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Invited review article

Haze, Hunger, Hesitation: Disaster aid after the 1783 Laki eruption

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ABSTRACT

The 1783–1784 Laki eruption was one of the most severe natural catastrophes to occur in Iceland since settlement (around 870 CE). Vegetation damage by sulphate aerosol and fluorine poisoning caused a massive decimation of livestock which brought famine and excess deaths of 1.6 of the population. 18th Century Iceland was a Danish dependency and, despite the abundance of fish in the surrounding waters, a subsistence farming community and thus highly dependent on livestock. During the famine, the Danish government was in principle willing to provide relief. However, local authorities in Iceland were slow to ask for help, and did not dare to exploit the means at their disposal (e.g. the right to ban the export of Icelandic foodstuff) without consent from Copenhagen. The Danish officials in turn were unwilling to act decisively upon incomplete information. These two factors prevented timely measures. While $4.4 \times 10^5 kg$ of grain were provided for famine relief in summer 1784, the merchants exported $1.2 \times 10^6 kg$ of fish, which greatly aggravated the hunger in the second winter. The effects of this 'natural' catastrophe could therefore have been significantly reduced by efficient government measures.

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1. Introduction

The 1783 Laki eruption was, in terms of lava output, the second largest eruption in Iceland since the country was inhabited around AD870. Lasting from June 8th, 1783 to February 7th, 1784, it produced about $15 km^3$ of lava (Thordarson and Self 1993), spread fine poisonous ash over most of the island, and produced a persistent sulphurous haze which was observed over large parts of the Northern hemisphere (Thordarson and Self 2003; Thordarson, 1995) and caused wide-spread climate perturbations, including significant northern-hemisphere cooling (Zambri et al. 2019a, 2019b, and references therein).

The so-called Haze Hardships (*Móðuharðindin*) were accompanied by a severe population decline in Iceland, from 48,925 at the end of 1783 to 38,368 at the end of 1786 Hálfdanarson (1984). (No decline was recorded during 1783.) Disregarding the ca. 1500 victims of a smallpox epidemic which started in November 1785 (and may have been causally unrelated to the eruption), and assuming a normal mortality rate of 30/1000 (the average of 1778–1782, (Hálfdanarson 1984; Gunnarsson, 1983)), the excess mortality for 1784–85 was around 8000 persons, 1/6 of the 1783 population. Population decrease was aggravated by a reduction of births, particularly in 1785–86 Vasey (1991).

Written accounts (e.g. Steingrímsson (1788/1998); Finnsson (1796)) agree that the main causes were famine - caused by loss of livestock - and "landfarsótt", nonspecified contagious diseases. Hálfdanarson (1984) argues that "landfarsótt" were not directly hunger-related diseases (such as scurvy). However, it could still be an indirect consequence of hunger, because seemingly unrelated diseases often surge during famines (Ó Gráda, 2007). More recently, fluorine poisoning and inhalation of volcanic haze have been suggested as additional contributors to human mortality (Grattan et al. 2003; D'Alessandro, 2006; Balkanski et al., 2018; Schmidt et al. 2010). A critical review of this hypothesis will be left for another study. The current paper will discuss the famine and relief operations.

Perhaps remarkably for those times, the government of Denmark - of which Iceland was a dependency - was in principle willing to provide significant famine relief, but on the whole the operation was not successful. In the English literature, this attempted disaster relief has received relatively little attention. A milestone contribution on the history of the Laki eruption is the Icelandic volume 'Skaftáreldar 1783–1784' (The Skaftá Fires/Laki eruption 1783–1784), which contains research articles and a compilation of original letters, mostly reports by Icelandic officials to the Danish authorities (Gunnlaugsson and Rafnsson 1984). The history-oriented chapters still provide valuable material which to my best knowledge is not available in such detail in English. The current article reviews this material, also in the light of studies on the socio-economic situation in Iceland such as Gunnarsson (1983); Eggertsson (1998); Vasey (2009). Historical sources are used to add some details. Original contributions in this study are the quantification of aid measures in terms of calorie intakes, and the attempt in the final section to interpret the disaster aid from a risk reduction perspective.

The most important original sources used are: a collection of laws and regulations for Iceland (Stephensen and Sigurðsson, 1854), accounts by the Icelandic parson Jón Steingrímsson (Steingrímsson 1788/1998, 1791/2002) and the student Magnús Stephensen (Stephensen 1785), a treatise by Bishop Hannes Finnsson Finnsson (1796), and the reports in (Gunnlaugsson and Rafnsson 1984, p. 299–417). These are letters by Icelandic officials to the Danish authorities, and statements by local farmers (þingvitni), sent in 1784. They will collectively be referred to as [Rep1784]. For a summary of these reports, sorted by topic, see the Supplementary Material (referred to as SMx, where x is a section number).

First, an overview over Iceland's socio-economic situation will be given, with particular focus on famine vulnerability (sect. 2). The eruption's impact on food production is described in sect. 3. Next, a chronology of attempted relief is given (sect. 4), followed by a discussion of its effectiveness (sect. 5) and a brief summary of lasting effects of the eruption (sect. 6).

2. Iceland's socio-economic situation

This section presents an overview of Iceland's administration, food production and trade.

2.1. Administration

Iceland was a dependency of Denmark-Norway, and was ruled from Copenhagen. The administration was ordered in a hierarchical fashion (see Fig. 1). As Denmark-Norway was an absolutist monarchy, all power officially lay with the King by God's grace. King Christian VII, however, was mentally ill, so de facto power lay with those who attained control over the king. From 1772, this had been the conservative Ove Høegh-Guldberg, but in April 1784 he was succeeded by crown prince Frederick. Although 'the Crown' had to sign most decrees concerning Iceland, actual decision making was left to lower administrative bodies, especially the Rent Chamber (*Rentekammeret*, the finance department), which issued orders to and received annual reports from the Icelandic officials.

The highest official on the island was the governor (stiftamtmaður); in 1783 the office was held by an elderly Norwegian named Lauritz Thodal, who was regarded a competent, well-willing governor, but suffered from ill health at the time of the eruption (Stephensen & Sigurðsson, 1854, vol. 4, p. 759). In north and east Iceland he was represented by the deputy governor Stefán Þórarinsson, an energetic young Icelander who had replaced his uncle Ólafur Stephensen in July 1783. Under them stood the roughly twenty district commissioners (*sýslumenn*). See Fig. 2 for a map of the districts (*sýslur*, singular *sýsla*). On an even more local scale, the communal overseers (*hreppstjórar*) organised local matters, especially poor relief. The clergy (two bishops, about 16 deans, and the parsons) also performed administrative tasks, such as keeping parish records and co-organising poor relief.

The Rent Chamber also gave orders to the director and local representatives of the Iceland trade company (sect. 2.3.1). Its chief executive, Carl Pontoppidan, was situated in Copenhagen, while the trade representatives stayed in Iceland. It was stipulated that local merchants and Icelandic officials cooperate (Andrésson 1984; Gunnarsson, 1983). District commissioners had to control the quality of goods, order goods for the following year, inform the Rent Chamber about possible complaints, and supervise emergency loans (sect. 2.3.2).

Formally, the government system was top-down, but in reality, Icelandic officials were often consulted by the central government (Karlsson 2000, ch. 2.12). Still, Stephensen & Sigurðsson (1854) shows that the Danish authorities minutely regulated even minor administrative issues such as the height of contributions to an insurance for widows of Icelandic reverends or funding for repairing old medical instruments (a cost of 11 ríkisdalir 82.5 skildingar, roughly the value of two cows). The instructions for the newly appointed Stefán Þórarinsson (Stephensen & Sigurðsson (1854), vol. 4, p. 728–740) repeatedly order

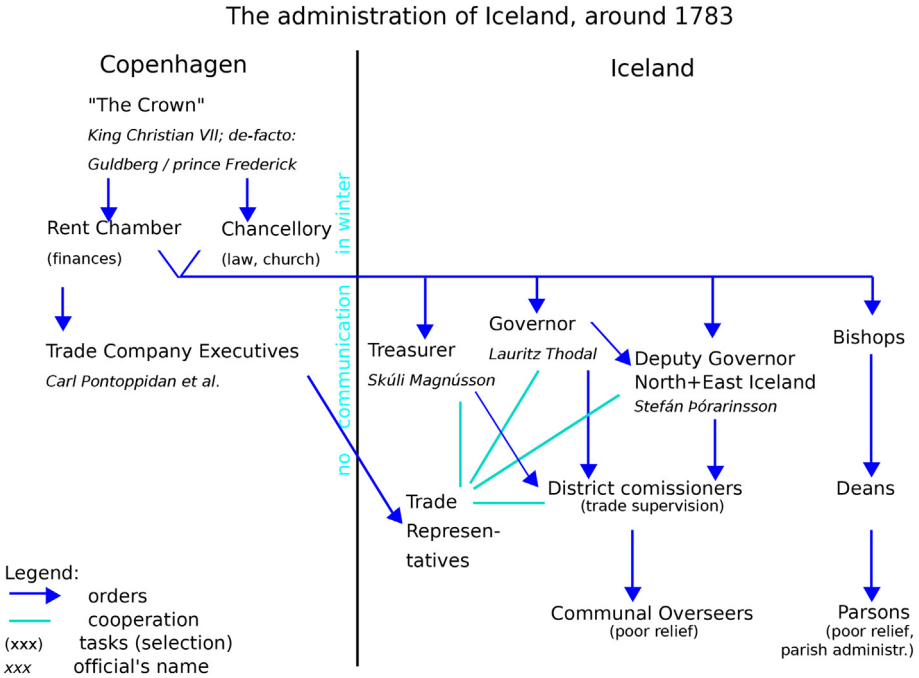

Fig. 1. Structure of the administration of Iceland in the late 18th century. The names of the officials are for July 1783–April 1785. Based on Gunnlaugsson, 1984; Gunnarsson, 1983; Steingrímsson 1791/2002, p. 309ff (comments by translator).

him to submit suggestions, complaints, or observations to the Rent Chamber. A point not raised in the instructions is the possible need for independent action during emergencies. However, as crossing the North Atlantic in the stormy season was considered infeasible, it was impossible for Icelandic officials to consult their superiors during winter.

