite the opposite. They said we feel safe at home because we know you are watching us. We feel safe to go home. We know that you are watching what is happening and we know that you will let us know as soon as you know anything. It was quite difficult for me to stand there because I had been awake for days and to get this response back... to get these emotions from the people it was a very good feeling.*

Some residents were quite critical of scientists because they did not predict the first eruption, and also of police and authorities at the Icelandic Civil Protection Office in regards to how they dealt with the management of the Fimmvörðuháls eruption site: "they should have closed the roads and the glacier to all traffic… they did not warn enough about the danger at the eruption sites".

Among Álftaver residents, the announcement of the eruptions in March and April 2010 invoked feelings of calm and relief that it was not a Katla eruption. Residents were, however, concerned about family and friends who lived close to Eyjafjallajökull. Nevertheless, Álftaver was one of the first areas to be affected by the ash: "at first it [the ash] came to Álftaver and it was pitch black there."

In relation to the ash, southern Iceland residents were reported as being incensed about the lack of clear information and they found it unacceptable that no response plan had been established prior to the eruption. Despite the availability of online information from 20 April 2010 (Ríkislögreglustjóri almannavarnadeild et al. 2010) and distribution of pamphlets, residents requested more information about the ash concentration levels, what effect the ash would have on human health and agriculture and what measures people should adopt to avoid adverse effects. Officials recognised that there was limited information available: "…we were measuring the ash concentration… We didn't know what to do with the results… I thought a lot about it and I didn't have the answers… I know that people felt that they didn't get clear enough answers about the health effects of the ash… The specialists didn't have the answers. I've been reading all I can about these measurements because I wanted to have better answers than I did… I just told them what I knew… the people are of course sensible and they can see it for themselves as well."

Residents were also frustrated with the media and officials for stating that the Eyjafjallajökull eruptions were "a show and nothing in comparison to what Katla can do". Residents believed that they were already well aware of this based on their inherited knowledge: "The media people used to talk about the Eyjafjallajökull eruptions, and following that they always asked the scientists when is Katla coming, it was like that they thought it would be much more fun to have the third eruption to report from." It was obvious that residents were not happy to be continuously reminded that a Katla eruption might follow. In addition, there was some resentment of the international media's focus on the impacts on air travel and very little about the localised impact in Iceland.

Despite the aforementioned issues, there was a relatively open communication network between scientists, police, civil authorities, and local residents during the eruptions. We suggest that this distinctive feature of Icelandic society, which has been previously documented by Lebon (2009), occurs because of the small close-knit population.

Willingness to comply with emergency advice

Álftaver residents were not ordered to evacuate during the eruptions since they were not at risk from jökulhlaup, but

they were given the option to evacuate to Vík or Kirkjubæjarklaustur because of ash fall. No one in the community chose to evacuate.

During the first eruption, community members were asked by the Red Cross to assist at the evacuation centre in Vík and they were eager to help after they had assessed the risk of ash fall in the area. "I already knew from the computer what the wind directions were, so I said that it wouldn't be a problem for me to go to Vík and work at the evacuation centre because there was no danger that the ash would reach us because of the wind direction."

Residents reported that some evacuees enjoyed the atmosphere at the evacuation centre on 21 March but others were somewhat traumatised. Additionally, quite a few were angry about being evacuated despite officials' explanations for implementing compulsory evacuations for certain areas (see Text box 2). Fuelling residents' anger, however, was live media coverage of reporters and officials within the evacuation zone. Many residents did not understand why they had to leave their homes while media crews, who did not belong in the area, were allowed in (Bird et al. 2011). There were further reports of people who had refused to evacuate because they believed it was not safe to do so.

Text box 2. An official explains how he justified to residents during the information meetings prior to the eruptions about the proposed compulsory evacuation for certain areas.

We had a bit of discussion about it because we have to explain to people that they have to evacuate even though they live in a safe area. I said that you have some safe areas but they are also isolated. It is much easier for me to have the people in the same area, no one isolated because if someone gets heart attack, if someone gets hurt, it's very difficult to help them. You need to have a helicopter or something. They bought that idea because I said it on the meetings... I said if your child gets sick or you get hurt you are isolated. We have a lot of ash fall and it's difficult for a helicopter to fly. Maybe you have to stay in your isolated farm for many days. I said to them that I don't take it as an option. I think they understood it and they agreed.

