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# INSTITUTIONAL AND SOCIAL RESPONSES TO HAZARDS RELATED TO KARTHALA VOLCANO, COMOROS

PART II: The deep-seated root causes of Comorian vulnerabilities

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## Abstract

Although Karthala volcano in Grande Comore Island has erupted four times since 2005, the government and the local population still remain unprepared for a major eruptive crisis. The reasons for this lack of preparation lie in a deep tangle of political, socio-economic, cultural, and environmental factors. Consequently, the population accepts the volcanic threat in different ways and to different levels. The ways in which Comorians deal with this threat lead to important changes in their society (eg social links evolving, exposure to volcanic hazards in exchange for some improvements in daily life, and easier access to resources). On a national scale, deep structural adjustments are required in order to reduce vulnerability sustainably.

## Keywords

Volcanic hazards, vulnerability, risk perception, Karthala volcano, Grande Comore island, Comoros

## Introduction

This paper complements the study by Morin et al (this issue). It addresses people's vulnerability in the face of volcanic hazards around Karthala volcano in Grande Comore Island (see Figure 1 in Morin et al, this issue). Vulnerability is the proclivity of a society to suffer damage related to the occurrence of a given hazard (eg Lewis, 1999; Wisner et al, 2004; for expansion of island-related discussion, see also Lewis, this issue). This approach implies that non-hazard related factors (demography, health, poverty, access to resource, social protection, religion, etc.) can increase or decrease the susceptibility of losses from volcanic eruptions (Cannon, 1994). Vulnerability thus reflects the economic, social, cultural, and political daily conditions of society (eg Wisner, 1993; Wisner et al, 2004; Gaillard, 2007a). Blaikie et al (1994), Wisner et al (2004) and Chester

(2005a) underline the necessity of studying the deep causes of vulnerability to better understand “how these are channelled by social and economic mechanisms into unsafe conditions for a population” (Chester 2005a: 425). Resilience differs from vulnerability by addressing the capability and the ways people deal with crises and disasters (Gaillard, 2007b). Resilient societies are those able to overcome the damage brought about by the occurrence of natural hazards.

Perhaps the only study that slightly addresses vulnerability of Comorian people in facing Karthala volcano is Nassor (2001) but it neither explores the daily societal conditions that lead to vulnerability, nor tackles the resilience of the Comorian society in the aftermath of volcanic eruptions. The discussion here aims at filling this gap. It relies on field work conducted in May 2006 and April-May 2007, including interviews with key informants and a questionnaire-based survey. The objective was to understand how cultural and socio-economic factors serve as determinants of vulnerability in facing volcanic hazards. Methodology is further described in Morin et al (this issue).

In this article we explore the deep-seated root causes of this vulnerability that made it possible for an ordinary eruption without risk to people (the May 2006 event) to become a real crisis. The next sections cover, in order, the historical and political causes of institutional vulnerability, social and economic aspects, cultural dimensions, and the environmental dimension of vulnerability. We argue that Grande Comore needs deep structural changes in society to address the volcanic risk. In the current geopolitical and socio-economic setting, these changes are unlikely to arrive soon. In the final section, followed by conclusions, we try to understand how Comorians, while waiting for these deep changes, accept and integrate risk in their daily life.

### Historical and political causes of institutional vulnerability

Comoros Islands became a French colony in the 19th Century. Independence was proclaimed in 1975; except for Mayotte, where people decided to stay under French political control. Since then, political instability in Comoros has been continual, with numerous coups d'état, culminating in the secession of Anjouan and Moheli islands in 1997. This separatist conflict led to deep political reforms. In 2001, the Islamic Federal Republic of Comoros became the Union of Comoros, with greater autonomy granted to the different islands. The Union comprises a central government and three other governments: one for each main island. These three governments contest their level of autonomy while the Union tries to maintain national political cohesion through federal governance. As a consequence, political tensions are noticeable and Anjouan tried to secede again in 2007, further exacerbating Comoros-France tensions.