2.2. Food production and local safety net

2.2.1. Farming and Fishing

The Icelandic economy consisted mainly of subsidence farming, combined with some fishing. There were no urban centres: The largest settlement, Reykjavík, had about 200 inhabitants.

Farmers mainly kept cows and sheep for food (mostly dairy), clothes (wool) and light (tallow). Horses were used for transport. Although most winters had mild intervals in which the animals could graze, the hay harvest was of utmost importance to keep the livestock alive. After the hay harvest, farmers had to decide how many animals they would try to keep alive over the winter; the rest was slaughtered. However, farmers tended to take considerable risks, often not reducing their herds sufficiently to get their animals through a harsh winter (Eggertsson 1998), which could lead to large losses of sheep even under conditions far less extreme than the Laki eruption. In 1784, farmers in several regions regretted not to have reduced the livestock sufficiently in the previous autumn (see SM3).

Fig. 2. Overview map of Iceland, with districts and the trade posts active in 1783 (data from Gunnarsson (1983)).

Horse meat was usually not eaten (Andrésson (1984), although an official ban (going back to a papal decree of 732 CE) had been lifted in 1757. Wild food could complement farming products: land-based sources included birds and eggs, lichens (Iceland moss, *Cetraria islandica*), berries, and freshwater fish, while the sea provided sea shells, seals, and of course fish Hambrecht (2009).

Although the sea around Iceland is rich in fish, fishing remained secondary to farming. It has been estimated that about 2/3 of the catch (110 g of dried fish or roughly 400 kcal per person per day) served for domestic consumption and the remainder, mostly high-quality dried cod, was exported (Karlsson 2000, ch. 2.14]. Valuable migratory cod was abundant in the Southwest of Iceland in winter and spring, and in the Northwest in spring (i.e. in a time when there was little farm work). The cool and windy conditions allowed wind-drying fish. In the North and East, fishing was possible from spring (if not hindered by sea-ice) to autumn, but had to be interrupted from July to mid-autumn for hay making (Ogilvie and Jónsdóttir 2000). Farmers in these regions could send their farmhands to the southwest to participate in the winter fisheries or barter fish for farming products.

Fishing was hampered by technological level (using open rowing boats, rather than decked vessels like foreign fishermen visiting Iceland), artificially low fish prices (sect. 2.3), and administrative measures: The formation of fishing villages was prevented by laws prescribing that everybody had to be registered at a farm - either as farmer or as farmhand (Gunnarsson, 1983; Eggertsson 1996). These factors kept Iceland in a "poverty trap" of relatively unproductive subsistence farming, while the rich maritime resources remained underused.

Nonetheless, Icelandic food production was adequate in normal times. Jónsson (2009) estimated that male and female farmhands were entitled to rations of 3300 and 2600 kcal/day, respectively. Taking into account that children and possibly non-working elderly ate less, I will use 2500 kcal/day as a rough estimate for normal average calorie intake. During the census of 1703, Iceland had 24,467 cows and 167,937 ewes. A cow could produce about 1600 l of milk per year (Jónsson 2009). If the traditional value ratio "1 cow = 6 ewes" roughly reflects milk production, then milk alone may have provided 2500 kcal/day for 57,000 persons (assuming 625 kcal/l milk). The actual population in 1703 was only 50,358 (Karlsson 2000, ch. 2.14) and never rose much above 50,000 through the 18th century. This population ceiling was a product of birth control rather than endemic hunger (Gunnarsson, 1983; Vasey 2009): Acquiring a farm was required for marriage, and since the number of farms was roughly fixed, the number of married couples was limited. Iceland was thus not, in a Mathusian sense, overpopulated, but severe events, especially consecutive cold years, could cause famine (Finnsson 1796).

Storing food provided a buffer against bad years. Steingrímsson (1788/1998) reports that several (wealthy) farmers had more than enough food to last through the crisis of 1783–85; probably even poorer households accumulated some reserve in good years.

2.2.2. Local safety net

At least in principle, everybody in Iceland was entitled to food and shelter (Eggertsson 1998). Servants were mostly paid in food, shelter and clothes, and working contracts between farmers and farmhands lasted for a year; servants could thus not be turned out in winter or in case of temporary illness. Households with sufficient means were obliged to take in their poor relatives, and poor people without suitable relatives had to provided for by their commune (*hreppur*). Communes could also support households in temporary difficulties.

Food was thus fairly well distributed among farmers, workers, and paupers on communal assistance, although vagrants and beggars also existed. However, this safety net operated only on a local level (there were about 160 communes in Iceland), hence climatic or volcanic risks could affect the whole commune and overwhelm the system. After the Laki eruption, several communes had more than two paupers per household, partly because farmers could not afford to hire farmhands, who then became paupers (Finnsson 1796). In many regions, farmers were forced to give up their farms and become vagrants (see also SM8).

There was no strong relief organisation beyond the local level, except some church charity. The bishops of Skálholt donated 20 ríkisdalir from a 'fund for the poor' to the parishes closest to the Lakagígar (Steingrímsson 1791/2002), ch. 41) - the value of 20 ewes for a population of several hundred persons. Neither the communes, nor another authority, organised food or hay stores; this would likely have been difficult because building and transport were expensive. The Land Commission of 1770 suggested to build emergency stores at all trading centres to prevent famine. This suggestion was not carried out (Andrésson 1984); instead, an emergency credit system was decided upon (sect. 2.3.2).

2.3. Trade

2.3.1. Monopoly Trade

This section is based on the extensive study by Gunnarsson (1983).

Iceland was not a self-sufficient economy: It depended on the import of building wood (for houses and boats), iron (tools) and hemp (fishing lines). Grain was also imported, but in normal years it was a luxury good rather than a necessity. As export goods, Iceland mainly offered wool products, sheep meat and hides, and dried fish. The trade was carried out by merchants or trade companies from Copenhagen who rented the Icelandic harbours from the Crown and had a trade monopoly. From 1774, the trade was carried out by a company run by the Crown. Iceland had around 25 trade harbours (see Fig. 2), which were mostly visited by one ship per harbour and per year, ships arriving in late spring and leaving in early autumn. In northern Iceland, sea ice occasionally prevented ships from landing. In 1785, blocking of two harbours likely contributed to the high number of deaths in Húnavatnssýsla that year Hálfdanarson (1984).

Trade was mostly carried out by barter, partly because merchants preferred selling brandy and tobacco to handing out money. However, this made it difficult for the farmers to save money for bad years (or better fishing boats). All prices were fixed by the Crown. For many decades, fish prices in Iceland were very low compared to prices abroad, making dried fish a lucrative export good for the merchants. During the American war of Independence (ending in 1783), Icelandic fish fetched particularly high prices in Europe, as no fish was imported from Newfoundland.

The trade company was the only agency providing transport to and from Iceland, hence it was *the* organisation through which the government could administer relief.

2.3.2. Trade as buffer against food crises

Trade can smoothen local food shortages. Domestic trade within Iceland was common, e.g. farming against fishing products. However, under distress, it could happen that farmers (or fishermen) had nothing to barter. Transport could also be a limiting factor: Coastal shipping or navigable rivers hardly existed, neither did roads, bridges and carts, so goods were transported on horseback, and horses (and healthy men) were scarce after the Laki eruption (see SM7&8).