Local rescue volunteers were called in to assist media personnel and scientists who found themselves in difficult situations within the evacuated area, which exacerbated the situation further: "I got a special request after the very end of my first shift during the eruption, there were scientists that had run into trouble on Fimmvörðuháls… and we were asked to help them." Rescue members questioned decisions to allow scientists and media personnel access to evacuated areas, even though the Icelandic Civil Protection Office had highlighted that they do so at their own risk: "if I receive an emergency call and am asked to go and rescue them, can I say no or am I to go and rescue them, even though they are there at their own risk? This became a real situation during the first hours of the eruption."

Despite the enforced evacuation of certain areas, one or two people were permitted to return to each farm in order to tend to livestock. Special registration checkpoints were established at roadblocks where officials recorded farmer's names and telephone numbers. As per their request, farmers were given a maximum of 2 h in the evacuated zone: "They told us they needed two hours and after two hours if they hadn't come back then we would call them. We knew who were in the area… [The farmers] registered to the area and off the area and they were very good about that."

Lack of preparedness for ash fall

When the ash began to fall in Álftaver the evening the second eruption began, residents remained calm: "I was just really calm over this and wasn't really thinking much about it [the ash]." But later that evening, "…it was getting dangerous to drive due to the ash. It was getting so dusty that when you met an oncoming car it just disappeared in the dust."

Residents agreed that when the ash fell in Álftaver on 15 April, the day after the second eruption began, it became completely dark (Text box 3) and they recounted stories from their ancestors of the darkness during past Katla eruptions: "It got so dark that the tale was true. If you put out your hands in front of you, you couldn't see them."

Text box 3. An Álftaver resident's account of waking up to almost total darkness on 15 April, 2010. This detailed and descriptive quote highlights the social, emotional, and cultural impacts of an eruption on local residents.

I woke up at 6 am, looked out of the kitchen window [to the north] *and it was completely black, I had a look out the south window and there was daylight... and I thought to myself, this won't reach me and I went back to bed... Then I woke up at 7am, and it was completely dark here. I thought 'oh my God what was I thinking this morning, why didn't I go out and close the cowshed, the sheep shed and the horse stable, what was I thinking? How stupid was I!' Of course when I went outside to work I couldn't breathe because I didn't have a mask... so I went back inside to get a tea towel and tied it around my face and went back to the cowshed and closed all windows there and doors and everything I could close. Then I went east to the paddock to close the sheep shed doors and windows. There was dust and mist everywhere inside at that time. Then I went to the stable to try and get the horses inside.*

I went and got two horses out of six. I could hear the other ones and knew that they were there, close to me. I just couldn't see anything. I couldn't see where I was going or what I was doing. So I went back into the shed and got some light, and put it into the stable and gave them water and hay, and left it open and went back inside. I went back about an hour later and the horses had gone inside, so I was able to close the stable door.

I was really relaxed about it considering, I don't know, I just thought about the past, the stories. How good it was that we had heard the stories, I knew that it had happened again, I knew that it wouldn't last forever. Of course we didn't know for how long it would last, but what I thought more about was how the girls would take it once they woke up [eight girls aged 14 and 15 years had slept the night at the house]*. The school bus was meant to arrive in the morning to pick the girls up... I said* [over the phone to the bus driver] *that it was pitch dark here and it wouldn't be possible to pick up any children from here to go to school, it was impassable to get here, there was so much ash fall. So he* [the bus driver] *turned around and didn't pick the children up for school.*

Then of course the girls woke up when I was closing all the windows and trying to put wet cloths around them [the windows] *and some of girls were more worried than others. One was in complete shock because she thought we wouldn't be able to breathe, that we would be out of oxygen, because I was closing all the windows... There was an open window in here that I didn't think of closing in the beginning, so it was getting dusty in here. It didn't take much, just opening the door you would always get stuff inside. And then of course, some were more worried than others, some were really worried about the animals, the sheep and the horses. I said, 'girls I know what we should do, let's go outside and take a photo'. Then it was 10.30 am, we were starting to get some light in the south, a little daylight was starting, just down by the ground. I said 'let's go out and take a photo and send it to* [the national news media agency]*, and then you'll write an article and all of you can write what you think'. That's what we did but nothing was published except the photo but this took their minds off the issue, then they started talking about how they felt and they opened up.*

