EXPERIMENTAL USE OF PARTICIPATORY 3-DIMENSIONAL MODELS IN ISLAND COMMUNITY-BASED DISASTER RISK MANAGEMENT

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Abstract

This article documents an attempt to integrate Participatory 3-Dimensional Models (P3DM) into Community-Based Disaster Risk Management (CBDRM). It particularly focuses on the islet of Divinubo, located off the island of Samar on the Pacific edge of the Philippine archipelago. The P3DM methodology proved to be useful for many reasons - it facilitates the participation of the population; raises people's awareness of their territory; allows the 3-dimensional mapping of natural and other hazards, threatened assets, vulnerabilities and capacities; better enables CBDRM to be integrated into the larger development framework; proves very useful in marginalised areas like small islands; is cheap to set up and easy to reproduce; and may provide valuable data for scientists interested in disaster research. There are several issues that turned out to be instrumental in the successful implementation of such a methodology, since neither the scientists nor the sole NGO sector were able to achieve the best results with the community on their own but had to work together. The article also emphasises that it is critical to complete a long-term confidence-building stage before attempting to implement the project.

Keywords

Participatory 3-Dimensional Model, Mapping, Community-Based Disaster Risk Management, Philippines, Divinubo

Introduction

The Hyogo Framework of Action (HFA) adopted by 168 governments at the World Conference on Disaster Reduction held in Kobe, Japan, in January 2005, emphasised the need for "developing and strengthening community-based disaster risk management" (CBDRM) (United Nations International Strategy for Disaster Reduction, 2005). CBDRM fosters the participation of threatened communities in both the evaluation of risk (including hazards, vulnerability and capacities) and in the ways to reduce it. For communities to delineate hazard-prone and vulnerable areas, participatory mapping is increasingly promoted (eg De Dios, 2002; Abarquez and Murshed, 2004; Cronin et al, 2004a, b; Benson et al, 2007; Haynes, 2007). CBDRM eventually empowers communities with self-developed and culturally acceptable ways of coping with crises brought about by the occurrence of natural hazards (eg Anderson and Woodrow, 1989; Maskrey, 1989). CBDRM has been initially implemented in the developing world by NGOs (eg Benson et al, 2001), followed by international organisations like the Red Cross and Red Crescent federations (eg International Federation of Red Cross and Red Crescent Societies, 2007). CBDRM is now increasingly promoted among local governments in order to strengthen the links between the official disaster management system and community-based organisations (Kafle and Murshed, 2006). CBDRM is also being introduced in western and other industrialised countries (Kelman and Karnes, 2007, Bajek, Matsua and Okada, 2008).

In parallel, Participatory 3-Dimensional Models (P3DM) are being increasingly used in community-based resource management as well as for territorial conflict resolution (Rambaldi and Callosa-Tarr, 2002, 2000; Rambaldi et al, 2006, Bacic, 2006). P3DMs basically consist of the building of stand-alone scaled relief models that are overlaid with thematic layers of geographical information. These models facilitate the interpretation, assimilation and understanding of geo-referenced information by making it visible and tangible to everyone. These 3-dimensional models raise local awareness of territories, provide stakeholders with powerful mediums for land-use management and serve as effective community-organising tools (Rambaldi and Callosa-Tarr, 2002).

The Philippines has pioneered the development and implementation of both CBDRM (eg Anderson and Woodrow, 1989; Heijmans, 2004; Heijmans and Victoria, 2001; de Dios, 2002; Allen, 2003, 2004, 2006; Delica-Willison and Willison, 2004) and P3DM (Integrated Approaches to Participatory Development, 2007; Ramirez, 2007). The Philippines is known for being one of the most disaster-prone countries in the world. Between January 1900 and May 2006, the EMDAT database of the Centre for Research on Epidemiology of Disasters (CRED) listed 379 disasters that each killed at least more than ten people, affected more than 100 individuals, or required international aid (Centre for Research on Epidemiology of Disasters, 2006). These events caused economic damage worth US$ 7 billion and killed more than 48,000 people. Millions of other Filipinos were directly or indirectly affected. As suggested by Lewis (this issue), the archipelagic nature of the Philippines combined with a history of exploitation by colonial powers results in high vulnerability in the face of natural hazards.

In this article we document an attempt to integrate P3DM into CBDRM in the islet of Divinubo. The first section presents the study area. Section 2 describes the methodology, materials and tools used to build the model. Sections 3 and 4 show how the P3DM served as the basis for risk assessment before being incorporated into CBDRM. The final section assesses the potential and limits of this methodology.