The monopoly trade company both imported and exported food. Grain import averaged 16,950 Danish tons or $1.4 \times 10^6 kg$ over 1763–84(Andrésson 1984), whereas the export of mutton amounted to 3223 barrels ($4 \times 10^5 kg$) around 1770 and dried fish to 8120 skippund ($1.3 \times 10^6 kg$) (Gunnarsson, 1983). As a rough estimate, assuming a population of 50,000 and a daily calorie intake of 2500 kcal/person, imports and exports amounted to 41 and 47 daily rations, respectively. The export volume can be regarded as the maximum buffer provided by trade: If the distressed population could obtain the imported grain without handing in the food earmarked for export, about 7 weeks of additional food could have been gained with respect to normal years. This would require either the possession of sufficient

non-food tradable goods or cash reserves, or a credit system. Many households lacked tradable goods in bad years. Woollen products were the most important non-food export good, but wool could be scarce when very many sheep were dying, at least in the second winter, after the wool from dead sheep was used up. Cash reserves were scarce; in fact, farmers used to be indebted with the merchants, obtaining goods for credit in early summer and paying with farming products by the end of the year (Gunnarsson, 1983).

The trade regulations from 1776 stipulated that if widespread hunger threatened, the governor, deputy governor and district commissioners could ban the export of Icelandic foodstuff (Andrésson 1984). In addition, the merchants were obliged, in cooperation with the district commissioners and communal overseers, to give farmers in distress an emergency loan of foodstuff and tools, typically for one year. This rule was clearly meant as a temporary relief measure and did apply neither to officials, who were considered wealthy enough to not need emergency loans, nor to persons deemed unlikely to be able to pay back the loan. However, it is doubtful whether this law could have prevented a nation-wide famine, because the trade company did not have significant emergency stores of food in Iceland, particularly in winter. To make things worse, in early 1783, the authorities in Copenhagen felt that the emergency loans had been abused (even by officials) and sent stern orders both to the merchants, who should collect outstanding debts and give fewer credits, and to the Icelandic officials to pay their debts and be less generous in suggesting ordinary farmers for loans (Andrésson 1984).

Increasing food import during a crisis was time-consuming, because shipping between Iceland and Denmark only occurred in summer, i.e. orders could be placed only for next year. In 1774 and 1778, it was discussed whether a Danish ship should annually be sent to Reykjavík in autumn, stay there over winter and return with news in spring (Stephensen & Sigurðsson (1854), vol. 4, p.107, p.437). Maybe the measure was not implemented; at least in spring 1784, no ship was sent from Reykjavík to Denmark. In 1787, this postal service was definitely established (Stephensen & Sigurðsson, 1854, vol. 5, p. 432).

To summarise, the Icelandic society provided considerable safety against moderate crises and individual misfortune, but logistical obstacles faced any large-scale famine relief.

3. The effect of the eruption on food production

The Laki eruption affected Icelandic food production in several ways. Locally, 42 farmsteads and cottages (≈0.8% of all Icelandic farms) were given up temporally or permanently directly because of the eruption (Fig. 3). Others were abandoned for other reasons including loss of animals (Guðbergsson & Theodórsson, 1984). Several hundred persons lost their homes; 500 out of 1964 inhabitants of Vestur-Skaftafellsýsla left the district, mostly moving west, either to other farms or to the fishing districts, e.g. Vestmannaeyjar and Gullbringusýsla (Gunnlaugsson 1984a).

The sulphurous haze and deposition of sulphur compounds caused severe damage to the vegetation over almost the whole island. Grass whitened, withered to the roots (Steingrímsson 1788/1998). Grass growth, and hence the hay harvest, was reduced, and it was observed that the hay had less nutritional value, so that 1.3–3 times the normal amount was needed to feed the animals (see SM2). The situation was aggravated by lack of sunshine (due to the haze) and by the very cold winter 1783–84, which prevented grazing and inhibited grass growth in the following spring, due to frozen grounds. Strong rainfall spoilt the hay harvest in summer 1784. Secondary food suppliers like lyme grass, berries, and Icelandic moss were also diminished by the eruption (Steingrímsson 1788/1998; Pétursson et al. 1984).

Livestock was severely affected by the eruption (see Table 1), both through lack of fodder and through fluorine poisoning due to ash deposition (Pétursson et al. 1984; Thordarson and Self 2003; Thordarson, 1995). Gas poisoning or inhalation of ash particles may have added to

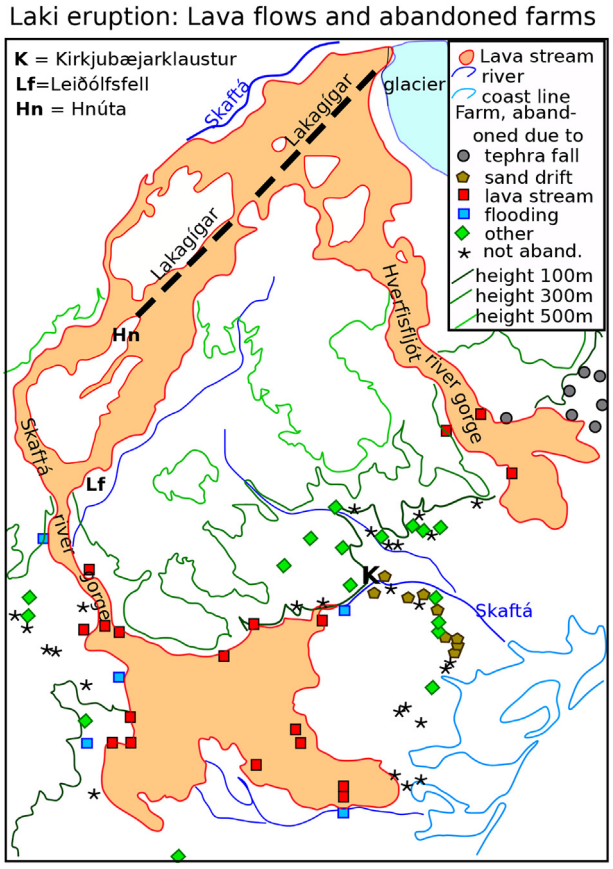

Fig. 3. Map of the surroundings of the Lakagígar (based on (Thordarson and Self 1993, fig. 7) and (Guðbergsson & Theodórsson, 1984, chap. 6.3)). Sand drift occurred due to exposure of the Skaftá river bed when the river temporarily dried up due to lava streams. Inundation was caused by tributaries dammed up by lava.

the symptoms (Pétursson et al. 1984). A drop in milk production to one-half or even nothing was noticed immediately after the arrival of the haze in Vestur-Skaftárfellssýsla (Steingrímsson 1788/1998), but also in the north (see SM3), where the milk yield did not suffice to feed the people, let alone to set aside winter stores. Animals, especially sheep, started to die within two weeks after the onset of the eruption in nearby parishes (Steingrímsson 1788/1998); elsewhere it took several month for livestock to die (Pétursson et al. 1984). The southwest and especially the northwest escaped relatively lightly (Rafnsson, 1984; Thordarson, 1995). In many regions, animals starved or had to be culled for lack of hay, and in some cases to provide meat for humans, e.g. in Þingeyjarsýsla (see SM2,3). The loss of horses prevented farmers from fetching food from trade posts or reaching fishing stations.

Wild animals, such as fresh water fish and birds, were also reduced (Steingrímsson 1788/1998; Pétursson et al. 1984), but there is no indication that marine fish was affected. However, during summer and autumn 1783, fishermen often could not go out due to poor visibility

Table 1
Number of farming animals in Iceland before, 2 years after, and 12 years after the Laki eruption. Based on data from Rafnsson (1984).

	1703	1785 (% of 1703)	1795
Cattle (total)	35,860	16,592 (46%)	22,488
Cows	24,467	12,898 (53%)	15,497
Sheep (total)	278,994	64,459 (23%)	241,171
Ewes	167,937	43,895 (26%)	139,125
Horses	26,909	12,786 (48%)	22,599

caused by the haze (SM4). In winter and spring 1784, sea ice hampered fishing in the north and east. The district commissioner of Snæfellsnessýsla, a main fishing district, complained that several boats in his district could not venture out for lack of healthy men from the north, who were too weak or had too few horses left to come fishing. In the main fishing regions in the west and southwest, the spring fishing was not bad overall, and the Danish merchants were able to buy roughly the average amount of fish in winter/spring 1784 (Andrésson 1984). Often good and meagre catches occurred in close vicinity (SM4), so yields could have been higher if the Icelanders had possessed more seaworthy boats to cover greater distances and to follow the fish like foreign vessels did.

Food shortage in most of Iceland led to starvation deaths from December 1783 (after food reserves were used up) to summer 1785 (Hálfdanarson 1984).

4. Disaster (mis)management

Successful famine relief would have to overcome three problems: Increasing the amount of food in Iceland, by increasing import or reducing export; distributing the food across regions; and enable even households with insufficient cash reserves or barter goods to access it. As outlined below, success on all three counts was limited.