Some residents reported there was minimal ash accumulation (2–3 mm), "so little that it is not worth discussing" and it had 'no impact' on their home or health, or financial or emotional status. Others advised they received up to 50 mm of ash which fell intermittently during the first 2 to 3 weeks causing 'a little' to 'a great deal' of impact. In this period, the weather was very calm but winds of only 4 m/s would redistribute the ash causing further disruption and damage. When winds were stronger "it was a like a snow storm". According to residents, the ash in Álftaver was much finer than that which fell in the town of Vík.

There was some relief, even on farms where minimal ash accumulation was reported, when officials distributed face masks to residents, several days after the ash began to fall in Álftaver. Prior to obtaining the masks some residents experienced sore eyes and throats from the ash while others reported no ill effects.

Residents found the masks quite challenging to use. These masks were purchased by the Icelandic Civil Protection Office in preparation for H1N1 (swine flu), not volcanic ash, and they were unsuitable for use while undertaking physical labour, such as milking cows and lambing. "They [the masks] were so airtight, with no nozzle, it was impossible to work with it, just sweating underneath and then it was like you were suffocating and you had to take it off sometimes to breathe. You just got so tired, and sometimes you were even gagging and throwing up. It's hard work and using such air tight masks, it was incredibly difficult." Fortunately, more appropriate masks with oxygen flow control devices were distributed to residents about a week later.

During the ongoing crisis, farmers were advised by the Farmers Association to secure all livestock inside or within tight fences to prevent them having access to ash contaminated water or hay. This information was posted on the Farmers Association website. Except for one farm that lacked facilities, all farmers in Álftaver housed their livestock for 2 to 5 weeks, despite some residents reporting that there was minimal ash accumulation.

Irrespective of the information posted on the Farmers Association website, there was no response plan established for the ongoing eruption and residents found this unacceptable. Despite efforts from agricultural departments, they were not included in emergency planning or the initial response. As a result, livestock evacuations were not considered until during the ongoing crisis and as the eruption continued, some farmers evacuated their livestock away from the ash fall area, under their own initiative. During intense ash fall periods, however, some people became claustrophobic, and this affected their ability to make vital decisions in regards to safeguarding their livestock. Residents therefore called for more information on how to prepare for and mitigate the effects of ash in relation to livelihoods and personal wellbeing.

Discrepancies in financial and physical assistance during the response and recovery phases

Álftaver sits in the parish of Skaftárhreppur with Kirkjubæjarklaustur (see Fig. 1). Vík on the other hand sits in the parish of Mýrdalshreppur. As such, ash measurements for Álftaver were read from the parish metre in Kirkjubæjarklaustur. However, Kirkjubæjarklaustur was not impacted to the same extent as Álftaver and it was therefore assumed that everything was OK in the entire parish. But this was not the case for many residents in Álftaver and Meðalland (see Figs. 1 and 2) and during the initial stages of the eruption, residents found it difficult to convince the authorities that they needed assistance in dealing with the ash and possible contamination of drinking water. Furthermore, some residents felt that other residents in their community were shutting out the issues by denying that ash was impacting the area and as a consequence, assistance was not offered in Álftaver and Meðalland from the outset. Mýrdalshreppur collaborated with the Directorate of Labour to assist residents in cleaning ash from infrastructure within each community, as soon as it was considered possible to do so. Skaftárhreppur on the other hand, did not collaborate in the cleaning initiative and farmers within this parish were therefore left out of the initial process.

Officials, however, were quick to remediate this disparity by sending five men from the Directorate of Labour to assist in the clean-up around Álftaver and Meðalland. It was reported that Mýrdalshreppur received some money to cover cleaning expenses but this was not the same for Skaftárhreppur. Officials recognised that economic loss in the area had been far-reaching and it was unlikely that residents would be fully compensated or receive sufficient support: "At first they didn't get clear answers about what to do… and I mean there are still a lot of questions to be answered." Some farmers in Álftaver stated that they had been promised full financial support for recultivating ash-impacted land but they had only received a small part of the cost and many were under economic strain.