On Grande Comore, the opposition between the federal and autonomous governments is palpable in the management of volcanic risk. In 2003, South African President Thabo Mbeki was expected to come for a diplomatic mission regarding power sharing within Comoros. At that time, seismicity was high. It seems that the Comorian government declared a volcanic alert without advising the Karthala Volcanological Observatory (OVK) and cancelled South African president Thabo Mbeki's visit, using this false emergency situation as an excuse. The stratagem was successful, leading the population to focus on worrying about the volcano rather than politics. Some officials (see Morin et al, this issue) consider that management of Karthala eruptions is part of the Union government's prerogatives because ash and gas plumes potentially concern

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the whole Comorian territory. For example, in November 2005, the ash plume stretched 280 km westward from Grande Comore (UNOSAT et al., 2005). Other interviewees believe it to be the responsibility of the Grande Comore autonomous government because the volcano is located on that island. Moreover, the proliferation of stakeholders at both governmental levels complicates eruptive crisis management. The renewed tensions between Comoros and France could further hinder warnings because these would be issued by the French Embassy should the Comorian OVK be unable to perform this task (see Morin et al, this issue).

Wisner et al (2004) and Gaillard et al (2008a, 2008b) conducted studies on Mount Nyiragongo in the Democratic Republic of Congo (volcanic hazards) and Aceh in Indonesia (earthquake and tsunami hazards), respectively. They reached similar conclusions in that armed conflicts increase vulnerability. Although the Grand Comorian political feud involved little violence and does not physically affect most islanders, political instability augments vulnerability in other ways, including contributing to the disastrous Grand Comorian social and economic situation.

### Social and economic constraints as factors of vulnerability

(Information provided in this section derives from Union des Comores [2005], UNDP [2007] and The World Bank Group [2007] databases.)

<b>Human development index</b>	
Human Development Index (HDI):	0.561 (world rank 134/177)
Life expectancy at birth (years):	64.1
Infant mortality:	70.7‰
People living under the poverty line:	42.7%
Combined primary, secondary, and tertiary gross enrolment ratio:	46.4%
Adult literacy rate (over 15 years):	56.2%
<b>Economic development index</b>	
Gross Domestic Product (GDP in US\$) per capita:	1993 (world rank 142/174)
Agriculture, value added (% of GDP):	45.2%
Industry (% of GDP):	11.8%
Services (% of GDP):	43%
Exports of goods and services (% of GDP):	11.7%
Imports (% of GDP):	35.5%
Debt (in 2005):	€189 million
Average annual salary by household:	€1420

Table 1: Comoros' social and economic development

The Union of Comoros is among the world's poorest countries as shown by development indices (Table 1). Agriculture represents 45.2% of the Gross Domestic Product (and employs two thirds of the workforce), services 43% and industry 11.8%. The economy relies on cash crop production of vanilla, cloves and ylang-ylang (*Cananga odorata*), representing 98% of the country's exports. The dependence on overseas food (rice, vegetables, meat) and on secondary product imports (petroleum, cement) is heavy. Variations in the rates of such products on the international market -

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for example, the value of vanilla has plunged while oil products have soared over the last few years - weaken the Comorian economy.

Grande Comore lacks solid infrastructure. The road system is damaged and not well developed. The rudimentary harbour, in Moroni, is not deep enough to accommodate ocean-going ships, which have to anchor offshore to be loaded and unloaded by smaller boats. Ships are reluctant to call at Grande Comore because this procedure is costly and dangerous especially during the cyclone season. Telecommunication services are also limited. In the event of a volcanic eruption, evacuation of those affected would be difficult.

Households comprising (on average) 5.8 people, largely make a living from subsistence farming. Only 20% of the food produced locally is sold, therefore access to cash is difficult for farmers. In compensation, most own some areas of vanilla, which generate cash once a year by selling vanilla to exporters (Guébourg, 1995). Statistics indicate that each working individual supports 3.4 inactive or unemployed people. In such circumstances, the lack of savings often prevents people from taking measures to reduce their natural hazard vulnerability. 10% of households live in makeshift houses (walls in *pisé*, straw roof, and beaten-earth floor), which are structurally weak. Permanent structures may also be unsafe. As an example, a building collapsed in the middle of Moroni following relatively weak earthquakes associated with the January 2007 Karthala eruption. Only 53.6% of households have access to electricity, so wood is the main source of energy for cooking. Running water at home or at neighbours' homes is accessible for only 19% of the population. Other people access water through private tanks (57%), public fountains (22%), wells (1.8%) and rivers (0.2%). The difficult access to water resources partially explains the fear of new ash falls that would pollute water supplies. 56% of children contribute to domestic chores, and work at least three hours a day. Illiteracy is widespread (43.5% of adults above 15 years old), a serious concern for risk communication. Health standards are extremely poor; for instance, 22.2% of children are affected by malnutrition. Medical personnel are often trained abroad and are then reluctant to return to Comoros due to the poor working conditions. Malaria and cholera are endemic. 23% of women who have been pregnant have given birth to at least one stillborn child (44.2% in rural areas).