4.1. Troubled communication

4.1.1. Reports to Copenhagen in 1783

In the vicinity of the Lakagígar, the threat of (local) famine quickly became imminent. Reverend Jón Steingrímsson, the dean of Vestur- and Austur-Skaftafellssýsla, reacted quickly and wrote several reports to the bishop in Skálholt, asking for financial aid (Rafnsson 1984b). On July 4th, he also sent a letter to the parting deputy governor Ólafur Stephensen, which includes a cautiously worded plea for government help: “May God [...] awaken the hearts of the officials so that they report the misery which befell this district to His Royal Majesty, who in His mercy will not let us die from hunger and wretchedness” (Steingrímsson 1783). Ólafur Stephensen passed this letter on to Copenhagen along with his own report dated August 15th (Stephensen 1783). The governor, Lauritz Thodal, only informed the government on September 16th (Gunnlaugsson and Rafnsson 1984, editor's comment in section II), because he first wanted to gather more precise information - a serious delay seeing that the season for crossing the Atlantic was closing. The first news of the eruption to reach Copenhagen were no official report but a few, rather inaccurate remarks in a letter by merchant J.C. Sünckenberg of Reykjavík to the directors of the trade company. It reached the capital at the end of August.

4.1.2. The investigation ship and Danish hibernation

Despite the vagueness of the first reports, the Rent Chamber took action and decided on September 17th to send a ship to investigate the situation (Gunnlaugsson, 1984). The ship was loaded with grain, and aboard were two emissaries, the young lord-in-waiting and Rent Chamber member Hans C.D.V. von Levetzow “who likely desired soon to take the place of the current governor of Iceland” (Stephensen 1888, p.229) and the student of law and natural science Magnús Stephensen, a son Ólafur Stephensen. They were ordered to investigate how to help the victims, including fugitives, and which of the damaged farms could be made inhabitable again. In addition, Magnús Stephensen was told to investigate the eruption scientifically, including taking samples with an earth drill (Stephensen 1785, p.XIV) to search for traces of lignite (to test the contemporary theory that volcanic eruptions were caused by subterranean coal fires). They were also ordered to investigate a new island which had formed in spring 1783 off Reykjanes during a submarine eruption. The Danish authorities were anxious to take formal possession of this island to forestall other nations to use it as a base for fishing in Icelandic waters or breaking the trade monopoly (Stephensen & Sigurðsson (1854), vol. 4, p.744ff). They needn't have worried: The island was eroded before anyone found it again (Stephensen 1888, p.252).

The ship departed another three and a half weeks after the Rent Chamber session, on October 11th. Around that time, further worrying news arrived from Iceland, including Thodal's report and Jón Steingrímsson's letter. The Danish authorities were now convinced that something serious was happening in southern Iceland (but had no idea that the north would also be affected). On October 23rd, the Crown issued an order (Stephensen & Sigurðsson, 1854, vol. 4, p. 763–764) that needy persons in southern Iceland should obtain food from the trading posts without payment, under supervision of governor Thodal. However, this order came too late to be shipped to Iceland before winter, because the investigation ship had already left. The decree of October 23rd also approved a suggestion by Carl Pontoppidan, the executive of the royal Iceland trade, to collect money in Copenhagen to support the Icelanders. The collection was eventually held in January 1784 and yielded almost 10,000 ríkisdalir (Gunnlaugsson, 1984).

Meanwhile, the investigation ship had run into several Atlantic autumn storms. After three attempts to reach Iceland, it took winter shelter near Kristianssand in southern Norway (Stephensen 1888, p.236–237). Due to the advanced season, no further attempts were made to reach Iceland. The ship departed again for Iceland in early March, carrying 1700 ríkisdalir of the collected money for distribution among the farmers from the devastated area. Due to further inclement weather, it only arrived in Reykjavík on April 16th 1784.

4.2. Food aid and food trade

4.2.1. Loans and export bans (1783)

Already in his letters to Thodal (Guðmundsson, 1783, July 26th) and the Rent Chamber (Guðmundsson, 1783, August 2nd)), district commissioner Lýður Guðmundsson complained that the inhabitants of Vestur-Skaftafellssýsla were denied emergency loans at the trade post and asked his superiors to persuade the merchant to hand out foodstuff for the needy. He did not mention any intention to try persuading the merchant by himself, even though district commissioners were co-responsible for overseeing the trade. It might have played a role in Lýður Guðmundsson's case that the nearest trading post, Eyrarbakki, was outside his district, in a region less affected by the eruption, making it harder to persuade the merchant of the gravity of the situation. However, many other district commissioners were also unsuccessful in forcing the merchants to give emergency loans (see SM7). This was probably partly due to the recent orders regarding outstanding Icelandic debts (see sect. 2.3.2). Many Icelandic officials trying to argue that these orders did not apply in case of actual famine, had a weak position because they themselves were indebted to the trade company and thus at the merchants' mercy, and merchants were reluctant to disregard the recent letters without consent from Copenhagen (Andrésson 1984). This consent, of course, could not be obtained with winter approaching.

Similar difficulties arose concerning the ban of exporting Icelandic foodstuff (Andrésson 1984). Merchants had direct financial interests to export as much as possible from Iceland, because they received 1.5% of the value of their exports and merchants' assistants 0.5%. In late summer 1783, the Icelandic governor and district commissioners did not enforce an export ban. To be fair, the crisis had not fully unfolded by then, but the withering of the vegetation and reduced milk production had manifested themselves widely. After the exports, no significant emergency stores were at hand in Iceland, and food could not be bought (even by farmers who could pay) in several trade posts in the course of winter and spring 1784 (see SM7).

In the course of the winter and spring 1784, the fishing season in southwestern and western Iceland was not bad, and the merchants succeeded in acquiring the usual amount of fish from Icelandic fishing boats: around 1.5 million kg (Andrésson 1984). In addition, the trade

company caught fish with its own vessels. In spring 1784, Thodal banned the export of butter and tallow, but not fish (probably the most desired export good). Stefán Þórarinsson banned the export of all Icelandic foodstuff from his harbours until further notice; the merchants were obliged to sell such goods back to the population at purchase price (see SM7). But northern and eastern Iceland had only very limited fishing and, due to the livestock decimation, also very limited meat products, hence this export ban was little effective.

On the district level, while district commissioners complain about uncooperative merchants, few report having tried to confront merchants or having decreed export bans (see SM7). The district commissioner of Suður-Múlasýsla banned the export of meat and tallow in July 1784, but could only express his hope to the Rent Chamber that the merchants would be held responsible in case they disobeyed. His colleague in Norður-Múlasýsla complained that district commissioners had no legal means against merchants (except sending a complaint to Copenhagen). In north Iceland, 4400 kg of dried fish were exported despite the ban (Andrésson 1984). But there are also examples of compliant merchants who willingly handed out foodstuff, e.g. in Skagafjarðarsýsla (see SM7), and the district commissioner of Rangárvallasýsla organised grain to be handed out to fugitives from Vestur-Skaftafellssýsla (Steingrímsson 1788/1998, p.80). The success of the emergency loan system thus varied between trade posts, depending on the firmness displayed by the local district commissioners and the cooperativeness of the merchant, and of course on the available stores.

4.2.2. Further communication delays (spring 1784)

As mentioned, the investigation ship arrived in Reykjavík on April 16th. By this time, governor Thodal was aware that the situation was grave in most of Iceland, i.e. over a much larger area than anticipated last autumn. Nonetheless, he hesitated for about two months to send the investigation ship - or some incoming trading ship or the seaworthy fishing vessels owned by the trade company - back to Copenhagen with the bad news.

In northern Iceland, the sea ice blocked the coast until the end of May (SM1, Guðjónsson (2010)), preventing all communication by sea. On May 14th, deputy governor Stefán Þórarinsson wrote a lengthy report [in Rep1784; see also SM] to the Rent Chamber and sent it over land to Reykjavík, hoping that shipping would be possible from there. In his report, he submitted numerous suggestions on how to aid the impoverished and starving population. The most notable short-term measures suggested supplying north Iceland with 8000 Danish tons[1] (ca 667,000 kg) of grain and a shipload of (low-quality) dried fish. Part of the aid measures might be financed by a special tax on luxury goods such as brandy, tobacco, and coffee. In the longer run, the deputy governor suggested the donation of whaling ships, and generating employment for those who normally processed wool (now impossible due to the loss of sheep), e.g. by stimulating the processing of eiderdown.

Stefán Þórarinsson's letter reached Copenhagen with the returning investigation ship in July 1784. Thodal's reports (in Rep1784) do not indicate that he was familiar with the content. In any case he neither sent Icelandic fish to the northern harbours nor decreed a full ban on exporting Icelandic foodstuff (Andrésson 1984).

4.2.3. Flour and fish (summer 1784)

In spring 1784, the ordinary trading ships were sent to Iceland earlier than usual and given strict orders to do everything possible to reach their destination (Andrésson 1984). Should a harbour be blocked by sea ice, the ship should not return to Denmark but wait in the vicinity for the ice to break. However, no significant additional amount of foodstuff was shipped to Iceland this spring: Compared to the 1764–1784 mean of 16,950 tons, 24,203 tons of grain were imported in 1784, i.e. 7073 tons above average; but of these, 5300 tons were only shipped after mid-July.