Moreover, people believed that the financial crisis and collapse of the Icelandic banks (see Haarde 2008; Danielsson 2009 for details) had affected the government's response and the extent of financial assistance on offer. What money was made available, did not filter down to the local level to where it was most needed: "The farmers and everything they have is this—their whole life is this. People had loans and things… It is harder to fight for your right and look here and look there at what can be done. They are trying. There are some people that are supposed to be helping but I feel that… you can't wait until the people come to you and tell you what is wrong. You have to go and say 'here I am!'"

Nevertheless, at the time of writing, The Icelandic Catastrophe Fund (CAT-fund, Lög um viðlagatryggingu Íslands Nr. 55/1992) had compensated for damages to houses while the Emergency Relief Fund, owned by the Icelandic Government

and the Farmers Association (Lög Nr. 49/2009), had compensated farmers for damage to cultivated land due to flooding and ash loading. However, compensation is only provided if they have paid an agricultural fee[1] (Article 49/2009).

Adding to farmers' concern was the unknown effect on hay. Since their fields were covered in ash, farmers were advised to cut their pastures higher than usual to avoid capturing ash in the hay bales. This resulted in an approximate 30 % loss from normal harvest which could lead to shortages of food in winter. Prior to this, there had been very little discussion among the authorities on how they would deal with the potential shortage of fodder. Farmers in Álftaver suggested (in the national agricultural newspaper (Bændablaðið 2010)) that farms from around the nation harvest more hay than needed in order to form a 'hay bank' that farmers in the ash affected areas could access. This suggestion was received favourably and a 'hay bank' was formed. Regardless of these measures, residents were still concerned about the long-term health effect of ash in terms of teeth degradation and irreparable damage to the digestive and respiratory systems of livestock.

According to some reports, sheep that died during the eruption were not assessed for a cause of death as the cost of performing a post-mortem and transporting the carcass to Reykjavik was estimated at 30,000 ISK (180 Euro). Farmers could not afford nor justify this expenditure when sheep are worth only 5,000 ISK (30 Euro) each. It was believed, however, that very few sheep died because of the eruption (Andrésdóttir and Ólafsson 2011). Although residents were concerned about having to bear these costs, they were quick to admit that it was possibly a small error within the system and that was to be expected as people were learning from this eruption.

In addition to the impacts on agriculture, there were significant impacts on the tourism industry. Several officials recognised the severity of the disruption to local tourism but questioned how it could be accommodated: "...if they are going to pay something to a hotel in this area the hotels in Reykjavík will say 'we were losing money too and we will need to get something as well'." Officials thought it necessary for local tourism operators to receive some compensation and were hoping to work towards an agreement.

At the time of writing, tourist operators had received compensation for damages to their infrastructure from the Icelandic CAT-fund (personal communication, Hulda Ragnheiður Árnadóttir, general manager of the Icelandic CAT-fund). Nonetheless, no compensation has been given for business interruption. However, the Icelandic Government and the Icelandic tourist industry invested 700 million ISK (4.3 million Euro) to finance a special marketing campaign entitled *Inspired by Iceland* (Iðnaðarráðuneytið 2010). Whether or not motivated by this campaign to save Iceland's tourism industry, tourist numbers increased by about 17 % in 2011 from 2010 (personal communication, Oddný Þóra Óladóttir, research manager of the Icelandic Tourist Board).

Health impacts on residents

It was widely recognised and accepted, by officials and residents alike, that people should protect themselves from ash inhalation. However, little was known about how serious protective measures needed to be. Residents (and some officials who were surveyed) questioned whether people, especially children, should evacuate. According to an official, there were thoughts about introducing an evacuation plan for residents in regards to ash fall. It was decided, however, that residents would be safer in their homes due to the risk of lightning. When the ash fall became intense, residents were given the opportunity to evacuate but most declined the offer. One rescue team member who has inherited knowledge of the severity of ash during the 1918 Katla eruption has been fighting for several years for a specific evacuation plan that considers ash fall distribution from Katla, based on current weather reports. At present, all plans are focused on responding to jökulhlaup hazards but "this may be re-evaluated after the experience from Eyjafjallajökull".

