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Discussions

Reducing volcanic risk on Fogo Volcano, Cape-Verde, through a participatory approach: which out coming?

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Abstract

This research paper presents the outcomes of the Work Package 5 (Socio-economical Vulnerability Assessment and Community-Based Disaster Risk Reduction) of the MIAVITA Research Program (MItigate and Assess risk from Volcanic Impact on Terrain and human Activities) conducted in Fogo Volcano, Cape-Verde. The study lasted for almost 3 yr (May 2010–January 2012) of which most of the time was spent in the village of Chã das Caldeiras, situated within the 9 km-wide caldera of the volcano inside the Fogo Natural Park. The objectives of the program included assessment of the vulnerability of the community at risk in terms of livelihoods, access to resources, and power relations between the local people and the different public and private institutions. These are important factors that need to be investigated in order to understand the root causes of vulnerability of the local people. This case study shows that the voluntary exposure of people at volcanic threats is linked with daily access to sources of livelihood specially agriculture and tourism. This is despite the perception of people of the risk on their lives and properties. In order to counter the factors of vulnerability, the study also aimed to identify and enhance local capacities. To achieve such objective, a Participatory 3-Dimensional Mapping (P3DM) activity was conducted to facilitate the dialogue between the local people and the different stakeholders as well as to prepare plans and measures to reduce volcanic risk. The P3DM was a half success considering that it has not yet led to an operational plan which takes into account the local capacities. The main reasons included (1) the non-participative aspect of the project at the beginning which should have identified priorities for people and let them lead the project to ensure the sustainability (2) deep conflicts within the community which complicated the focus group discussions around the 3-D map, and the difficulties to involve more marginalized people like women and youth, and (3) the fact that volcanic risk is not the priority for people who are more concerned on daily difficulties due to unsustainable livelihood, lack of access to water, land tenure, and the restrictions by the Fogo Natural Park administration and the municipal officials.

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Still, the study was successful in creating a space for dialogue between the local people and the outside stakeholders such as the Natural Park administration, the National Civil Protection Service (SNPC), and the Municipality of Santa Catarina who have all participated actively during the implementation of the project.

1 Introduction

Presently, the development of communities in developing countries is hindered by numerous factors. Among the most important is the occurrence of disasters associated with natural hazards (floods, volcanic eruptions, tsunamis, cyclones, etc.), which affected and continue to threaten many communities especially those situated in hazard-prone areas.

As a result, many practitioners' handbooks, scientific publications, and international policies about disasters and development goals emphasized the importance of disaster risk reduction (DRR). There is a consensus within the scientific community that efforts for DRR should integrate the socio-economic factors from daily activities of local people in order to strengthen their livelihoods (O'Keefe et al., 1976; Hewitt, 1983; Chester, 1993; Blaikie et al., 1994; Wisner et al., 2004; Chambers and Conway, 1991; Benson and Twigg, 2007). Secondly, it should adopt context-appropriate measures to develop the capacities of local communities against disasters (Anderson and Woodrow, 1989; Maskrey, 1989). Thirdly, it should be based on a real multi-stakeholder collaboration at different scales (institutional, different levels of government, local communities) to merge scientific and local knowledge including technical and political capacities (Gaillard, 2007, 2009; Texier, 2009). The theoretical arguments on the integration of bottom-up and top-down for the betterment of efforts for DRR are well established. However, some difficulties remain particularly on the methodological aspect. The methods and tools should allow integration of knowledge and capacities from different actors and should help practitioners in the field to facilitate efforts for DRR and as well as resource management (Gaillard, 2007; Texier, 2009; ISDR, 2009).

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Difficulties in DRR are often embedded in inappropriate strategies (neglecting social realities and economic constraints especially at the local level) which further enhance vulnerability. These difficulties are not associated with a lack of knowledge about risk or low capacities from the local people. For example, some conflicts between actors may come out of the land use restrictions and pressure and of the strong technocratic and top-down approach in resource and risk management. They are real difficulties in building integrated and efficient DRR characterized by merging of both scientific knowledge (from outside stakeholders who keep political power and financial capacities) and indigenous knowledge (from local communities who are at risk and possess significant local capacities).

Thus, the general objective of the Work Package 5 of the MIA-VITA research program was to analyse the strategies and the relationships between various stakeholders including those in ~~in~~ the local communities, and to enhance ~~dialogu~~ between actors for a more efficient DRR. The research program was conducted in four volcanoes which include Kanlaon ~~volcano~~ (Philippines), Merapi ~~volcano~~ (Central Java in Indonesia), Mount Cameroon and Fogo ~~volcano~~ (Cape Verde).

This paper focuses on the Fogo case study. First, we present the conceptual framework of the study. Secondly, we assess the exposure of the community of Chã das Caldeiras to volcanic hazards as well as the peoples' vulnerabilities and capacities in facing such hazards (Sect. 4.1). Data collection and the analysis of the results have been done using combined methods and tools from quantitative (survey questionnaire), qualitative (key informant interview and anthropological observation), and participatory research methods (focus group discussion, participatory 3-D mapping, and film).

Secondly, we argue on two conflicting priorities – the necessity of protection of people from volcanic risks and the necessity of protection of nature from human activities. These conflicting priorities had caused conflicts between the community and the outside stakeholders such as the municipal government and Fogo Natural Park Administration (Sect. 4.2).

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Thirdly, we elaborate on the role of P3DM to promote a participatory management of both volcanic risks and resources (Sect. 3.3). The process of conducting P3DM, as well as its limits and contributions are discussed in the last part.