On April 19th, the Crown issued a decree (Gunnlaugsson, 1984; Stephensen & Sigurðsson (1854), vol. 5, p. 45–46) that Thodal and Levetzow should collect information about which inhabitants were in need of food aid, and how help could be administered. It was decreed that no food aid was to be handed out unless under the supervision of Thodal or Levetzow. Local administrators were ordered to help with collecting information concerning the needs of the victims of the eruptions for aid (building material, animals, food) and the possibilities to relocate fugitives. The Danish authorities clearly still believed that the catastrophe was only regional, in particular, it did not occur to them that northern Iceland (the region hardest hit by the famine) might be affected at all (Gunnlaugsson, 1984). Also, the Danish officials apparently considered it essential to collect all possible data prior to spending money on aid.

The only aid given in spring 1784 was a financial support for the farmers of Vestur-Skaftafellssýsla. In May 1784, Thodal handed Reverend Jón Steingrímsson 600 ríkisdalir out of the collection money brought by Levetzow, and ordered him to bring this money to the local district commissioner Lýður Guðmundsson, who would distribute it among the needy farmers. However, on his way back, Jón Steingrímsson met several of his parishioners who were walking west in the hope to acquire livestock or means of subsistence, and handed out about 240 ríkisdalir on his own account. This act of disobedience brought about a lawsuit against the dean, although eventually he was condemned only to a minor fine of five ríkisdalir and a public apology (Steingrímsson 1791/2002, Chapter 42–43).

As mentioned, the news of the devastating famine reached Copenhagen in mid-July 1784. Now that the government had received certainty about the situation, swift action was taken to meet the emergency. On July 21st, it was decided to send 3000–4000 Danish tons of flour to Iceland (Gunnlaugsson, 1984; Stephensen & Sigurðsson (1854), vol. 5, p.99–100); by autumn, 5300 tons had been sent (Stephensen & Sigurðsson (1854), vol. 5, p.106–107). In addition, a letter was sent to Eyrarbakki, decreeing that part of the fish catch from western Iceland (which was of lower quality than the fish in the southwest) should be transported by the vessels of the trade company to the harbours where the need for food was greatest, i.e. northern and eastern Iceland. Unfortunately, only one of the four ships sent to Iceland carried these instructions, and this ship was shipwrecked off Vestur-Skaftafellssýsla, and the letter got lost (Andrésson 1984). Governor Thodal and the district commissioners in the fishing regions still did not dare to declare a ban on exporting foodstuff without explicit orders from Denmark. Thus in late summer of 1784, the merchants exported nearly all fish they had acquired during the last spring, namely 7558 skippund (=1,200,000 kg) bought from Icelanders plus their own catches. No fish transports took place towards the north and east (Andrésson 1984). In the following winter, another several thousand Icelanders died, for a large part of starvation (and landfarsótt). Meanwhile, the Danish merchants profited considerably less from the fish than expected: Fish prices, which had been unusually high during the American war of Independence, had dropped dramatically after the Treaty of Paris in summer 1783, from 0.17 ríkisdalir/kg (averaged over 1780–82) to 0.12 ríkisdalir/kg (1783–87) (Gunnarsson, 1983), p. 151).

Even the food aid which did reach Iceland was not necessarily effective, especially in the remote areas, due to the lack of horses required to transport food from the harbours overland (Andrésson (1984), SM7). An attempt to ship some grain from the Vestmannaeyjar trading post to Dyrhólaey in the particularly remote Vestur-Skaftafellssýsla district was given up due to bad weather. Reverend Jón Steingrímsson complained that it would have been more effective to provide his parishioners with fishing and sealing gear, which would have allowed them to feed themselves to some extent (Steingrímsson 1791/2002, p. 84–85).

[1] a grain ton was a volumetric measure, equal to 139 l. It was specified that 1 ton of grain should weigh at least 83.4 kg (Gunnarsson, 1983, p. 41).

4.3. The second year: Good intentions with meagre results

4.3.1. Total evacuation? (Autumn 1784)

After the bad news of the famine in winter 1783/84, further bad tidings reached the Danish authorities in the course of the autumn: On August 14th, 1784, a severe earthquake had hit the southwest of Iceland, especially Rangárvallasýsla and Árnessýsla. Although the loss of life had been limited, several hundred farms and about 10 churches had been severely damaged or even completely collapsed (Guðjónsson, 2010).

It has long been claimed in Icelandic history books that the Danish authorities now considered Iceland uninhabitable and contemplated a complete evacuation by relocating the remaining Icelandic population to Jutland in Denmark. However, written protocols do not support this hypothesis, although it remains possible that a complete or at least large relocation has been considered orally and informally (Gunnlaugsson, 1984). What has been considered officially is moving 500–800 unproductive persons (the elderly and infirm, beggars and orphans) to Denmark. Apparently, this proposal lead to heated discussions in the Rent Chamber in early 1785. Levetzow suggested using the military in case the evacuees proved unwilling, while the high-ranking Rent Chamber official Jón Eiríkson (a native Icelander) considered the use of military forces against a peaceful population as a breech of law and pointed out that Iceland had no resources to feed hungry soldiers (Eiríksson, 1785). The whole plan was given up shortly afterwards.

4.3.2. Donations and Debts (1785 and beyond)

In February 1785, a special commission ('the later land commission', *landsnefndin síðari*) was set up to investigate how to restore the Icelandic economy (Gunnlaugsson, 1984; Stephensen & Sigurðsson (1854), vol. 5, p. 118–120; 124–127). Among its members were Jón Eiríksson of the Rent Chamber, the executive board of the trade company, and Levetzow, who was to replace the retiring Thodal as governor in April.

The commission decided to put an end to the aforementioned evacuation plans (Stephensen & Sigurðsson (1854), vol. 5, p. 216 ff), and to hold a second collection of money, this time in all market towns of Denmark-Norway (Stephensen & Sigurðsson (1854), vol. 5, p.123–124). This took several months to organise, but eventually, about 36,000 ríkisdalir were collected in 1785 (Gunnarsson, 1983, p.145). Some further aid measures were decided upon and confirmed by royal decree on June 22nd, 1785 (Gunnlaugsson, 1984; Stephensen & Sigurðsson, 1854, vol. 5, p. 216 ff): Iceland was to be provided with food stores for the winter, and 4 shiploads of fish were to be sent to northern and eastern Iceland and sold to the local population for the purchase price, i.e. without charging freight costs. Farmers in need were to be provided with emergency loans from the trade, but only under careful supervision by the district commissioners. In addition, the trade company should put two ships at the new governor's disposal in case it would prove necessary to ship further goods among Icelandic harbours. Norwegian timber was to be sent to the harbour of Eyrarbakki and handed out to the victims of the earthquake of August 1784, who needed to rebuilt their homes (Stephensen & Sigurðsson (1854), vol. 5, p. 121–123 ff). Timber and further material for building boats were also to be sent to the fishing districts of Gullbringusýsla and Snæfellssýsla, such that the fugitives from the North and Southeast could settle down as fishermen. Governor Levetzow had to supervise the handing out of the timber. Finally, the Rent Chamber sent orders to the district commissioners to count the population and the remaining livestock. In particular, it should be investigated which farms were in urgent need of additional livestock to remain inhabitable; it was planned to provide these farms with money (from the collection funds) to acquire animals.

Not all of these measured proved as effective as was hoped. The Danes sent almost twice as much grain as usual (32,200 rather than 16,950 Danish tons), and three (not four) shiploads of fish were sent to the northern and eastern harbours, but no other shipments in between harbours were made (Andrésson 1984), and there were repeated complaints by the Icelanders that it was difficult to obtain goods at the trade posts, partly because they were badly stocked (Gunnlaugsson, 1984). Note also that the food aid was not a gift; it was sold (albeit without profit) or handed out as emergency loan to eligible people, i.e. farmers in acute distress who were however expected to pay their debts.

Concerning the timber, it appears that Levetzow was hesitant to hand it out (even though it was already paid for by the collection money), and set up a complicated bureaucracy for the applicants to prove their need (Andrésson 1984). At the end, a good part of the timber, both in Eyrarbakki and the fishing districts, was never handed out but remained in the merchants' store and was sold as ordinary merchandise. About the boat timber, Levetzow claimed that no new boats were needed because enough people had died the last two years to free up boat places for the fugitives, though it may be that he acted to please incumbent boat owners, who feared that new boats would make it more difficult for them to find labourers for their own vessels (Andrésson 1984).

In some cases, fugitives were also sent back. For example, 40 paupers who had fled westward from eastern Vestur-Skaftafellssýla, were forced by Levetzow to return to their homes in early autumn 1785. By law, paupers were entitled to poor relief in their home commune. However, the 90 remaining, impoverished inhabitants had no means to provide for the 40 returning fugitives, and even the charitable parson Jón Steingrímsson wrote that nothing could be done but 'simply finding them a place to die' (Steingrímsson 1788/1998, p. 88). At the end, the parish was saved by an exceptional catch of seals, but the episode clearly illustrates how rigidly authorities applied the law, and that aid was far from sufficient.