D'Ercole (1991, 1994, 1996), D'Ercole and Peltre (1992), Tobin and Whiteford (2002), Lane (2003), Lane et al (2003) and Lavigne et al (2008) demonstrate that access to livelihoods is critical in shaping people's vulnerability in the face of volcanic hazards. As in previous paragraphs have established, access to livelihoods and resources (cash, education and health services, water, etc.) is difficult in Grande Comore. Poverty and restricted resources inevitably limit the capacity for protection, evacuation and recovery in the face of volcanic hazards. The situation worsened from June to September 2008 when supply difficulties led to a petroleum shortage, paralysing the country. There was no road transportation (leading, for example, to the cancellation of academic exams), electricity was rationed and worked only in the capital Moroni from 6:00 pm to 10:00 pm, and water was cut because it relies on electricity. The price of food soared, government employees did not receive their salaries from March to July (in addition to being many months overdue from past years) and the Comorian people called for the President's resignation. The political and economic crisis heightened the usual factors of vulnerability summarised in Table 2. In this context, an eruption of Karthala volcano would be dramatic. Future prospects for the island are sluggish despite international aid and development programs. Many people are left with no alternative but to emigrate

illegally, often in dangerous conditions on small boats (*kwassa kwassa*) that sometimes capsize. The 2004 census indicates that 363,200 Comorian people live on Grande Comore, and 'at least as many' in metropolitan France (especially in Marseille and Paris), Mayotte and La Réunion Islands. These communities abroad send vast amounts of money to Comoros, totalling between €40 million (Ministère des Affaires Etrangères et Européennes, 2007) and more than €70 million per annum (Union des Comores, 2005); becoming a main economic stimulus for Grande Comore. Remittances are sometimes invested in small businesses (eg buying a car that is converted into a taxi or opening a small café). While these measures contribute to reducing household vulnerability in Comoros, emigrants are themselves vulnerable because they often have an illegal status, without social protection. Some cultural constraints further increase people's vulnerability.

### The cultural dimension of vulnerability

The *Grand Mariage* ("big wedding") ceremony is at the heart of Comorian culture. It consists of an exchange of expensive gifts between the couple's families, including feasts for an entire village, and gives access to superior social status. This ceremony, which may cost up to €20,000, compels men to emigrate in order to secure the required amount of money as quickly as possible. It is a central issue in the economic vulnerability analysis. Some people consider it to be an incentive for increasing consumption within the domestic market. Conversely, others think it puts a brake on the Comorian economy, absorbing all funds without much left for investment in the national economy. Ostentatious expenditure is made, rather than investment in preventive measures for decreasing vulnerability (sustainable livelihoods, water tank covers, infrastructure improvement, access to alternative energy sources, etc.). Some Comorians favour the abolition of this custom. In contrast, religion, which is also an important element of Comorian culture, has unanimous backing. Only a few authors have dedicated papers to the influence of religion on risk perception and people's behaviour in the face of volcanic hazards (Bankoff, 2004; Schlehe, 2005; Chester, 2005b; Chester et al, 2008; Gregg et al, 2008). Chester et al (2008) show that it is an important factor in understanding how people respond to volcanic hazards. Among them, the perception of divine responsibility for disasters in post-modernist societies has been replaced by the ideas of de-moralised nature and hazards affecting vulnerable stakes. In Comoros, nature remains fully moralised, negatively (divine punishment) or positively (divine gift).

The Union of Comoros is an Islamic Republic where 99% of the population is Muslim (Union des Comores, 2004). Islam regulates the minor details of Comorian daily life. Difficulties have to be overcome by prayers. It explains why the population headed to the mosques and stadiums (transformed into prayer places) when the latest eruptions occurred. In some circumstances, people gathering in refuge areas that were threatened by volcanic hazards but that were considered to be safe by the population, might increase vulnerability and complicate the official evacuation process. Islam might also explain why Comorians do not feel the need to develop measures for dealing with volcanic hazards. They think that their protection is in Allah's hands. Similar behaviour has been observed on the Dieng Plateau in Indonesia (Lavigne et al, 2008).