2 State of the art in disaster risk reduction

The increasing disaster at the worldwide scale is a clear indication of the failure of the traditional disaster management system that is basically reactive and focus on crisis management (Bankoff, 2003). This system is the product of the traditional technocratic top-down government framework wherein the state and the concerned government agencies decide and act according to their mandates. The government considers itself as a "technician" who could "fix environmental problems" such as disasters associated with natural hazards (Wisner et al., 2004). In most cases, the indigenous knowledge, vulnerabilities and capacities of the local people at the local context are not recognized (Mercer et al., 2007). The government favors the usual command-and-control disaster prevention policies and actions that fail to address many issues of DRR. In the Philippines, for instance, government itself admits that the current policies and responses are inadequate and unsatisfactory both in the local and national context (Heijmans and Victoria, 2001). In some cases, the "bureaucratic rationalization, complexity, and the high social status of technology" in DRR efforts even increase the vulnerability of the local population (Mercer et al., 2007; ISDR, 2004; Wisner, 1993).

Since 1980s, there is a growing interest in alternative strategies, which involve the local people at the community level in all stages of DRR efforts as an alternative to the approach of the government and other aid agencies. This approach addresses not only issues associated with disaster events but also larger social and political issues such as inequity and underdevelopment that can be considered as root causes of increasing vulnerability (Heijmans and Victoria, 2001).

Recent efficient and remarkable initiatives are being devoted to Community-Based Disaster Risk Reduction (CBDRR) as a framework for DRR.

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For example, UNDP (2010) and Gautam (2009) have compiled the best community-based practices of DRR (or CBDRR) from countries in South and Southeast Asia, Southeast Africa, and Southwest Indian Ocean. These examples of best practices have emphasized on the empowerment of the marginalized sectors, the integration of DRR in broader development planning to address the root causes of disasters, and the roles of the state and the local government units in risk reduction.

CBDRR emphasizes the participation of communities in both the evaluation of their vulnerability and in the ways to reduce it. It further empowers communities with inbred and culturally acceptable ways of coping with crises brought by the occurrence of natural hazards.

CBDRR is now increasingly promoted among local governments in order to strengthen the links between the official disaster management system and community-based organizations. The local authorities are instrumental in fighting poverty and providing vulnerable communities with better resources and services as well as technical and financial assistance to mitigate disaster risk. They also play a critical role in raising disaster management awareness and early warning at the local level. It is further recommended that local officials should be the ones organizing community-based disaster reduction in their respective territory (Kafle and Murshed, 2006).

The use of participatory methods has become central to CBDRR to facilitate the participation of local communities. Some of the methods include calendar sand timelines, problem trees, Venn diagrams, transect walk, participatory mapping, etc. Practitioners have also developed more specific tools and toolkits such as the Vulnerability and Capacity Analysis (VCA) matrixes, which have become widespread in terms of application in the field especially among NGOs (e.g. Anderson and Woodrow, 1989).

Scientists, government officials, local communities, and Non-Governmental Organizations (NGOs) seldom work with each other simply because of the absence of a common tool or a methodology that is acceptable to several stakeholders of DRR. Local communities, usually in collaboration with NGOs, conduct community-based

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programs such as CBDRR, which emphasize initiatives at the grassroots level promoting local knowledge in the process of planning and actions. As explained by Gaillard and Maceda (2009), however, scientists tend to dismiss CBDRR as they found it "too subjective and removed from scientific methodologies and rigorous protocols." Local government officials, on the other hand, are often constrained by a structured national disaster management framework of which compliance means dismissal of alternative methods such as participatory methods.

In order to bridge the gaps mentioned above, the Work Package 5 of the MIAVITA program utilized P3DM in association with other qualitative and quantitative methods to assess vulnerabilities and capacities of the local people. They were realized following the guidelines and ideals of CBDRR.

3 Geographical context of the Fogo Island

3.1 Geological context: a volcanic island

Fogo is an active volcanic island in the southwestern part of the Cape Verde archipelago, some 800 km off the African coast (Fig. 1a). Fogo volcano is a stratovolcano of which the origin of formation is consistent with the drifting hotspot model. The volcano is relatively small (476 km^2) but it has an elevation above sea level of 2829 m, which ranks this volcano second in terms of altitude in the North Atlantic after the Teide in the Canary Islands. The geological formation of the volcano occurred in two main stages. First, a large flank collapsed and led to the removal of the summit and the eastern flank of the former volcano (Foeken et al., 2007). The collapse had then produced a 9 km wide escarpment locally known as *bordera* (the rim) with a height of at least 1 km (Fig. 1b). The event had triggered a large scale tsunami which had occurred probably between 123.6 ± 3.9 ka U–Th age and 86 ± 3 ka K–Ar age (Paris et al., 2011). Earlier dates have been proposed by Foeken et al. (2007).

Historical accounts have indicated that between mid-16th century and early 18th century, Fogo volcano was in continuous eruption with lava erupting from volcanic

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fissures (Ribeiro, 1960; Day et al., 1999, 2000). The lava flows had reached the eastern coast of the island, especially during the 18th century (1721–1725, 1769, 1785, and 1799) and 19th century (1816, 1847, 1852, 1857) (Fig. 2). Two eruptions had occurred during the 20th century (1951 and 1995) (Fig. 3). In the last two eruptions, lava flows reached the central part of the caldera called Chã das Caldeiras where lava fountains were observed. In April 1995, about 46×10^6 m^3 of lava have erupted for almost 8 weeks from the vents situated in the southwestern slopes of the volcano (Amelung and Day, 2002).

3.2 Socio-economic context: a remote area

Fogo Island experiences a dry tropical climate with very short rainy season from July to October. The caldera presents a relatively rich biodiversity thanks to its altitude and exposure to Alizee humid winds. The volcanic origin of the island offers fertile soils that are fit for agricultural activities. Situated within the 9 km-wide caldera of Fogo volcano is the village of Chã das Caldeiras which is composed of two parts: the Portela in the upper part and Bangaeira in the lower part. The village is part of the municipality of Santa Catarina and is also situated within the Fogo Natural Park created in 2003 (Figs. 3 and 4).