Nonetheless, the acute famine ended in summer 1785 (Hálfdanarson 1984), probably because the weather and the hay harvest were very good that summer (Guðjónsson, 2010). However, many farms still suffered severe difficulties due to lack of livestock (Steingrímsson 1788/1998, p.87). Already in April 1786 the Crown - under the impression of the past favourable weather and recent losses in the monopoly trade, inflicted by the eruption as well as low fish prices and high grain prices - ordered that fewer credits should be given in Iceland and debts be reduced as soon as possible (Stephensen & Sigurðsson (1854), vol. 5, p. 253–255). These orders were given despite the significant amount of money collected in 1785. This money remained largely unused and was saved as the so-called 'collection funds' in case Iceland should ever be hit by hardships again. The funds depreciated due to inflation and was eventually used in the 1840ies to construct a highschool building in Reykjavík (Gunnarsson, 1983, p.145–146).

The attempt to aid farmers in urgent need for animals to replenish their livestock was not very successful: Not only was gathering the information a slow process, but what was worse, animals were scarce in the whole country, and it was nearly impossible to buy them (Gunnlaugsson, 1984). A Danish request to England in February 1785 to export some English sheep to Iceland was refused as the English were keen to protect their wool export (Agnarsdóttir 1992), and the Danes did not pursue the matter (Stephensen & Sigurðsson, 1854, vol. 5, p. 216 ff). Still, some money (from the collection funds) was handed out to farmers in the following years and may have been of some help, although, as Jón Steingrímsson remarked, 'A great number of farmers and farms could have been restored more quickly if the money, which was given to them for the purchase of livestock, had not been taken back for the payment of rents and other debts' (Steingrímsson 1788/1998, p.89). The considerable amount of unpaid Icelandic debts with the trade company 1783–88 may have been due not to leniency, but to the fact that many debtors had died of hunger (Gunnarsson 1984).

5. 'Something rotten in the state of Denmark'? - Appropriateness of relief

The Danish reaction the Laki eruption has been criticised both by contemporary and later authors, especially by 19th century Icelandic nationalists who considered it an example of harmful Danish influence on their island (Gunnarsson 1984; Oslund 2011, Ch. 1). However, large-scale government relief was by no means the obvious reaction to famine in earlier centuries (Gunnarsson 1980). For example, during the Irish potato famine of the 1840ies, initial (costly but insufficient) relief schemes were gradually abandoned for fear of disturbing the market and allowing the population to grow accustomed to government support (Ó Gráda, 2000). The Laki eruption, by comparison, took place during an enlightened period in which it was considered good governance to foster economic activity and mitigate famine (Gunnarsson 1984, 1980). Rather than lack of political will, logistic problems and clumsy organisation were the greatest obstacles to efficient relief after the Laki eruption.

Here the magnitude of relief expenditure is put into context (sect. 5.1), followed by a brief discussion on organisational issues (sect. 5.2).

5.1. Greedy or generous? The magnitude and cost of Danish aid

The first significant food aid, the 5300 Danish tons of flour imported in 1784, could provide 50,000 people with 2500 kcal/day for ca. 12 days (assuming 83.4 kg/Danish ton and 3460 kcal/kg flour). For comparison, the over 1,200,200 kg of fish which were exported the same year could have fed 50,000 persons for about 5 weeks. More importantly, the imports came nowhere near covering the shortfall inflicted by the eruption. As a rough indicator, the lost milk production due to the death of cows and ewes can be estimates as 52,000,000 l per year (based on Table 1 and the assumptions in sect. 2.2.1). Regarding calorie intake, this is equivalent to 110,000 Danish tons of grain. Note, however, that due to the 'slack' in Icelandic food production in ordinary years, this shortfall would not have to be fully compensated to preserve human life.

Over the years 1783–87, the Danish Crown supported the trade company with 76,209 ríkisdalir to finance emergency grain import to Iceland (and, to a much lesser extent, the Faroe Islands). In addition, the trade company incurred losses of about 460,000 ríkisdalir with the Iceland trade in 1784–1788, which hit both the Crown (ca. 260,000 ríkisdalir) and private shareholders (Gunnarsson, 1983, p.142,144). It has been argued that these losses can partly be seen as indirect aid (e.g. unpaid Icelandic debts), while a substantial part of these losses was also caused by changing market prices outside Iceland and liquidation of the company 1787–88 (Gunnarsson, 1983, p.146 ff). The money raised during the collections in 1784 and 1785 was about 46,000 ríkisdalir in total, but much of it remained unspent.

To assess whether this amount was 'large' or 'small', consider a few comparisons. In the traditional Icelandic price system, one ewe with a lamb cost 1 ríkisdalur and one good milking cow 6–7 ríkisdalir. Purchasing and transporting the 5300 tons of flour cost ca. 31,000 ríkisdalir (Stephensen & Sigurðsson (1854), vol. 5, p. 215–216). As this grain was not necessarily handed out for free in Iceland, the actual costs may have been lower. The 1.2 million kg of fish which were exported in summer 1784 would have cost 54,000 ríkisdalir in Iceland (abroad: 144000 ríkisdalir). The government expenditure after the Laki eruption was a significant amount of money by Icelandic standards, but certainly not enough to avoid food shortage, let alone to compensate for the loss of livestock (see Table 1) and damages to pastures and buildings. Compared to other Crown expenditures, these relief costs are actually quite modest. For example, in the early 1780ies, the Crown had funded three new trade companies, partly with capital from private shareholders. When these companies went more or less bankrupt after the end of the American war of Independence, the Crown compensated the shareholders for their lost capital and non-forthcoming profits by paying them 7.8 million ríkisdalir over the next years, 100 times as much as the direct aid for Iceland (Gunnarsson, 1983, p.141). Another, albeit trifling, expenditure may illustrate royal priorities. In normal years, the Crown imported 50 falcons from Iceland, but in early 1785 it was feared that no oxen could be purchased there to feed the falcons during the journey to Denmark. It was thus decided to limit the import to 30 falcons and send 20 living oxen to Iceland, to feed not the starving Icelanders but the royal falcons. The additional costs (including refurnishing the falcon ship to transport the oxen) were estimated to be 1896 ríkisdalir (Stephensen & Sigurðsson, 1854, vol. 5, p. 128–129). These two examples suggest that the Danish Crown could have afforded to spend more to save its Icelandic subjects from starvation.

5.2. A case study in disaster (mis)management?

Why was the disaster relief not more successful? It is interesting to discuss this question from a disaster risk reduction perspective, even though this is 'unfair' in the sense that disaster risk reduction is a fairly modern concept.

The first step to take measures is to detect the threatening disaster and raise alarm. Local authorities in Iceland took a long time to realise that the Laki eruption might have severe impacts beyond the area closest to the volcano. In particular governor Thodal lost crucial time trying to confirm information prior to writing to Copenhagen, for fear of risking a false alarm (see sect. 4.1.1). To be fair, eruptions with such widespread effects are not common in Iceland, and Thodal's residence near Reykjavík was in one of the least exposed regions. The fluorine poisoning of livestock had not fully manifested itself in late summer 1783, although severe withering of grass had been observed throughout most of Iceland. Foreseeing the magnitude of the famine was thus difficult (and remains a difficult issue today, e.g. Hillier and Dempsey (2012)). To their credit, the Danish government already acted upon Sünckenberg's letter before Thodal's report came in, and decided to sent a ship to Iceland - a considerable expenditure.

One important problem was undoubtedly communication troubles. When the full extent of the famine became obvious in the course of the winter, Iceland had no means to communicate with the outside world. A cautious government could have stationed a postal ship on the island each winter to be ready to sail in spring (see sect. 2.3.2). This way, the news of the famine could have reached Copenhagen about 3 months earlier in 1784, significantly enhancing the time window for action before the next winter. Even in summer, communication lines were fragile: The ship carrying orders on export bans got shipwrecked in August 1784, and the government had not taken the precaution of sending copies with all four ships sailing for Iceland. Of course, the loss of the letters would not have had such ill consequences if Thodal - who by summer 1784 must have been aware of the grave situation in wide parts of the country - had taken more initiative and banned the fish export on his own account.

Communication troubles could have been mitigated by installing competent local representatives and to give them wide discretion to implement measures on their own. However, the top-down administrative system of absolutist Denmark rather stifled initiative. Both local officials (governor, district commissioners) and trade representatives frequently delayed decisions waiting for detailed orders from Copenhagen. This attitude was likely stimulated by the central government (see sect. 2.1). Another example is the lawsuit against Jón Steingrímsson (see sect. 4.2.3) who was sanctioned for showing too much initiative by disobeying not the spirit, but the letter of Thodal's orders. Still, the Icelandic officials were empowered by law to supervise emergency loans and decree export bans. Fear for potential frowns of the rent chamber does not absolve them from their responsibility,

and it is possible that some of them could have been more active in confronting merchants (see sect. 4.2.1).