During the ongoing crisis, many officials recognised the importance of revising decisions based on current situations: "The first thing you do is you have to be in contact with the people. And to feel how they feel, what are their worst worries… People were worried about the ash and they asked a lot. How will it affect their health? How will it affect the children's health and animals? And the grownups always talked about the kids and the animals. They didn't talk so much about themselves… I know that there are people here [in Vík] who felt very, very badly. They were afraid of the noises and the ash was disgusting but they just didn't feel that they had the right [to complain] because they knew it was so much worse somewhere else."

The Icelandic Directorate of Health undertook medical investigations involving spirometric measurements, blood sampling, and questionnaires regarding physical and mental symptoms (Briem 2010). The research was carried out among 207 exposed residents living between the river Markarfljót and the township of Vík from 31 May to 11 June

[1] The agricultural fee (Búnaðargjald) is 1.2 % fee based on the turnover of agricultural production including wool, meat, milk, etc. All farmers are required to pay this fee to the government and part of it is allocated to the Emergency Relief Fund (Bjargráðarsjóður). Those who do not sell their products on the market, e.g. hobby farmers or retired farmers, and choose to not pay this fee do not have access to the Emergency Relief Fund.

2010. While the results revealed that the majority of participants were in good health with no serious problems relating to the eruption, approximately 11 % were suffering from reduced respiratory activity (Briem 2011). Residents in Álftaver were not asked to participate in the investigation, but they reported respiratory problems and sore eyes during periods of ash fall and redistribution.

Furthermore, residents felt that the health survey did not take into account the psychological impact, which varied throughout the community. For example, some farmers in Álftaver stated that they were not at all emotionally affected by the eruption, while others said they were greatly affected. It was obvious to several officials that many adults suffered tremendous stress during the eruption and the continual redistribution of ash exacerbated their experience: "Everyone was disappointed. It [the eruption] stopped coming up from the glacier, there were two good days and then there was some wind and everything was as black as before. That was really a hard time because then people realised that it could continue for some time." During these days, buildings were cleaned and re-cleaned, newborn lambs were constantly fed and cared for, and preparations were undertaken for the annual confirmation ceremonies of local teenagers (aged 13 or 14 years). Confirmation ceremonies are a significant part of Icelandic culture, and it was important that this continued as planned, regardless of the ash. Although the ceremony gave people some normalcy during the crisis, it was evident that it placed immense pressure on them.

The psychological impact on children is more difficult to quantify: "What we know about children is when they feel bad and when they are worried they don't really talk about it so it's very important to take good notice and to follow up… [The children] keep it by themselves if they are really worried because they don't want to make mom worry more." The district nurse felt that Katla will be more real to the children after their experience during the Eyjafjallajökull eruption and this could lead to further anxiety during emergency response preparations: "Of course we have to be prepared, we can pretend that Katla isn't here but we have to be aware of how they [the children] can think."

Changes in attitudes and behaviour

It was apparent that most residents' and officials' personal experience of ash fall from Eyjafjallajökull had given them a greater perspective and understanding of what to expect from Katla. As a consequence, people's attitudes towards emergency management had changed since the 2004, 2006, and 2008 surveys (Table 2). Moreover, officials' perceptions of risk are more aligned with residents in relation to ash, jökulhlaup and lightning. When asked to rate levels of preparedness, Álftaver residents stated that they themselves and the rescue teams are prepared to deal with a future Katla eruption. This is an interesting result as past surveys showed that residents underrated their personal level of preparedness (Bird 2010; Bird et al. 2011) and this result was based on people's perceptions prior to experiencing an eruption themselves. It is therefore possible that residents have actively prepared themselves following this first-hand experience.