Encouraged by long term drought and lack of arable lands, the first settlements within the caldera were established in 1860s during the Portuguese colonization (Ribeiro, 1954; Lesourd, 1995; Andrade, 1996; Madeira Santos et al., 2007). Since then, only two eruptions occurred. Despite a strong diaspora to United States and Europe of the local populations, the community of Chã das Calderas continues to grow due to high birth rate. From 1010 inhabitants in 2004 and 1700 inhabitants in 2010, the growing population is permanently exposed to volcanic hazards.

The inhabitants are observably more family-centered than community-centered in terms of way of life and daily social interaction. A complex network of family ties shapes the social structure. Most of the people are relatives and they claim a common French forefather, Armand Montrond. Many families are decomposed and recomposed with

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single mothers often living with their parents, while many men have several households. De facto, families are of matrifocal type. Above family unit, there is not a formal or an informal chief who insures community links.

The political administration of the village is managed through the permanent representative or liaison officer of the municipality in Chã das Caldeiras. The liaison officer handles social services and tax-related issues. Despite strong kinship, social conflicts are frequent but are usually settled through public debates. The 7th Day Adventist and Roman Catholic churches are the two religious that are prevalent in the communities which regularly conduct weekly activities.

Farming is the main component of people's livelihoods especially for food sustenance and commercial purposes. All families rely on cattle and goats. They also cultivate several types of crops (mainly beans, corn, manioc, apples, grapes and figs) throughout the year for the sustenance of people's basic needs particularly food supply. Farmlands are not irrigated and water supply depends on irregular rainfall. Grapes and pomegranates are processed to produce wine and liquor and are sold outside the village. The local wine cooperative is composed of 102 farmers and is a group with a major economic stake in the community. Tourism is a growing economic activity which provides important additional resources for many households of Chã das Caldeiras. Since last eruption in 1995, tourists are continuously attracted by the volcanic landforms and eventually led to geotourism industry. The male members of the community often serve as guide of tourists in climbing the summit of the volcano while kids and women make souvenirs at home. Tourism activities are yet volatile sources of livelihoods because they are totally dependent on the international demand. However, it brings many opportunities for local development.

Other economic resources include remittances from overseas workers which are similarly dependent on the international political and economic conditions.

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4 Results

4.1 Vulnerability and capacities assessment in Chã das Caldeiras

4.1.1 Vulnerability and capacities of the community in facing volcanic hazards

The volcano is both a threat and an asset. The community is directly threatened by volcanic eruptions. People can lose all their farmlands and houses in case of lava flow which has occurred already in 1995. No one was killed during the 1995 eruption of Fogo volcano but many families were relocated beyond the rim of the caldera. Most of the people came back to Chã das Caldeiras shortly afterwards. It is important to note that the steep and elevated caldera which surrounds the community may also collapse. Yet, the most severe hazard is drought. It is frequent and endangers people's main resource, i.e. farming, which has caused severe food shortage in the past.

Socio-economic factors have been identified as more important compared to hazard-related factors in explaining risk behaviours during an eruption as well as in pre-disaster and recovery periods. People suffer from social deprivation and marginalization characterized by low access to public services. The community had been self-sufficient for more than 50 yr until the Portuguese built the first paved road in 1975. At present, access to Chã das Caldeiras still relies on a single road to the south and one small trail to the north. The undeveloped road system is a critical factor that could hinder the evacuation procedure in case of volcanic eruption. Presently, the road leading to the south is the most efficient to facilitate the evacuation. However, considering the past eruptions, there is a greater possibility that the road can be blocked by lava flows. In that case, the north rail is the only remaining option. However, the rail is not well developed which could slow down the evacuation procedure and make it more complicated. The community also suffers from a lack of communication facilities, which could be problematic in terms of emergency planning and of evacuation. The effects of decades of isolation are still evident today in the absence of police forces. Thus, in order to settle conflicts, people resort to informal agreement between stakeholders involved.

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Another consequence is the lack of public facilities. The construction of the primary school is fairly recent while the health centre operates only on an intermittent basis. In order to access proper healthcare, the people need to go to Fogo's capital ~~Saõ Felipe~~, where hospitals and health facilities are located. The failure to provide medical services in the village is the responsible for the high maternal and infant mortality rate. In fact, the absence of health care services had caused more deaths compared to deaths resulting from volcanic activity in Fogo which had killed only 2 people in the last 200 yr (Ribeiro, 1960).

Furthermore, there is neither electricity nor running water in Chã das Caldeiras. Only electric generators provide the wealthiest families with electric power while the poorest households have no choice but to rely on candles. People rely on water reservoirs filled with rain water for domestic use. Bottled water are being purchased from municipal delivery trucks which sustain the daily need for drinking water. Presently, the community is being connected to the telephone and internet networks.

Cultural factors may explain the strong attachment of people living in the caldera with the volcano. Despite the absence of local beliefs, local people consider the volcano as a "friend", a source of life or livelihood which may be a crucial factor in determining the response of the people to volcanic hazards. However, people's response is more likely due to economic reasons and constraints and lack of alternatives to access livelihoods outside the caldera. The volcanic soils within the caldera are fertile, the climate conditions are better than in the lowlands, and the volcano is a source of additional income since 1995 with the development of geotourism. People might choose to stay inside the caldera in order to sustain their livelihoods despite of apparent threats of volcanic hazards. However, livelihoods are fragile for many reasons: farming is climate-dependent, farmlands can be buried by lava flows, absence of land registration implies absence of insurance thus potential losses could not be compensated, limited alternatives for livelihoods (especially secure and formal employment), growing dependence on unstable national and international economies (wine industry, tourism, and remittances from overseas workers).