An alternative to encouraging local initiative could be to set up in advance well-designed emergency plans which the local authorities simply have to carry out. The laws concerning possible export bans and loans for needy farmers can be seen as an attempt of an emergency plan (although it would have been more potent if backed up by significant emergency stores on the island). However, when famine loomed, there seems to have been confusion as to what was an 'emergency' and who was eligible for a loan. The Danish government had further undermined its own emergency plan in early 1783 by sending letters concerning the need to reduce Icelandic debts, underestimating the tendency of Icelandic authorities and trade representatives to follow the most recent instructions rather than the overarching goal of preventing starvation.

Another difficulty diminishing the efficiency of aid were conflicts of interests arising from the multitude of roles of the trade company. As the only organisation providing transport to Iceland, and the only owner of significant food stores on the island (at least between the fishing season in spring and the departure of the trade ships in summer), it was *the* instrument through which the government could administer relief. At the same time, the trade company was a commercial enterprise, and both the shareholders (including the Crown) and the employees in Iceland expected to make profit from it. On the Copenhagen end, the Crown could, if it wished, override the shareholders' economic interests and decree that unprofitable rescue actions be carried out. However, the trade representatives in Iceland had a strong financial incentive to export as much from the island as they could, and thus to oppose any attempt by Icelandic officials to ban export. They also refused in some cases to put their large fishing vessels at the disposal of the governor for transporting foodstuff, possibly because they considered fishing more profitable. Maybe the central government did not foresee this problem; at least no reference regarding financial compensation is made in the order of July 21st, 1784 (Stephensen & Sigurðsson (1854), vol. 5, p.99–100), which (unsuccessfully) ordered that local tradesmen should 'provide their Hukkerter [fishing vessels] to transport fish and other foodstuff from one district to the other' (sect. 4.2.3).

Finally, while the Danish government was willing to take significant action when confronted with definite bad news, it proved unwilling to do so in view of incomplete information. For example, given the disturbing, but unclear news that had reached Copenhagen by winter 1783/84, the government could have chosen for a 'least regret' option to send a substantial additional amount of grain to Iceland in early spring, even while not being sure whether it would be needed. This would have been costly in the short run, but if the situation had turned out less serious, the surplus grain could have been stored and less been sent in 1785. The extra cost of sending too much grain in the absence of famine should have appeared much less severe then the loss of human life brought about by not sending the grain in the presence of famine. But instead of acting decisively based on a plausible worst-case scenario, valuable months were spilled waiting for the return of the exploration ship and sending repeated requests to the Icelandic officials in the region nearby the Lakagígar for surveys of population, fugitives, livestock etc. In the words of Jón Steingrímsson, who as dean was co-responsible for gathering this information, 'These [census lists] could hardly be expected to make sense or to agree, as people were constantly moving back and forth and some dying' (Steingrímsson 1788/1998, p. 86). Collecting information in the large, thinly populated Iceland was a tedious business, and the data could be shipped to Copenhagen only with the ships departing in autumn, so that they would be acted upon only in the next year. In spring 1785, renewed requests for a careful survey of livestock and human population were sent to the whole of Iceland, partly to assess which farms were in need of assistance to buy livestock. From many districts, this information was delivered only in 1786. In short, it seems that the Danish government was so afraid to incur aid expenditures that might later prove unnecessary, that it preferred to delay action by a year or more and risk that the aid might come too late to do any good.

6. A turning point in history?

In his treatise on famines in Iceland, Finnsson (1796) wrote that "Iceland never has been defeated by bad years to that extent, that during better years it could not recover". This also holds for the Laki famine. Livestock was nearly restored after 12 years (see Table 1). The population began to increase again after the smallpox epidemic of 1785–87; more people were born than died each single year from 1787 to 1801, and in the decade 1791–1801 the population increase was 1–2% each year (Gunnarsson, 1983, Fig. 2.1). This rapid increase was facilitated by the high fertility of married Icelandic women (Vasey 2009), and by the requirement of farm possession for marriage, which created a 'reserve' of unmarried labourers who could take over the deserted farms and found a family. In the region near Kirkjubæjarklaustur, 43 out of 47 abandoned farms and 9 out of 14 deserted crofts were eventually rebuilt, in some cases after re-location.

The events of 1783–85 made a small contribution towards urbanisation in Iceland: As the southern bishop's see in Skálholt had been largely destroyed by the earthquake of 1784, the later land commission decided to relocate it to Iceland's largest settlement, Reykjavík, then a village of about 200 people, which became the administrative centre of Iceland in the following years.

Although treasurer Skúli Magnússon remarked in 1784 that 'it looks as if nature is teaching the people to show in the future increased carefulness and to have better control over the economy' (cited in (Gunnarsson 1980)), there was no 'building back better' of the economic system. The farming crisis could have lead to an abandonment of the most precarious farms and the establishment of fishing villages. However, neither was the vicious circle between poverty and the lack of seaworthy boats broken, nor were the laws changed which forced each individual to be registered at a farm and prevented the formation of permanent fishing villages. Thus, for the next decades, Iceland remained a subsidence farming community. The most significant economic reform caused at least partly by the Haze Hardships was the abolition of the monopoly trade in 1787/88 (Stephensen & Sigurðsson, 1854, p. 416 ff). This measure was taken not to improve the freedom of the Icelandic population, but to save government money: The Haze Hardships and unfavourable price changes abroad had rendered the previous trade company bankrupt (Gunnarsson, 1983, p.148–149). After 1788, the Iceland trade was free for all subjects of the Danish Crown, including the Icelanders themselves. Direct trade between Iceland and foreigners remained forbidden, as the Danes feared that such trade would eventually result in the loss of their sovereignty over the island. This new trade regulation allowed Icelanders to gradually become involved in the trade. However, new difficulties arose during the French Revolutionary Wars: Now the merchants were no longer obliged to visit Iceland annually (as had been the case during the monopoly period), they found it more profitable to use their neutral status to trade between European belligerents, rather than undertake the perilous journey to Iceland, so severe shortages loomed there. An Icelandic appeal in 1795 to the Danish authorities to open the Iceland trade to foreign nations was not granted (Agnarsdóttir, 2013, p.27).

In summary, though the Haze Hardships were perceived as a dramatic event and inflicted much suffering in Iceland, they brought no turning point in history.

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References

Gunnarsson, G., 1983. Monopoly trade and economic stagnation. studies in the foreign trade of Iceland,1602–1787. PhD thesis at Lund University URL. https://babel.hathitrust.org/cgi/pt?id=uc1.b3524053&view=1up&seq=6.

Stephensen, O., Sigurðsson, J., 1854. Lovsamling for Island, indeholdende Udvalg af de vigtigste ældre og nyere Love og Anordninger, Resolutioner, Instructionere og Reglementer, Althingsdomme og Vedtœgter, Collegial-Breve, Fundatser og Gavebreve, samt andre Aktestykker, til Oplysning um Islands Retsforhold og Administration i ældre of nyere Tider (Law collection for Iceland, containing a selection of the most important elder and newer laws and orders, resolutions, instructions and regulations, Althing verdicts and by-laws, council letters, grants and endowment letters, as well as other documents, for information on Iceland's law system and administration in elder and newer times, in Danish). Copenhagen. URL. https://baekur.is/bok/000195669/Lovsamling_for.

Thordarson, T., 1995. Volatile release and atmospheric effects of basaltic fissure eruptions. PhD thesis, University of Hawaii, Honolulu URL. http://hdl.handle.net/10125/9865.

Agnarsdóttir, A., 1992. Scottish plans for the annexation of Iceland 1785–1813. Northern Studies 29, 83–91.

Agnarsdóttir, A., 2013. Iceland in the eighteenth century: an island outpost of Europe? Sjuttonhundratal 10, 11–38. https://doi.org/10.7557/4.2619.

Andrésson, S.H., 1984. Aðstoð einokunarverslunarinnar við Íslendinga í Móðuharðindum (support of the monopoly trade to the Icelanders during the Haze Hardships, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, P. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík: Mál og Menning, pp. 215–234.

Balkanski, Y., Menut, L., Garnier, E., Evangeliou, N., Jourdain, S., Eschstruth, C., Vrac, M., Yiou, P., 2018. Mortality induced by PM2.5 exposure following the 1783 Laki eruption using reconstructed meteorological fields. Sci. Rep. 8, 15896. https://doi.org/10.1038/s41598-018-34228-7.

D'Alessandro, W., 2006. Human fluorosis related to volcanic activity: A review. Transactions on Biomedicine and Health 10, 21–30. https://doi.org/10.2495/ETOX060031.