The 1977 Singani eruption remains a key element of Grand Comorian identity. A lava flow destroyed about 300 houses in Singani and Hetsa villages and forced 4000 people

to evacuate. A few weeks later, people came back to their village and saw that their mosques had been saved. This led the locals to rebuild their villages in the same places (Krafft, 1982). The memory of this eruption is celebrated annually on 5 April, both in Grande Comore and among Comorian communities abroad. The results of our perception survey described in Morin et al (this issue) show that 86% of the respondents cite the 1977 eruption (but never more than 25% for other eruptions - Figure 1) when asked “Which Karthala eruptions do you know?” This occurs despite the fact that respondents were 19 years old on average, so they did not experience the 1977 eruption, and that they were surveyed only a few days after the May 2006 eruption. During 21st Century eruptions, memories of the 1977 events led the people to fear that new destructive lava flows could reach inhabited places. That increases vulnerability by generating some excessive reactions (eg unjustified fear and evacuation) that may complicate crisis management.

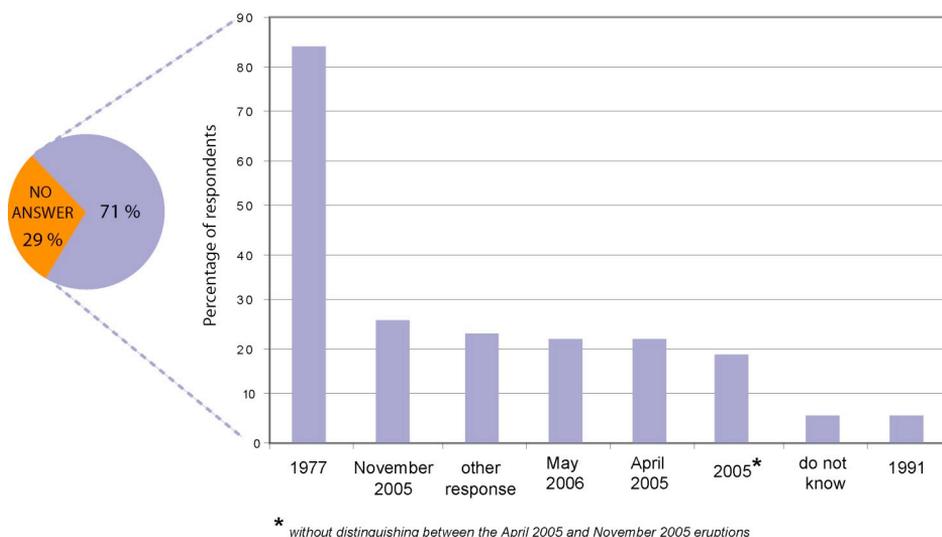


Figure 1 - Knowledge of Karthala's eruptive history: Responses to the question 'Which Karthala eruption do you know?'

The ways in which these cultural elements are translated into vulnerability are described in Table 2.

### The environmental dimension of vulnerability: hazard-related factors and geographical context

The type of volcanic activity (effusive, explosive), as well as the intensity, recurrence, and location of eruptive vents, plays an important role in crisis development and the population's behaviour. Increases in Karthala's volcanic activity during the past two years have led to several problems. While potential losses from eruptions are not heavy, the relative cost of damage is considerable for a poor country like Comoros (see also the discussion of proportional impact in Lewis, 1999). Conversely, the repetition of

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events is one factor identified for a better awareness of volcanic risk and renewed interest for information and education. Personal experience of previous eruptions may be critical in shaping adjustment to the threat (Perry and Lindell, 2008) and yet most Comorians have personal experiences of previous eruptions.

The increase in Karthala's volcanic activity may decrease an aspect of vulnerability through well-developed awareness. Finally, one may ask if all deep-seated causes described above lie in the country's insularity. Pelling and Uitto (2001) and Kelman and Lewis (2005) show that small islands can be more vulnerable than other territories due to their small size, their relative inaccessibility, and their difficulties in maintaining adequate water and energy supplies and self-sufficient economies. That is, insularity can generate vulnerabilities. Lewis (1999) notes that even a small hazardous event can threaten an entire country in a small island context. However, some islands like Hawai'i deal well with volcanic hazards thanks to effective warning systems, emergency evacuation plans, land use planning and affluence (partly generated from mass tourism). Disasters (viewed as extensions of daily conditions, eg Hewitt, 1983; Maskrey, 1989) mainly affect geographically, socio-economically and/or politically marginalised people (Chester et al, 2002; Wisner et al, 2004). The great majority of Grande Comore's inhabitants are marginalised, with the main cause lying in the deep socio-economic crisis, itself linked to geographical and political constraints. Therefore, a volcanic eruption may lead to a disaster due to existing, prevalent vulnerabilities. In these conditions, how does the population deal with the threat?