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Many households are also headed by single women with several children who have not yet experienced a volcanic eruption. Vulnerability is thus principally embedded in daily activities and cultural factors (Fig. 5). These results highlight why the community does not perceive volcanic threat as the main threat (only 12.8 % of the respondents). People have identified other human-induced threats as more important such as alcoholism and violence (26.6 %), and crops disease (19.1 %).

The vulnerabilities derived from socioeconomic factors are indeed major determinant of risk face by the people in Chã das Calderas. Still, people possess some strengths and resources which provide them capacities to face volcanic hazard and to recover from their impacts. Among the most important resources include the great diversity of the farming products throughout the year, the reliability of local associations as supports for farmers to market their products, and the presence of a permanent liaison officer who could lobby for assistances and supports from the municipality of Santa Catarina, etc. Although weaknesses have been identified in the social structure at ~~Cha~~, it can be translated to strength in case of volcanic crisis in at least two ways. Firstly, owing to the persistence of polygamy (or "serial monogamy"), extended families in Cape Verde are extremely large and members are distributed in several villages including those outside the caldera. During the 1995 eruption, many people who evacuated from Chã relied on their relatives in other villages for assistance which could not be provided by the government (e.g., boarding of evacuated livestock on land owned by extended family members in areas not affected by the eruption which permit people to preserve their capital in the form of livestock). Secondly, in times of disasters, a large number of Cape Verdeans overseas workers and expatriates send emergency remittances for their affected families in order to recover. The remittances from abroad directly uplift as well the national economy.

An additional strength is the good knowledge of volcanic hazards of the local people. Based on the MIAVITA database, 77 % of people who experienced the last eruption in 1995 fled from danger. Others (12.5 % of the respondents) waited until the last moment (paroxysm of eruption) before they leave the caldera, while some stayed in the village.

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Those memories and experiences of past volcanic events are also strengths in facing volcanic hazards. The permanent monitoring of the volcano and the enhancement of contingency plan through a two-day simulation are helpful. However, in addition to the potentially catastrophic hazards with very low probability of occurrence (e.g. flank collapse: Day et al., 1999), a resumption of the early historic period pattern of intense volcanic activity is likely to render Chã das Caldeiras unfit for habitation. This is a potential hazard of which the local people may be entirely unaware.

The results of our inquiry through survey suggest that there is strong variability between different social groups of people in terms of perception of vulnerability and capacity. Figure 6 illustrates the gap between perception of vulnerabilities and capacities of tourist guides and the single mothers raising alone their children. The guides are more open to external opportunities (numerous orange color) and can rely on stronger livelihoods than women who perceive themselves a lot more vulnerable and threatened by a lack of personal strengths (numerous blue colors).

4.1.2 Community's ability to recover from a volcanic event

The analysis shows that the community of Chã das Caldeiras can rely on some strengths and local resources to be able to recover in case of a volcanic eruption. During the last event in 1995, most of the families were relocated for 6 months within refugee camps in São Filipe, then in new houses funded by the German government, beyond the rim of the caldera. However, most people came back to Chã das Caldeiras afterwards because they had no sustainable sources of livelihood in the relocation areas. Even if they lost a lot of farmlands, the aftermath of the volcanic eruption offered a new economic activity, tourism, which is now a complementary activity.

These results highlight that DRR should focus on measures aimed at reducing vulnerability by addressing socio-economic root causes that are linked to unsustainable livelihoods and lack of access to resources.

The people of Chã das Caldeiras are closely tied to their place of origin which caters for their economic and social needs. This is evident in the abandonment of the 1995

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relocation site. Reducing the risks associated with rare volcanic eruption is not a priority for the locals. People are more concerns with droughts and lack of basic services which they deem are more pertinent to their everyday life. These results are noticeable during the ~~FGD~~, interviews and P3DM. All these findings should then be integrated into a holistic resource and risk management plan.

4.2 Double necessity of protection and conflicts

The present situation has induced two important priority objectives for the authorities. Firstly, there is indeed a need to protect people from future eruptions. After the last eruption of 1995, the government of Cape Verde created the National Civil Protection Service (SNPC), led by the Army, which had conducted several emergency supports and evacuation exercises in Fogo Island. This new risk management organization included land use restrictions and a permanent relocation of people outside the caldera. However, this relocation did not succeed since people decided to come back to the villages inside the caldera after two years. Since then, risk management mainly consisted top-down strategies such as the monitoring of the volcano with a local observatory. However, the formal responsibility for the monitoring of the volcano remains unclear. Therefore, in case of volcanic crisis, the local authorities in charge of the crisis management should rely on scientific data from two different institutions, namely the Cape Verde Civil Engineering Laboratory (LEC) and the National Institute of Meteorology and Geophysics (INMG), which both are located in the capital city of Praia (island of Santiago).

The first evacuation exercise was organized in ~~2007~~. However, it appeared unrealistic and impractical considering that it did not involve the concerned communities in the process. More recently, a table-top exercise was organized in June 2012 by INGM and the SNPC of Cape Verde with the support of the MIA-VITA research program through the Italian Civil Protection. The government of Cape Verde wishes to create a local civil protection within the Municipality of Santa Catarina but outside the caldera. Presently, it is not yet operational.

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Secondly, since the local socio-economic activities imply high pressure on the fragile natural environment, the Ministry of Environment, Agriculture, and Fisheries decided in 2003 to create the Fogo Natural Park, to enhance the protection of endemic species and regulate the tourism industry. However, its creation caused some constraints on land use and local economic development and induced conflicts among local people and the government agencies involved. The most important constraint is the limitation of space for land cultivation and cattle farming of which most families rely on. On the other hand, other people profit from the creation of the natural park through tourism. Indeed, this new structure imposed some restrictions of land uses within the caldera (Fig. 2) in conformity to a bio-focused ideology (Depraz, 2008). The restriction on livestock inside the national park is an important issue in Fogo. The economic and ecological consequences of these restrictions vary among different types of livestock. The efforts to reduce and remove goats in order to prevent destruction of vegetation and loss of soils predate the national park (since the mid-1990s) and are widespread throughout Cape Verde. On the other hand, the other types of livestock including cattle, pigs and horses are less destructive to the environment.