The 2010 survey also showed that residents rated their neighbours as slightly less prepared than themselves

Table 2 An overview of changes in residents' attitudes in relation to the 2010 Eyjafjallajökull eruptions based on results presented here and from Jóhannesdóttir (2005); Jóhannesdóttir and Gísladóttir (2010); Bird (2010) and Bird et al. (2009, 2011) (these conclusions are based on a combination of both qualitative and quantitative data)

Before the eruption	After the eruption
Residents displayed inherited and acquired local knowledge, attachment to place, community cooperation, and neighbourliness	Residents have inherited and acquired local knowledge as well as direct experience. They displayed values of attachment to place but less community cooperation and neighbourliness
Residents want community involvement in emergency response procedures and were frustrated because they had not been involved in developing plans	Residents are more positive about their involvement in the development of emergency response procedures
Residents' risk perceptions differed from emergency management agencies	Officials' risk perceptions are more aligned with residents by recognising the threat of ash and lightning hazards
Residents perceive that evacuating to Kirkjubæjarklaustur will make them more vulnerable to ash, lightning or jökulhlaup. They will therefore adopt a 'Plan B' and evacuate to Herjólfsstaðir or Mýrar.	Residents still perceive that evacuating to Kirkjubæjarklaustur will make them more vulnerable to ash, lightning or jökulhlaup. They will therefore adopt a 'Plan B' and evacuate to Herjólfsstaðir or Mýrar.
Connection to livelihoods (e.g., concern for livestock) and inherited knowledge were influencing residents ability to comply with evacuation orders	Connection to livelihoods (e.g., concern for livestock) and inherited knowledge were still influencing residents ability to comply with evacuation orders
Residents had not adopted personal preparedness measures	Residents are adopting personal preparedness measures and rate themselves as better prepared
Residents trusted information provided by scientists	Residents still trust information provided by scientists

(not assessed in previous studies) but more prepared than the Icelandic Civil Protection Office and the police. Nevertheless, residents viewed the Icelandic Civil Protection Office as better prepared in 2010 than they did in 2008.

Bird et al. (2011) described values of community cooperation and neighbourliness within Álftaver. However, issues described in "Discrepancies in financial and physical assistance during the response and recovery phases" section suggest otherwise. Some people stated that the eruption had no impact on them and residents were critical of each other in terms of requesting assistance.

Residents still believe that it is unlikely that Katla will erupt in the next 10 years and even more unlikely that it will erupt in the next year (not assessed in previous studies). On the other hand, residents feel that their community and property will suffer damage in the next eruption but it is unlikely that they will be injured or their home damaged. In spite of this, some residents admitted to making changes to their household to help them deal with a future eruption. These changes include ensuring masks and protection goggles are on-hand in addition to acquiring specialist knowledge in regards to cultivating ash-impacted soil.

Álftaver residents still have the greatest trust in information provided by scientists, followed by family/friends (not assessed in previous studies) and the Icelandic Civil Protection Office. However, residents' trust in information from scientists was slightly lower than that recorded in 2008. Residents ranked the police fourth as a trusted information source and the media were ranked last. Similar results were found by Bird (2010) but it is possible that trust in information from the police will be greater in communities in the immediate vicinity of Eyjafjallajökull since the police were in direct contact with residents during the crises and were often the first responders.

Lessons learned from the 2010 Eyjafjallajökull eruptions

There is no doubt that residents and officials have learned valuable lessons from the Eyjafjallajökull eruptions. Many people believed that the Eyjafjallajökull eruptions were "*a good exercise*" for Katla and learnt that response efforts must encompass an all hazards approach instead of focusing solely on jökulhlaup hazards. Emergency management officials are consulting with local residents and involving them in the development and implementation of response procedures. This will help to ensure that officials are aware of and consider the various cultural, economic and social issues affecting residents' ability to comply with warning and evacuation messages.

Even though residents of Álftaver are considered to be resilient (Bird et al. 2011), the isolation of the community and the lack of communication between officials and residents made them vulnerable during the eruptions. Moreover, the differing hazard experiences triggered feelings of isolation further heightening their vulnerability. Such situations need to be acknowledged by emergency managers and municipality officials. Some of these factors, coupled with those identified in the 2004, 2006, and 2008 research (Fig. 3), will impact on people's ability to prepare and comply with future warnings and evacuation messages.