Figure 2 - Weak housing: Farmers have to live on the higher slopes of the volcano in order to access pastures due to local land use pressures. (Photo – J.C. Gaillard)

	<b>Constraints' description*</b> *All factors interact with others, influencing their respective power of vulnerability generation	<b>Ways in which constraints are translated vulnerability and may lead to a disaster</b>
<b>Historical /Political</b>	<p><b>Political instability</b></p> <ul style="list-style-type: none"> <li>- Conflicts, military coups</li> <li>- Territorial integrity in jeopardy: autonomy interests</li> <li>- Tense relations between Comoros and France</li> </ul> <p><b>State inefficiency</b></p> <ul style="list-style-type: none"> <li>- Inefficient, wasteful (and in some cases corrupt) civil administration</li> </ul>	<p>→ <b>State unable to:</b></p> <ul style="list-style-type: none"> <li>- Support social protection</li> <li>- Prepare for disasters and apply PNPRU (see Morin et al., this issue).</li> <li>- Provide adequate early warning systems (tensions with France could further hinder the warning process)</li> </ul>
<b>Socio-economic</b>	<p><b>Position in the world economy</b></p> <ul style="list-style-type: none"> <li>- Debt</li> <li>- Structural adjustment programmes</li> <li>- Dependence on overseas food and secondary imports</li> <li>- Exchange rate of cash crops</li> <li>- Low food stocks and savings</li> </ul> <p><b>Local economy</b></p> <ul style="list-style-type: none"> <li>- High percentage of households dependent on subsistence farming and sharecropping: livelihoods at risk</li> <li>- Inadequate economic progress to provide alternative livelihoods</li> <li>- Low income levels</li> <li>- Lack of local markets</li> </ul> <p><b>Social indicators</b></p> <ul style="list-style-type: none"> <li>- Widespread poverty</li> <li>- Poor social protection (limited insurance options)</li> <li>- Poor nutrition</li> <li>- Poor health standards, prevalence of endemic (malaria and cholera)</li> <li>- Low access to electricity, good water, infrastructure and telecommunications</li> <li>- Low level of education: population ill-informed</li> <li>- Illegal emigration</li> </ul>	<ul style="list-style-type: none"> <li>- Organize effective evacuations</li> <li>- Support rescue organization and emergency response</li> <li>- Provide enough shelters for displaced people</li> <li>- Inform population</li> <li>- Maintain essential aid stockpiles</li> </ul> <p>→ <b>People:</b></p> <ul style="list-style-type: none"> <li>- Are vulnerable to loss of harvest by natural hazards</li> <li>- Have low ability and interest to try to develop self-protection strategies</li> <li>- Deliberately increase their exposure to natural hazards for better daily living conditions, sometimes through punishable behaviours (eg theft of solar panels)</li> <li>- Have inadequate knowledge implying inadequate behaviour during eruptions (eg move without waiting for information)</li> </ul>

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<b>Cultural</b>	<p><b>Customs</b></p> <ul style="list-style-type: none"> <li>- No investment in the national economy or in sustainable livelihoods because people invest their money in customs, such as <i>Grand Mariage</i> which also gives access to a superior social status</li> <li>- Promotion of emigration</li> </ul> <p><b>Religion</b></p> <ul style="list-style-type: none"> <li>- Wait-and-see attitude</li> </ul>	<ul style="list-style-type: none"> <li>- Do not trust the government (an essential element)</li> <li>→Major risk of water supply pollution by volcanic ash fallout</li> <li>→Potential for disease expansion from massive and rapid population displacement</li> </ul>
<b>Environmental</b>	<p><b>Hazard-related factors</b> (eg volcano, weather)</p> <p><b>Small island context</b></p> <ul style="list-style-type: none"> <li>- Country is geographically divided amongst several islands which enhances autonomy interests</li> <li>- Relative inaccessibility</li> <li>- Difficulties in maintaining self-sufficient economies</li> <li>- Difficulties in maintaining adequate water and supplies</li> <li>- Limited arable land</li> <li>- Narrow coastline, stormy sea conditions leads to reduced fishing activities</li> <li>- Difficulties in preventing emigration</li> </ul>	<p>→<b>Infrastructure:</b></p> <ul style="list-style-type: none"> <li>- Roads, harbour and airport do not allow orderly massive evacuation</li> <li>- Insufficient shelter capacity in case of population displacement</li> <li>- Infrastructure unsafe (eg ash-induced collapses)</li> </ul> <p>→<b>Insular issues:</b></p> <ul style="list-style-type: none"> <li>- The whole territory is threatened by volcanic hazards</li> <li>- No refuge area in case of a major event</li> <li>- Low materiel losses, but a high ratio of monetary losses to total national wealth</li> </ul>