Eggertsson, T., 1996. No experiments, monumental disasters: why it took a thousand years to develop a specialized fishing industry in Iceland. J. Econ. Behav. Organ. 30, 1–23. https://doi.org/10.1016/S0167-2681(96)00839-6.

Eggertsson, T., 1998. Sources of risk, institutions for survival, and a game against nature in premodern Iceland. Explor. Econ. Hist. 35 (1), 1–30. https://doi.org/10.1006/exeh.1997.0686.

Eiríksson, J., 1785. Notes on the Haze Hardships (Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík : Mál og Menning, pp. 423–435.

Finnsson, H., 1796. Um mannfækkun í hallærum (decimation of the population in Iceland due to famines, in Icelandic). Rit þess konunglega íslenska lœrdómslistaf(001)ags, XIV, pp. 30–226.

Grattan, J., Durand, M., Taylor, S., 2003. Illness and elevated human mortality in Europe coincident with the Laki fissure eruption. Volcanic Degassing. Geological Society Special Publications, London, pp. 401–414 https://doi.org/10.1144/GSL.SP.2003.213.01.24 213.

Guðbergsson, G.M., Theodórsson, T., 1984. Áhrif Skaftárelda á byggð og mannfjölda í Leiðvallahreppi og Kleifahreppi (consequences of the Laki eruption on settlement and population numbers in Leiðvallahreppur and Kleifahreppur, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík : Mál og Menning, pp. 99–118.

Guðmundsson, L., 1783. Letter to the Rent Chamber, August 2nd, 1783 (in Danish). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík : Mál og Menning, pp. 276–283.

Guðmundsson, L., 1783. Letter to governor Thodal, July 26th, 1783 (in Danish). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources) (pp. 276–278). Reykjavík : Mál og Menning.

Guðjónsson, S.Þ., 2010. Íslenskir annálar og aðrar gamlar veðurheimildir (Icelandic Annals and Other Old Weather Sources, in Icelandic). URL. https://www.vedur.is/media/vedurstofan/utgafa/hlidarefni/annalar_sig-th.pdf.

Gunnarsson, G., 1980. A Study of Causal Relations in Climate and History: With an Emphasis on the Icelandic Experience. Lund University URL. https://books.google.it/books?id=4Rk_AQAAMAAJ&printsec=frontcover&hl=nl#v=onepage&q&f=false.

Gunnarsson, G., 1984. Voru Móðuharðindin af manna völdum? (were the Haze Hardships caused by men?, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources) (pp. 235–242). Reykjavík : Mál og Menning.

Gunnlaugsson, G.Á., 1984a. Fólksflótti úr Vestur-Skaftafellssýslu í kjölfar Skaftárelda (emigration from Vestur-Skaftárfellssýsla following the Laki eruption, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources) (pp. 119–128). Reykjavík : Mál og Menning.

Gunnlaugsson, G.Á., 1984. Viðbrögð stjórnvalda í Kaupmannahöfn við Skaftáreldum (reaction of the central government in Copenhagen during the Laki eruption, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources) (pp. 119–128). Reykjavík : Mál og Menning.

Gunnlaugsson, G.Á., Rafnsson, S., 1984. Heimildir til sögu Skaftáreldanna og Móuhardinda (sources for the history of the Laki eruption and the Haze Hardships, Icelandic and Danish). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources) (pp. 265–435). Reykjavík : Mál og Menning.

Hálfdanarson, G., 1984. Mannfall í Móðuharðindum (human mortality during the Haze Hardships, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources) (pp. 139–162). Reykjavík : Mál og Menning.

Hambrecht, G., 2009. Zooarchaeology and the archaeology of early modern Iceland. J North Atlantic 1, 3–22. https://doi.org/10.3721/037.002.s104.

Hillier, D., Dempsey, H., 2012. A dangerous delay. The Cost of Late Response to Early Warnings in the 2011 Drought in the Horn of Africa. Oxfam Policy and Practice: Agriculture.

Jónsson, G., 2009. Scandinavian economic history review. 46 pp. 24–41.

Karlsson, G., 2000. The History of Iceland. Univ Of Minnesota Press, Minneapolis.

Ogilvie, A., & Jónsdóttir, I. (2000). Sea ice, climate, and Icelandic fisheries in the eighteenth and nineteenth centuries. Arctic, 53(4), 383–394. Doi: 10.14430/arctic869.

Ó Gráda, C., 2000. Black '47 and beyond: The Great Irish Famine in History, Economy, and Memory. Princeton University Press, New Jersey.

Ó Gráda, C., 2007. Making famine history. J. Econ. Lit. 45 (1), 5–38. https://doi.org/10.1257/jel.45.1.5.

Oslund, K., 2011. Iceland imagined. Nature, Culture and Story-Telling in the North Atlantic. Washington University Press, Seattle and London.

Pétursson, G., Pálsson, A., Georgsson, G., 1984. Um eiturárhrif af völdum Skaftárelda' (on the poisoning effects of the Laki eruption, in Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík : Mál og Menning, pp. 163–178.

Rafnsson, S., 1984. Búfé og byggð við lok Skaftárelda og Móðuharðinda' (Livestock and settlement at the end of the Laki eruption and Haze Hardships, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík : Mál og Menning, pp. 163–178.

Rafnsson, S., 1984b. Um eldritin 1783-1788 (on the descriptions of the eruption 1783-1788, Icelandic with English abstr.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík : Mál og Menning, pp. 243–264.

Schmidt, A., Carslaw, K.S., Mann, G., Wilson, M., Breider, T., Pickering, S., Thordarson, T., 2010. The impact of the 1783-1784 AD Laki eruption on global aerosol formation processes and cloud condensation nuclei. Atmos. Chem. Phys. 10 (13), 6025–6041. https://doi.org/10.5194/acp-10-6025-2010.

Steingrímsson, J., 1783. Lítið ágrip um nýja eldsuppkomu í vestaraparta Skaftafellssýslu og þess verkarnir sem framkomnar eru (A little summary on the new firy outburst in the western part of Skaftafellsýsla and the consequences thereof, in Icelandic.). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources). Reykjavík : Mál og Menning, pp. 272–274.

Steingrímsson, J., 1788/1998. The fires of the earth. The Laki Eruption of 1783–1784. University of Iceland Press, Reykjavík.

Steingrímsson, J., 1791/2002. A Very Present Help in Trouble. The Autobiography of the Fire-Priest. Peter Lang Publishing, Inc., New York.

Stephensen, Ó., 1783. Extract from a letter to Jón Eiríksson of the rent chamber, August 16th, 1783 (in Icelandic). In: Gunnlaugsson, G.A., Guðbergsson, G.M., Þórarinsson, S., Rafnsson, S., Einarsson, Þ. (Eds.), Skaftáreldar 1783-84: ritgerðir og heimildir (The Laki eruption 1783-84: articles and sources) (p. 279). Reykjavík : Mál og Menning.

Stephensen, M., 1785. Kort Beskrivelse over den Nye Vulcans Ildsprudning I Vester-Skaptefields-Syssel Paa Island I Aaret 1783 (Short Description of the New Volcanic Eruption in Vestur-Skaftafellssýsla on Iceland in the Year 1783, in Danish). Copenhagen. URL. https://archive.org/details/KortBeskrivelseo000255771v0MagnReyk/page/n5.

Stephensen, M., 1888. Autobiographia drs. magnúsar stephensens, in icelandic. Tímarit Hins íslenzka bókmentafélags Copenhagen. URL. http://timarit.is/view_page_init.jsp?pageId=2317831.

Thordarson, T., Self, S., 1993. The Laki (Skaftár fires) and Grimsvötn eruptions in 1783-1785. Bull. Volcanol. 55, 233–263. https://doi.org/10.1007/BF00624353.

Thordarson, T., Self, S., 2003. Atmospheric and environmental effects of the 1783–1784 Laki eruption: A review and reassessment. Journal of geopysical research 108 (D1), 4011. https://doi.org/10.1029/2001JD002042.

Vasey, D., 1991. Population, agriculture, and famine: Iceland, 1784-1785. Hum. Ecol. 19, 323–350. https://doi.org/10.1007/BF00888981.

Vasey, D., 2009. Population regulation, ecology, and political economy in preindustrial Iceland. Am. Ethnol. 23 (2), 366–392. https://doi.org/10.1525/ae1996.23.2.02a00100.

Zambri, B., Robock, A., M.J., M., & Schmidt, A., 2019a. Modeling the 1783-1784 Laki eruption in Iceland: 1. Aerosol evolution and global stratospheric circulation impacts. J. Geophys. Res. Atmos. 124 (13), 6750–6769. https://doi.org/10.1029/2018JD029553.

Zambri, B., Robock, A., Schmidt, A., 2019b. Modeling the 1783-1784 Laki eruption in Iceland: 2. Climate impacts. J. Geophys. Res. Atmos. 124 (13), 6770–6790. https://doi.org/10.1029/2018JD029554.