Some changes in economic activities were observed as adaptive strategies. One example is the progressive abandonment of cattle activity and the shift to new activities such as tourism and transport.

All these measures of protection of people and nature imply high constraints and pressure on local activities and development. There is thus contradiction at stakes in terms of territorial development: the development of "green" tourism in a high-risk site, and the development of the local community (access to infrastructures such electricity, road, water, agriculture). Generally, our results from survey suggested that DRR should focus on measures aiming at reducing vulnerability by addressing socio-economical root causes associated with difficulties of access to livelihoods. However, the present system of management does not address that point.

Furthermore, the management of the caldera is largely top-down. There are some efforts to make people participate in several government programs. One example is

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the AERIAS PROTEGIDAS national project, a pro-nature protection program led by the Fogo National Park administration. However, the program is likely to induce further management conflicts between inhabitants and institutional stakeholders because of the possible negative impacts on people's livelihood.

The local capacities and knowledge about risk of the community, on one hand, and the persistent local conflicts between external institutional stakeholders and the community (about land tenure, land restrictions, and access to water), on the other hand, justify a real need to build a dialogue among concerned stakeholders. The dialogue should promote a more integrated and community-based approach in resources management and DRR. In this study, we utilized P3DM to accomplish those objectives. The realization of the participatory 3-D map aimed at assessing vulnerabilities and capacities of people, and to integrate them into the broader development plan and in harmony to the objectives of the protection of the natural park.

4.3 A P3DM to build dialogue in DRR in Fogo?

The P3DM for DRR is one of the recently developed mapping tools. P3DM basically comprises of the building of stand-alone scaled relief maps made of locally available materials (e.g. carton, paper ...), which are overlapped, with thematic layers of geographical information (Rambaldi and Callosa-Tarr, 2002). This tool requires the participation of both the local communities including the marginalized sectors and the outside stakeholders such as the government, scientists and NGOs. People's vulnerability and capacity, hazards and other community information are depicted in the 3-D map using local materials such as pushpin, yarn and paint. P3DM is credible to both the local people who make it and to the scientist and authorities, who can overlap their hazard maps and other scientific data. P3DM thus allows the integration of local and scientific knowledge as well as bottom-up and top-down actions in DRR.

The development of CBDRR as a framework largely depends on the efficiency of its participatory methods and tools in encouraging the participation of the local people

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in the process (e.g. Vulnerability and Capacity Assessment or VCA, Participatory Vulnerability Analysis or PVA, Focus Group Discussions or FGD) as well as the collaboration between stakeholders of DRR. It should be noted that both the outcome and process of CBDRR should aim to empower the community. It should also be integrated in the larger development framework aiming to promote sustainable livelihood and development and consider them as part of DRR efforts.

This study follows a 6-phase process which is in conformity to other similar P3DM projects implemented under the Work package 5 of the MIA-VITA program. Figure 7 illustrates the step-by-step process of the P3DM.

Phase 1: Organization and communication. This stage has set the ground for the main P3DM activities. This has involved integration of the facilitators and the researchers to the community which is necessary in understanding the social dynamics and gaining the trust of the community. Preparations of logistics and base map as well as selection of participants and venue were accomplished at this stage. A vacant room in the liaison office was chosen as the venue and the scale of the base map was set at 1 : 2500. The precise scale is one of the advantages of the 3-D map compared to traditional participatory sketch map. This stage was crucial in gaining the trust of the people and in ensuring their participation.

This stage has also highlighted the lack of access to resources for the livelihood of the local people. Thus, it is important that the DRR activities should be accompanied by efforts to promote sustainable livelihood. For example, the evacuation plan should also include building roads and facilities for water and electricity which are critical resources in case of evacuation and during post-disaster periods.

Phase 2: Building the blank model. This stage has required 5 days. The participation of several sectors of the local population including farmers, women, children, teachers and students were very helpful in accomplishing this stage. Participants were grouped and organized to carry out specific tasks. For example, a group of children was tasked to prepare the cartoons. Another group prepared the small materials such as pushpins, yarns, paint, etc. that were used to depict information on the 3-D map.

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The activity was self-organizing and the participants were observably very active and excited. The teachers and the students conducted a parade and circulated the village to encourage many participants (Fig. 8). The campaign was successful and about 70 participants attended the kick-off meeting. In general, the number of participants during the four-month activity was sufficient. A local team composed of 6–7 permanent residents of the community was remarkably active and had helped facilitate the activities.

On the other hand, the participation of the institutional stakeholders was very limited. They attended only for 2 days during a month of project implementation.

Phase 3: Mapping the features. After the construction of the blank relief model, participants were gathered around the 3-D map to depict information. The depiction of information was based to a certain legend which was agreed by the participants. The legend consisted of a series of symbols represented by lines, points and polygons. The points symbolized individual features such as houses, schools, public buildings, farms, and other important landmarks. The lines represented linear features such as roads, trails and borders. Finally, polygons were used to depict information such as land uses.

Cultural significance of the symbols on the legend was taken into account through consultation to the participation of the colors they preferred for each element on the 3-D map. For example, the black sands were used by the participants to represent the large deposits of lava within the caldera. Also, rectangular gray foams were used to represent the houses which in reality are mostly rectangular in shape.

The activity provided opportunity for the several stakeholders to integrate their local and scientific knowledge especially in the depiction and assessment of peoples' vulnerabilities and capacities.