Table 2 Examples of vulnerability generation in Grande Comore Island

**Risk acceptance and societal evolution**

The way in which people perceive and accept the volcanic threat is influenced by diverse deep constraints, as previously described. Chester (1993) demonstrates that societies develop a wide range of adjustments in response to volcanic hazards: trying to modify the hazard and the loss potential, spread the losses, plan for losses, or bear the losses. Some examples developed below show how Grande Comorians perceived the latest eruptions of Karthala and undertook adjustments in diverse fields.

For most of Grande Comore’s inhabitants, volcanic hazards are due to a divine, unquestionable decision. Islam thus provides grounds for a total risk acceptance. Eruptions are presented as a deistic punishment due to bad human behaviour by 15% of the interviewees, which is certainly an underestimate, because of interviewees’ reserve concerning religion (see also Chester et al, 2008), and probably because it is considered as self-evident, which does not require further elaboration. The eruptions’ consequences are also interpreted as the fruit of positive divine intervention. This belief

may account for risky behaviour, as in M'Djoyesi in 1977. When an eruptive vent opened only one kilometre away from the village, people stayed at home awaiting for the reward of ash falling on their homes. Ashfall was indeed considered as a divine gift that would have enabled the people to restore their mosque (Krafft, 1983).

Comorians also consider that volcanic hazards may have a potential positive impact for the country. Lava flows entering the ocean create platforms that enlarge Grande Comore. As these platforms bring Grande Comore 'closer' to other Comorian islands, for many people it symbolises the political reunification of the Union (as expressed many times during our interviews and in informal discussions). A new island growing in the middle of the ocean could also replace the 'lost' island of Mayotte. Hazard occurrence is synonymous with an efficient political strategy, a utopian way to mentally reduce all vulnerabilities because the reunification of the islands would mean the end of political and geopolitical problems and the consequent improvement of the socio-economic situation.

Karthala serves as a marker of identity for 18% of the interviewees. Volcanic risk is thus ignored and even welcomed because hazards are symbols of a better life. This 'acceptance' of risk is in fact negating the threat. Negation of hazard could be an aggravating factor of vulnerability (should volcanic hazards not be a problem, the population would not feel the need for preparedness). The tendency of people living under volcanic threats to consider the benefits leading to more risky behaviour (eg activities in hazard-prone areas in exchange for a more profitable livelihood) and the consequent impacts on risk perception are described by Haynes et al (2008). For example, 28% of the survey's respondents consider Karthala volcano as a tourist attraction and as a potential source of energy.

Following the 2005 eruptions, lahars struck Vouvouni village, then several neighbouring villages, and finally the whole south-western Grande Comore coast, from M'De to Mitsoudje. Hundreds of houses and thousands of people were affected to varying extents (Figure 2 - top picture). Farmers were carried along by lahars, and one of them died. Many people were entrapped in their homes covered by mud. In Vouvouni, three houses were entirely buried, while dozens of others have been abandoned because of repeated damage. Yet lahars are not considered to be a problem (see Figure 4 in Morin et al, this issue: 46). Many Comorians are delighted with lahars because they bring precious 'sand' used for construction. 100,000 Comorian Francs (€203) for 5 cubic metres was the usual cost of sand before the 2006 eruptions. After this, the resource became freely available in the vicinity. Sand extraction is a way for poor families to increase their income from agriculture and fishing, or to build themselves a permanent dwelling (Figure 2). The sand is nowadays considered to be a divine gift, except by a minority of people who are the most directly and recurrently affected by lahars. In this case, hazards became an asset. In Vouvouni, people have even dug canals to channel the mud from the most affected area to their property in order to benefit from the sand. In that way, many people managed to get their own share of the volcanic sand—and in return are threatened by lahar onslaughts. People thus choose to increase their exposure to lahars to sustain their daily needs. Simultaneously, social vulnerability is reinforced with some villagers in conflict over control of the sand. The owners of the affected areas try to forbid other villagers from exploiting a resource that they consider to be theirs, while other villagers consider that they have the right to exploit this divine gift and consequently claim its free access to it.