It is also important to bear in mind that disasters have no borders. Impacts are not restricted within municipalities or in areas where the greatest ash fall has occurred. Response and recovery efforts must therefore encompass impacts at an individual and/or local level. People have varying levels of ability to recover from disaster, and these differences must be taken into consideration.

Officials and residents recognised that beyond the physical impact of the ash on peoples' health, psychological impacts need to be prepared for. The experience of issues related to the ash aided the Icelandic Governments' decision to increase health care services in the impacted area of the 2011 Grímsvötn eruption, not only in the form of general doctors and nurses but also psychiatrists (Forsætisráðuneytið 2011).

Gustafson (2009) showed how important it is for children that parents remain calm and sensible during traumatic situations. Messages to children must include information balanced with recommendations for reducing risks. Importantly, curriculum developers as well as teachers should balance negative information with more positive messages that may put a traumatic situation into perspective.

Many people were concerned about their economic situation and lack of compensation: impacts on properties, damages to vehicles and agricultural machines, and unexpected business expenses were outside of the defined role of the Icelandic CAT-fund and the Emergency Relief Fund (Búnaðarsamb and Suðurlands 2011). A similar situation was experienced in the aftermath of the earthquake in south Iceland in 2008 (Forsætisráðuneytið 2010). To avoid unnecessary economic failure, it is important to increase knowledge about insurance in relation to natural hazards. Residents must be encouraged to insure their properties and belongings as a part of their emergency response plans. Moreover, residents must prepare for ash by ensuring they have appropriate masks, spare air filters for vehicles, and defensive tools to protect infrastructure (Bird et al. 2011).

Individual tourist businesses suffered significant economic losses and this was aggravated by media discussion as tourists were reluctant to visit the region. An effective response plan for local tourism is therefore vital to increase community resilience. The experience from Eyjafjallajökull encouraged the Icelandic Government to support local tourism following the Grímsvötn

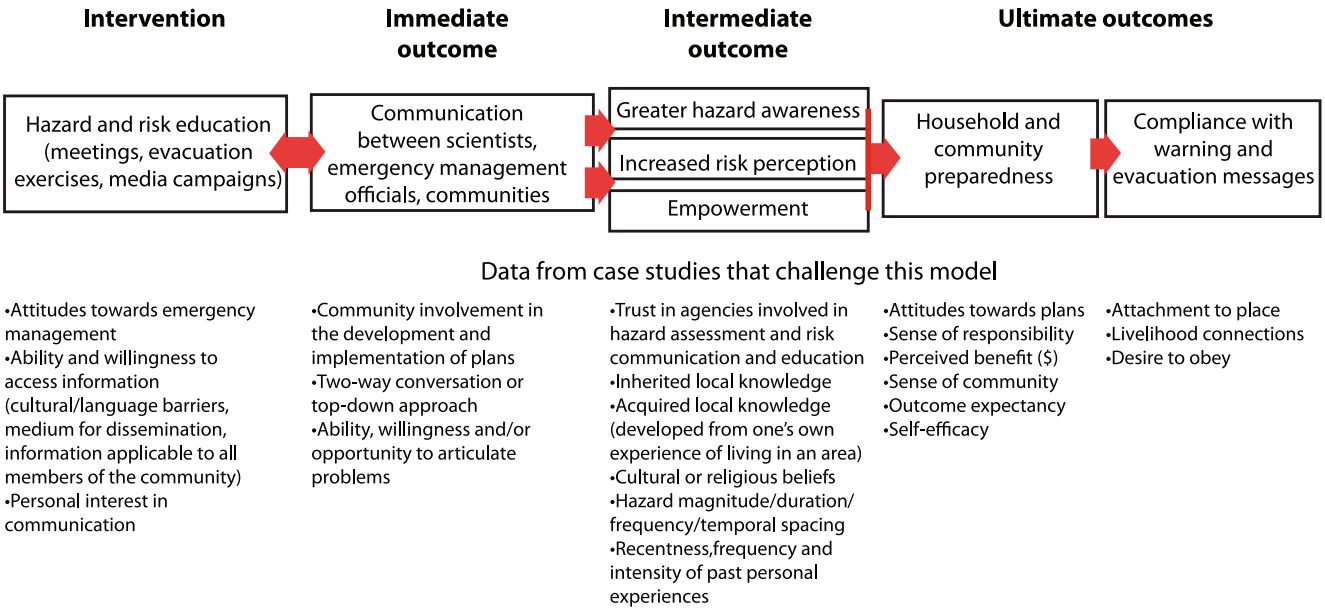

Fig. 3 Logic model of assumed process from education to response and the factors that impede successful outcomes based on results presented here and from Jóhannesdóttir (2005); Jóhannesdóttir and Gísladóttir (2010); Bird (2010) and Bird et al. (2009, 2011)