Phase 4: Enhancing discussions: the discussions centered on risk assessment and the participatory planning and action for DRR. This stage started by conducting CVA (Community and Vulnerability Analysis). On the 3-D map, hazards, vulnerabilities and capacities were easily represented and made more evident. For example, information that portrays household vulnerabilities (presence of disabled person, pregnant women,

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children, etc. and other resources of the household at risk) and capacities (presence of water reservoirs, livestock, vehicle etc.) was plotted for 75 households (60 % of the total households). Using these data, five group discussions involving different sectors were conducted to discuss the ways and means to reduce the factors of vulnerabilities and enhance the capacities identified on the 3-D map. Thus, risk assessment became more efficient.

Based on the results of risk assessment, the necessary plans and action were discussed. The participants were able to plan and decide more efficiently in locating the evacuation centers and routes in terms of distance and practicability since they have bird's eye view of their territory through the 3-D map. But this step has not yet been achieve.

Phase 5: Finishing the legend: this stage involved polishing the 3-D map. The participants finalized the legend and added the map components such as title, scale, and north arrow.

Phase 6: Follow-up: the full realization of this stage is beyond the project duration. In partial completion of the stage, a group of individuals was identified to monitor and regularly update the 3-D map. Among them are local volunteers and the representatives from government agencies such as the civil security, the Fogo National Park, and the liaison office of the municipality of Santa Catarina in Chã das Calderas.

The following discussions reflect on the achievements and shortcomings of the implementation of the P3DM. The P3DM activities which we detailed above should lead to fully operational CBDRR plans and actions. However, due to several constraints, they were not fully accomplished and an actual DRR plan was not finalized. Firstly, the time available for the planning was too short. Most of the time was spent during the actual P3DM activities. Secondly, the permanent involvement of the most important sectors (tour guides, women and farmers) was difficult to achieve. The long history of non-participation by these groups to democratic processes of public consultation and decision making which concern them is a major factor that makes them hesitant to participate on the participatory DRR activities conducted.

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Presently, there are doubts on the sustainability of the 3-D map. These are primarily due to the disengagement of former stakeholders and also some political and technical constraints. For example, the liaison officer who was very active during the activity was replaced by somehow who was not from the village and had not participated on the P3DM activity. During the change in personnel (January–March 2013), the 3-D map was inaccessible for the local people and thus the necessary updates were not done. On the part of the institutional stakeholders, they encountered several constraints related to budget which prohibited regular monitoring on the site. Due to financial incapacity, the representative of the SNPC who attended the whole month of mapping activity could not visit regularly. The organization of local group for DRR which the agency's personnel aimed to organize was not accomplished. Finally, due to lack of political will and technical capacities, the integration of the 3-D map into GIS was not realized by the personnel of the Natural Park Administration and the NCPS. This activity was deemed critical by the institutional stakeholders on the dissemination of results and follow-up activities.

In the end, the failure to fully accomplish the original activities and plans especially the CBDRR planning activities were due to complicated political context, absence of local leaders, internal conflicts between families, and engagement of the people to their livelihood activities. These are real challenges that future P3DM activities should take into consideration.

5 Discussion and conclusion: which perspectives of participatory management?

In the case of Fogo, there are several factors which explain the difficulties to implement CBDRR through P3DM activity. As an example, the members of the community prioritize their economic activities and thus it was difficult for them to dedicate time for the proposed activities for DRR. Furthermore, despite the huge effort to communicate with the identified actors during the P3DM and the commendable efforts of some local volunteers to organize several activities, the main problem lies on the lack of

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involvement of the community on the origin of the project which should be a local initiative and not an exogenous effort from a scientific team. Other experiences of P3DM realized in Philippines suggested that local involvement is a crucial aspect in the success of such project. It is the same problem with the lack of participation of outside stakeholders. The government agencies should have been more involved from the beginning of the project in order for them to integrate their objectives and expectations, and schedule by themselves the implementation of the program according to their availability. Those efforts should have stimulated more motivation and better communication on the part of the local and outside stakeholders. The evident outcome of the lack of participation is the insufficiency of information plotted on the 3-D map. Thus, it was difficult to proceed to actual CBDRR plan. This lack of information is linked also to internal conflicts, competition between socio-professional groups and taboos toward local management of resources like wine cooperative and the Natural Park. Indirect dialogues should have been necessary to develop self-confidence and trust between the actors involved. Involvement of all social-groups from the community into the process also appears essential. However, this experience also shows that there is risk to reproduce at inferior scale and aggravate the existing inequalities between more powerful actors and the marginalized groups (like women or unemployed youth). It is indeed one of the most important critics about participatory management (Rodary, 2001; Depraz, 2008).

Another difficulty encountered during the activity is related to the interpretation of collected data. In studies which utilized participatory approaches, the reliability of data depends heavily on the understanding of the history of the participating population in relation to the past occurrence of the hazards. In the case of Fogo, only two eruptions occurred since the establishment of the villages, whereas in the century 1760–1860 at least 7 eruptions were reported.

To legitimate access to resources and risk management for marginalized groups is a long-term process. It does not depend only on their knowledge and the recognition by the institutional stakeholders and the community itself (legitimacy). It also depends

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on the access of the marginalized groups to political rights and capacities (access to education, self-confidence to speak in front of people, time-management) to build their citizen status and act based on personal choice (Sen, 1987).

To conclude, it is still possible to improve the methodology of such participatory project. Initiative must come from the local people themselves, and their involvement should start from the beginning of the project.

Participatory research should be built on a long-term partnership with stakeholders, which is most of the time difficult, since a research project is often required to follow certain duration. It is thus very essential to rely on local organizations and local people who are capable to sustain the program even beyond the project duration. It should be noted that researchers can only stay few months on the field and thus project sustainability would always depend on the local stakeholders.