I. The study area

Divinubo is a small island that is roughly one kilometre long by one kilometre wide. It is located approximately 2.5 km off the coast of the city of Borongan, the capital of the province of Eastern Samar (Figure 1). Divinubo is exposed to an array of natural hazards that includes tropical cyclones, storm surges, earthquakes and tsunamis. The largest events occurred in 1984 and 1988 when tropical cyclones Undang and Yuning swept the central part of the Philippine archipelago and wrought havoc in Divinubo. More recently, in December 2006, tropical cyclone Seniang struck Divinubo and caused severe damage. Storm surges, locally known as *duluk*, are the most common phenomena as they occur every rainy season or *amihan* (the dominant north-eastern winds) also occur between December and May.

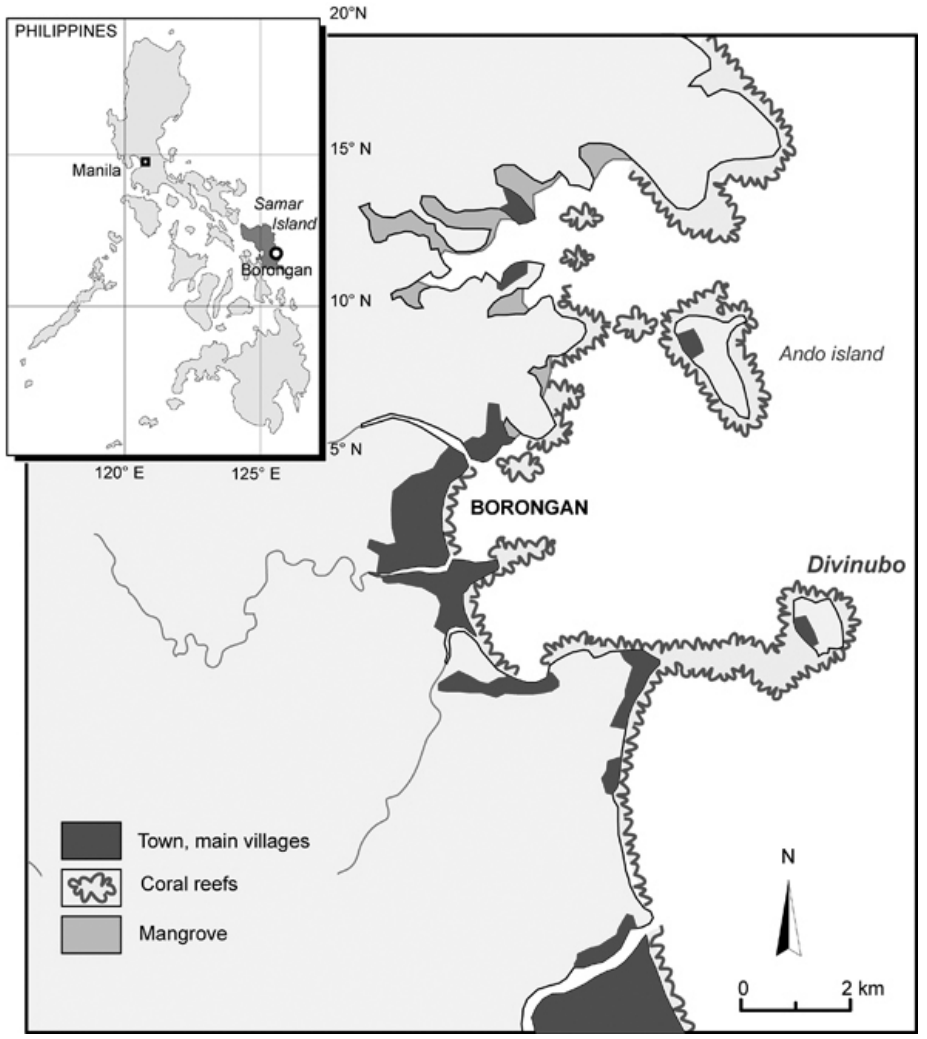

Figure 1 - Location of the study area (with insert showing position within the Philippine archipelago)

In 2000, the island was inhabited by 703 people, who chiefly live in small houses made of palm leaves (National Statistics Office, 2008; Gaillard et al, 2008). 92% of the people of Divinubo combine different livelihoods to sustain their daily needs, especially to purchase rice and other food stuffs. The primary source of income is fishing. There are three kinds of fishing practices. Fish are caught in the deep sea using motorised outrigger boats and small gear such as spears, nets and lines. Shallow sea fishing requires small non-motorised outrigger boats from which fishermen dive with spears and nets. Finally, people catch fish and gather shells within the intertidal zone during low tide. Deep-sea fishing is the most profitable source of income but also the most vulnerable in the face of typhoons and storm surges. On the other hand, fishing in the intertidal zone is much less vulnerable but less profitable too. To complement incomes from fishing and sustain daily food needs, 28% of Divinubo households rely on agriculture. Major agricultural products include copra, vegetables and root crops. As in many other places in the Philippines, some people also depend on small retailing businesses and shops, carpentry and overseas workers' remittances (Gaillard et al, 2008).