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Meanwhile, environmental vulnerability is affected without the population being aware of it. The demand for sand was estimated at 121,953 cubic metres in 1997. Factories that crush lava materials cover only 52% of this demand, meaning that 57,587 cubic metres are provided by individual exploiters who use marine sand resource (Abdoulhalik and Hamidou Ali, 1998). Furthermore, the demand for sand has been increasing, due to a dense and anarchic urbanisation mainly along the coast, while the capacity of crushing stations remains limited. The illegal extraction of sand along coastal areas erodes beaches, limiting the number of safe anchoring points and disturbing coastal ecosystems. After 2005, people abandoned the extraction of coastal sand and engaged in river sand mining. After each heavy rainfall, dozens of people wait along the roads to gather the sand deposited by the volcanic hyperconcentrated flows. Coastal vulnerability has thus been reduced.



Figure 3a - Damage caused by mud flows (above) is compensated by advantages Figure 3b(below)



There is another example of the people exposing themselves to hazards. The poor status of the OVK seismic network results from repeated human activity rather than from technical problems. In 2000, many thefts occurred, mainly concerning the solar panels which power the seismic stations. The observatory was deprived of the ability to pinpoint eruptive activity while solar panels miraculously grew on roofs around Karthala. Ironically, the highest number of home solar panels is observed in Idjikoundzi, which is the village closest to the caldera and the most exposed to volcanic hazards. People who should have the greatest interest in maintaining the OVK network are those who damage it to sustain their daily needs. Furthermore, acts of vandalism (eg arson) are committed on the OVK network, perhaps from a mounting opposition to the increasing involvement of foreigners in monitoring the volcano. Vandalism might also be a rejection of attempts to explain Karthala through technology that, according to the Comorians, could not explain the volcano's behaviour as well as the explanation that God owns Karthala.

These examples show how poverty interacts with vulnerability and risk. Hazards are accepted and vulnerability to them is deliberately increased for economic or cultural reasons. The higher risk is accepted because of the immediate, day-to-day benefit. For Karthala, people readily accept an increase in their vulnerability in facing volcanic hazards in exchange for a slight decrease of their vulnerability to daily hazards such as poverty or the lack of access to resources like electricity.

Recent studies (Dove, 2008; Gaillard, 2008; Haynes et al, 2008; Kelman and Mather, 2008; Lavigne et al, 2008) have demonstrated that access to sustainable livelihoods often constitutes a factor in explaining people's behaviour in the face of volcanic hazards. Structural social and economic constraints should thus be fully considered in risk management. Overlooking their importance may lead people to distrust official risk reduction policies. For such reasons, volcanic risk management could consider a sustainable livelihoods approach (Kelman and Mather, 2008); however Kelman and Mather (2008) underline that volcanic risk management measures are culturally and economically acceptable only if they are accompanied by community involvement. Community-based volcanic risk management may help in reducing the gap between authorities' policies and people's behaviour (Kelman and Mather, 2008; Leonard et al, 2008; Paton et al, 2008). The importance of community involvement in managing volcanic threats has been demonstrated by Anderson and Woodrow (1989), Cronin et al (2004a,b) and Mitchell (2006), supported by the Comoros survey in which 64% of the survey's respondents declared that they would like to be personally involved in risk management.

The unique awareness campaign conducted around Karthala volcano dates back to 2003 in the aftermath of the degradation of the seismic network (Figure 3). The campaign, which drew on Islamic law and beliefs, introduced the idea of short-term divine punishment. Although it was supposed to be adapted to the local context, it did not work well, because thefts continued. One reason for the information campaign's failure undoubtedly lies in the lack of consideration given to social processes and the Comorian socio-economic context. The non-involvement of local communities in risk management is probably the other main reason explaining the failure of the awareness campaign.