Furthermore, this research shows that the local people in the communities recognize the threats of volcanic hazards less harmful than the human-induced hazards of political restrictions. For example, farmland restriction linked to the protection of nature (with restricted areas in Fogo Natural Park) or the protection of people (the will of council to keep people away from caldera for safety or economic reason, or the will to make them pay a land registration and yearly taxes, or to prevent them to build new water-tank, whereas they do not have alternative sources of income and water which are crucial for their survival). The human (social, political or economic) threats from daily life thus appear much more important than hypothetical and temporary volcanic threats. In fact, the volcano is more a source of livelihood through fertile soils and geotourism rather than a threat.

DRR policies should therefore address these larger issues of development (education, health, basic services) to reduce people's vulnerability in facing not only volcanic hazards but also drought and socioeconomic hazards. Documentation of land tenure is crucial to secure people's livelihoods. Contingency planning should also consider all forms of resources which make up people's livelihoods, including food, water, farming equipment and livestock.

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This P3DM activity is considered half-success. Although most of the external actors and community members worked together to build the model and filled them with important information, the actors particularly the local people are yet to organize a stronger and more efficient CBDRR program that takes into account both people's livelihood and protection of the natural environment.

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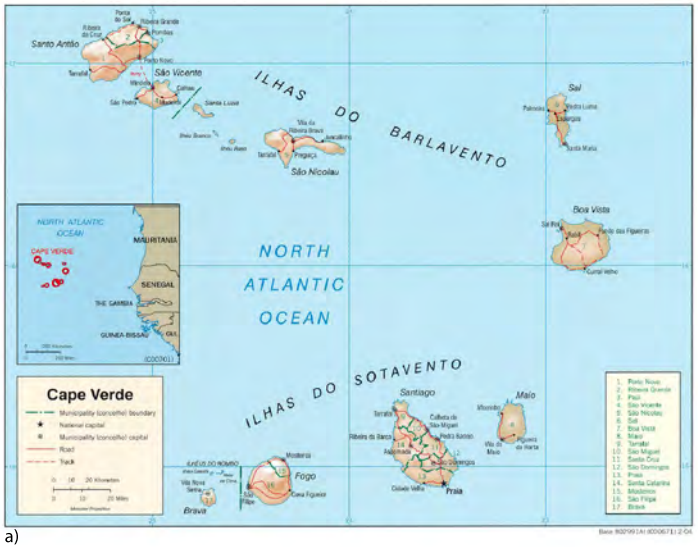

Fig. 1. (a) Map of Cape Verde, **(b)** scheme of Fogo volcano (modified from Day et al., 1999; Day and Amelung, 2002, p. 3).

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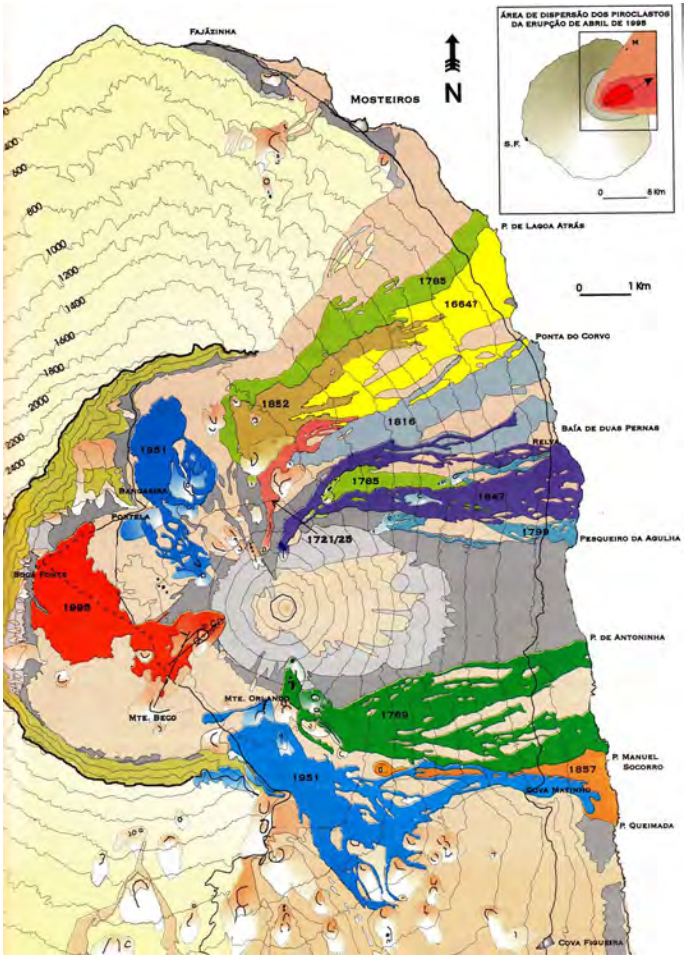

Fig. 2. Historical activity of Fogo volcano (source: Torres et al., 1997).

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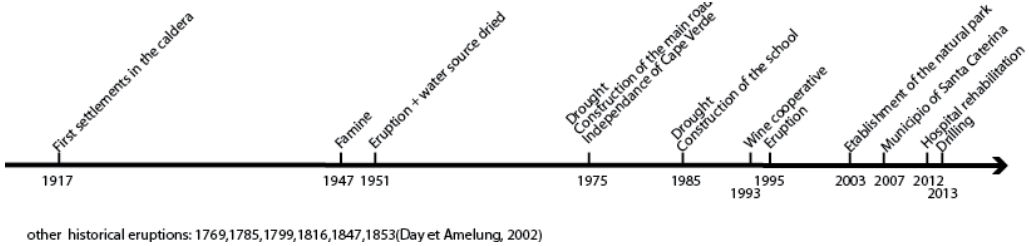

Fig. 3. Time line of Chã das caldeira's history.