eruption in 2011. This included posting extra personnel to mitigate and prevent negative discussions in the media. These positions were also tasked with marketing and strengthening regional information centres located in the south and south-east. The government also financed positions at the Katla Centre in Vík which focuses on culture, knowledge and research from within the region and the Katla Geo-Parks (Iðnaðarráðuneytið 2011).

Most importantly, officials recognised that things could be done better with respect to providing more detailed information about the impacts of ash and ensuring that people are better informed. Plans devised for a Katla eruption focused on the immediate response to preserve life. It appeared that there were no plans to deal with an ongoing crisis nor were there strategies to preserve livelihoods (in this case agricultural practices and safeguard livestock). One advantage that Iceland has over other regions is that sheep and cattle are housed during the winter. Farmers therefore have the capacity to safeguard most of their livestock in winter whereas this would be impossible to achieve in summer when from June to August/September sheep are free to roam, uncontained in the highlands. Furthermore, and as highlighted during the Eyjafjallajökull experience, it is difficult to provide shelter for all livestock during the lambing period as livestock sheds are not built to house one to three lambs per ewe.

Conclusion

This paper has taken advantage of an unusual situation where social data had been collected not only before and after an evacuation exercise but also following an *actual volcanic crisis* within the same case study area. While social science research can provide an insight into how and why people behave in a certain manner at a particular point in time, it should not be assumed that this behaviour will be replicated during future events. Nevertheless, a critical insight into the many factors that influence people's ability and willingness to respond to emergency management advice and warnings can be achieved by investigating attitudes and behaviour through longitudinal, qualitative and quantitative research methods.

The research presented here identified trends in people's attitudes and behaviour within a specific community over a number of years. It also showed that factors such as community cooperation and neighbourliness, which had been previously identified in 2004, 2006, and 2008 as important attributes in reducing residents' vulnerability, were apparently lacking during and after the Eyjafjallajökull eruption. In comparison, attachment to place and connection to livelihood remained important factors influencing residents' decision-making. Residents' have ongoing concerns regarding their vulnerability to ash, lightning and jökulhlaup hazards during future volcanic events. Significantly, the research provides a deeper understanding of the public's strengths and weaknesses, not only prior to and during a volcanic event, but also through the recovery phase.

While emergency management agencies provided immediate response plans to the community to preserve life and disseminated geophysical information during the crisis, a lack of information was identified with respect to ongoing problems associated with ash fall. Prior to and during future events, emergency management agents must therefore

ensure that residents are provided with detailed facts on the effects of ash fall on humans and agriculture, including necessary precautions and preparedness strategies to help reduce these risks. Moreover, officials must work in close collaboration with local communities in all affected areas to help them recover from physical and psychological impacts. Most significantly, however, this research demonstrates the importance of collecting longitudinal, social data before and after natural hazard events as such information can assist in developing safer, more resilient societies.

Acknowledgements All respondents are graciously thanked for their willingness to participate in this investigation. Contributions from the Ash Fall Impacts Working Group, Katharine Haynes, Carolina Garcia Londoño, and Guðrún Pétursdóttir are appreciated in relation to the development of the questionnaire. Reviews on early drafts of this paper by Pat Bazeley, Benjamin Gillespie, and Katharine Haynes are also appreciated. Further gratitude is extended to the handling editor, Clive Oppenheimer, and two reviewers, Ilan Kelman and one anonymous, for providing insightful comments and detailed recommendations which helped improve the manuscript from the original. This work was financially supported by Rannís—the Icelandic Centre for Research (Research Grant #081260008) and Vegagerðin (The Icelandic Road Administration).

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