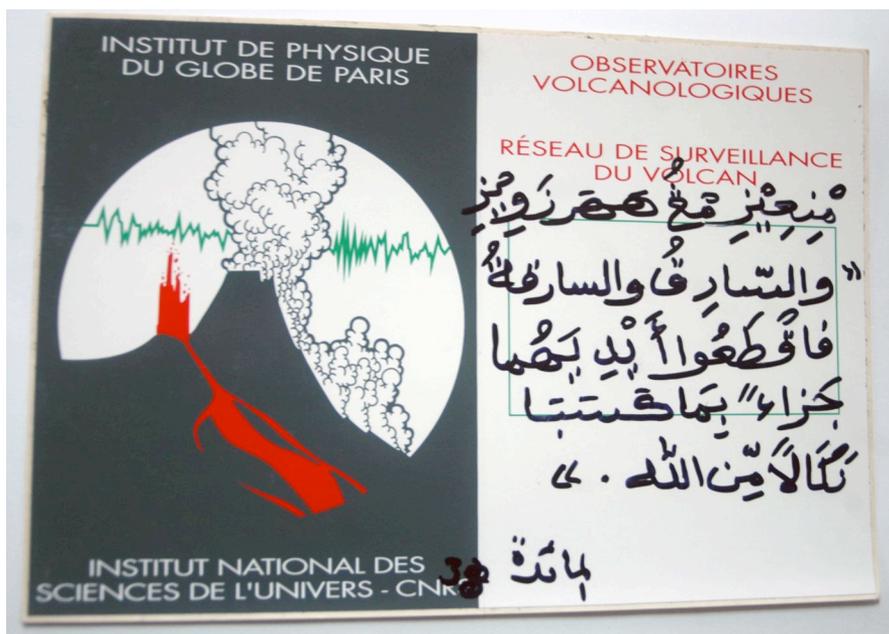


Figure 4 - religion used for the sensitising campaign. Koranic verse 38 (Sura 5) is placed on the IPGP monitoring network: “The thief, either male or female: cut off their hands”.

The repeated eruptions of Karthala volcano led the Comorian people to fear the potential insecurity of mid- and long-term economic investments that might be ruined by an eruption. On the social side, these investments are of two main kinds: 1) parents provide funds to their children to build their house in the future; and 2) Comorians abroad provide their families with additional income to meet daily needs and for *Grand Mariage* ceremonies, amongst other projects. Interviewees amongst the population and local officials acknowledge that remittances and parental allowances have been decreasing since 2005 as a result of the last Karthala eruptions. Away from their island, it is harder for the expatriates to experience the results of their investments, probably leading to the risk being less acceptable. This hesitation to invest is fuelled by the idea that Karthala will continue to erupt with a high frequency. By making the future uncertain, Karthala has facilitated a loss of social links (between parents and children as well as between Grande Comore residents and expatriates). The capacity of Comorian society to resist to these changes seems quite limited. If this evolution is largely due to hazard-independent factors related to the larger socio-economic and cultural context, Karthala’s activity may exacerbate these changes.

## Conclusion

This study emphasises some deep-seated causes for the failure of the crisis management system set up in the face of the 2006 eruption of Karthala volcano in Grande Comore (Morin et al - this issue). It shows that people’s vulnerability in the face of volcanic hazards results from historical and political roots; cultural, social and

economic constraints; and environmental factors. In consequence, there are diverse degrees of risk acceptance. Most of the population chooses to face a higher volcanic risk in exchange for some improvements in daily life, while long-term economic investments decrease. Social links, especially with expatriate community members, are further weakened. Consequently, Comorian society is experiencing major changes.

Reducing Grande Comore's vulnerability requires structural changes that will take a long time before occurring. Recent efforts undertaken by international organisations (eg the United Nations) to strengthen Grande Comore's capacity to face volcanic hazards may serve as a solid basis for the implementation of structural changes on a national scale (eg increased business investment, better access to education and health, and disaster preparedness). It requires a strong commitment from the Comorian government and stronger involvement of local communities in development projects.

Yet the island remains too heavily reliant on international aid and remittances. Grande Comore has to have increased economic autonomy through local resource development to substitute for imports. These may include tourism and alternative energy sources, notably geothermal resources. Such efforts should be accompanied by measures for increasing the Comorian standard of living: making up unpaid salaries, reinforcing the national infrastructure, and increasing people's confidence in authorities (eg enhancing political stability, combating corruption). Kelman and Mather's (2008) recommendations for 'living with volcanoes' through a sustainable livelihoods approach might be worthwhile trying in Grande Comore. Meanwhile, the people of Grande Comore must deal with the volcanic threat. An awareness campaign by the French Red Cross and the Comorian Red Crescent that partly draws on the results of the present study is scheduled for 2008. Hopefully, it will help in reducing human vulnerability by suggesting alternative behaviour in the face of volcanic threat.

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