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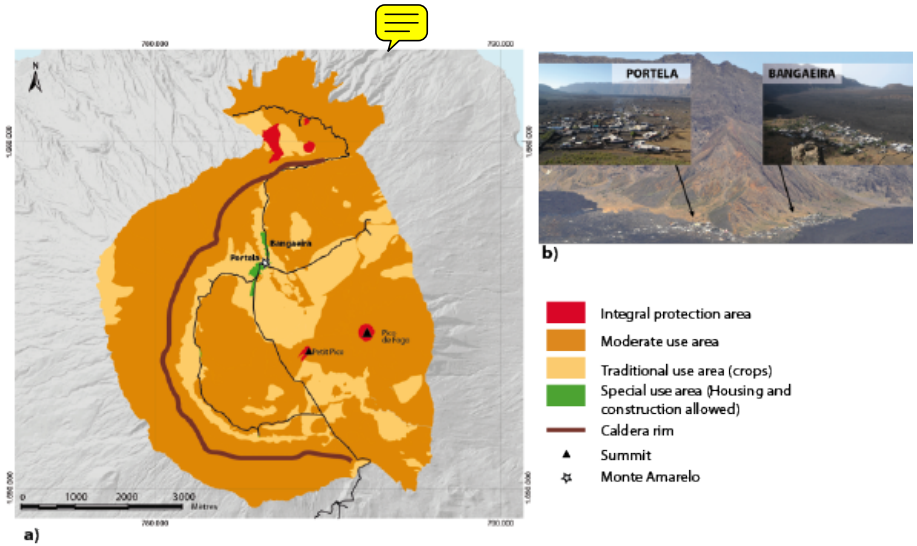

Fig. 4. (a) Villages of Portela and Bangaeira situated within the caldera and the Fogo Natural Park, a very narrow space to develop livelihoods **(b)** general photography taken from the Pico, J.R. Cadag; zoom on the 2 villages (taken from Monte Amarello, P. Texier, April 2011).

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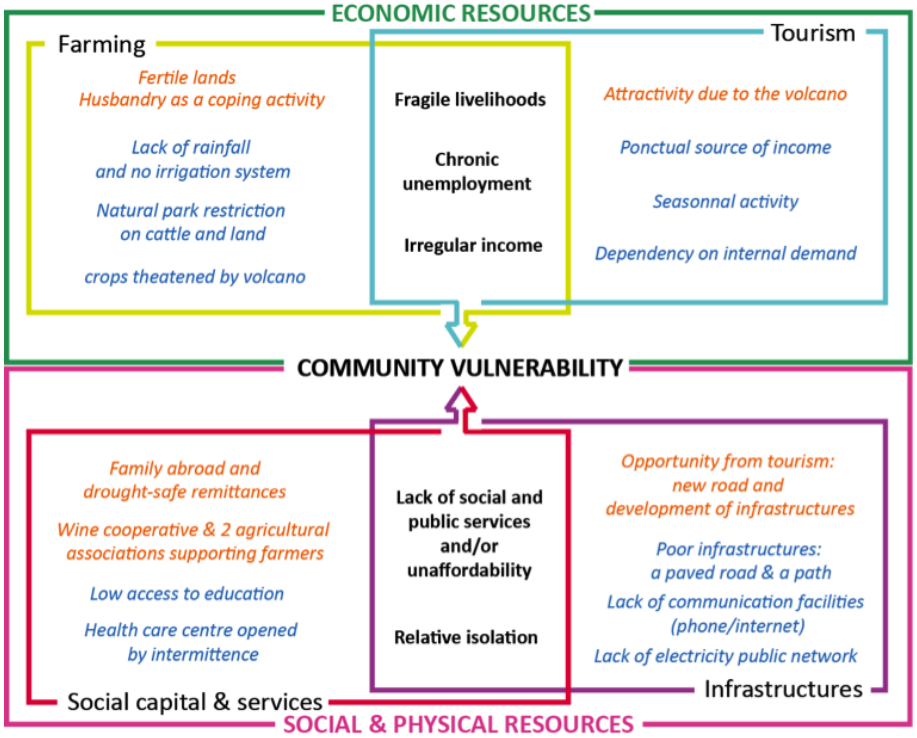

Fig. 5. Construction of vulnerability of the community living within the Fogo caldera (analysis from focus group discussions conducted in Chã Das Caldeiras, July 2010).

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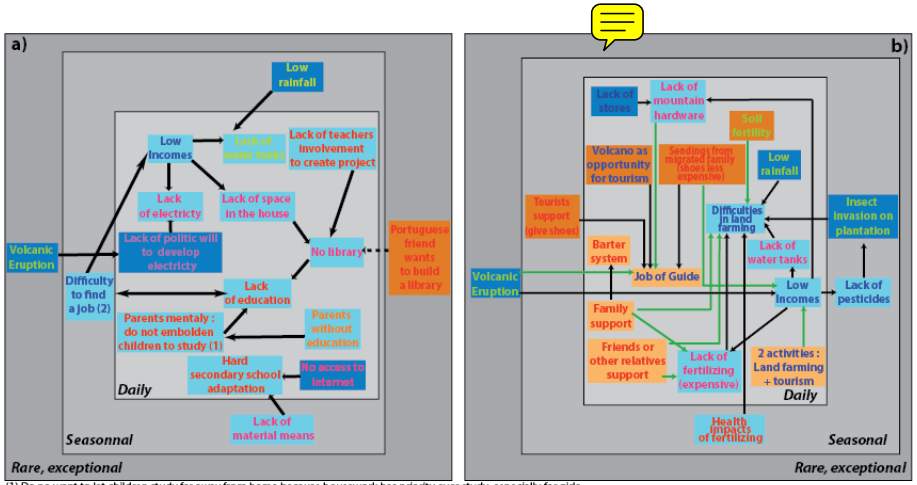

Fig. 6. Multifactor targets for **(a)** single mothers with children and **(b)** guides (from FGDs, July 2010).

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Fig. 7. Main steps of the P3DM methodology.

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Fig. 8. The building of 3-D mapping with children and adults from Chã das Caldeiras, April 2009 (Texier and Cadag).

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