The people of Divinubo primarily cope with natural hazards, by relying on their own resources - since external help is minimal and the island context constraining. As a result of being located off the shore of Borongan, Divinubo remains under-developed. There is no doctor on the island, for example, and one has to take a one hour boat and tricycle journey (two hours when tide is low) to reach the town proper in case of emergency. In times of crisis, the islanders display a wide range of coping strategies that include temporary evacuation to sturdy houses, reduction of daily expenses, adjustment of diet (less food intake per meal, skipping of meals, different foods), food and money savings, small loans and postponement of debt repayment among others (Gaillard et al, 2008). It is noteworthy that strategies to cope with natural hazards are anchored in the everyday activities of daily life rather than extraordinary measures adopted to face extreme and rare natural events. The capacity to adjust everyday activities, however, largely depends on the strength of people's livelihoods. The integration of P3DM into CBDRM facilitates the consideration of livelihoods as a major component of disaster risk in marginalised communities.

The project presented in this article emerged after successive visits to Divinubo organised by the local government of Borongan in 2005 and 2006 as part of a larger resource management program. Interviews with key informants and discussions with local officials revealed a real need and interest for improved disaster risk management in the island. In response, the P3DM/CBDRM project was eventually implemented in late August 2007.

II. Building the model

Building the 3D model of the island was based largely on the methodology developed by Rambaldi and Callosa-Tarr (2002). Because the island of Divinubo was small, it was decided to build a 3D model with a scale of 1:400. Due to budget constraints, certain materials like glue and cartons were sourced through the efforts of the community residents and the Local Government Units of Borongan. The building of the model relied on locally available and cheap materials such as corrugated cartons, glue made of cornstarch (or *gawgaw* in the vernacular), poster paint/acrylic colour, brush, map/push pins, yarns, carbon paper, Manila paper, crepe paper, masking/packaging tapes, plywood, nails and wood for the table, scissors, markers, cutters and pencils.

The people involved in building the 3D model consisted of members of the local community representing the Local Government Unit (LGU) and a people's organisation (PO). The PO has been organised by the LGU to become the major stakeholder of an eco-tourism project initiated a few years ago. It gathers male and female members who undertake regular activities such as welcoming tourists, cleaning the facilities and retailing goods to visitors. Members of the PO who participated in the project included women, children, elders, subsistence fishermen, subsistence farmers and entrepreneurs (retailers) selected by local leaders in collaboration with the project facilitators. These participants were representative of the wide breadth of economic and social class among inhabitants of the island, all of whom are vulnerable to and at risk from disasters.

After the arrival of the CBDRM-P3DM facilitators, a meeting was immediately held with the leaders of the PO to establish a schedule of activities. It was decided that building the model would take 3 days, which would also coincide with a CBDRM seminar for participants, and that the community would manufacture the 3D model inside the PO's function room. The function room would also be the centre of logistics, and most materials used in building the 3D model would be stored there. Food for the facilitators and participants would be prepared and cooked by female members of the PO. No actual building of the 3D model was made on the first day. Instead a meeting with all of the participants was held in the function room and the facilitators explained what was going to happen during the CBDRM seminar and the 3D model building. The base map to be used for the 3D model was also presented to the participants. This gave the chance for participants to ask questions and raise their concerns regarding the activities. In the afternoon, the CBDRM seminar started.

Figure 2: Assembling the P3DM of Divinubo island

The second day was devoted to building the 3D model. By seven in the morning, the facilitators arrived in the function room to find more than thirty participants already there! Since the island's highest point in elevation was only forty-four metres, the participants were divided into four groups with an approximate equal number of men and women, each group being in charge of a ten-metre elevation layer (0-10, 11-20, 21-30, and 31-44). A fifth, smaller group of women volunteered to cook the *gawgaw* and some men offered to build the table to carry the 3D model. With the use of the carbon paper, the four groups traced the contour lines corresponding to the elevation assigned to them into the corrugated carton and marked landmarks to be used for geo-referencing and orienting the layers once they were assembled. The paper was also marked to display north and labelled with the appropriate elevation equivalent. To enhance the visual perception of the elevation, vertical scale was exaggerated. This resulted in each 10-metre elevation layer/contour line being composed of multiple corrugated cartons glued together to reach 40cm in height. After each layer had been completed, they were assembled to form a blank relief on the constructed table (Figure 2). The relief was then pasted with crepe paper to smoothen edges and strengthen it.

The third day involved the participants locating terrestrial features on the relief map. These include beaches, forested areas, mangroves, bird habitats, coconut plantations, plots used for root crop, vegetable and fruit farming, animal raising areas, fishing grounds, houses, public facilities (schools, church, LGU building, watch tower), tourism facilities (cottages, function halls), outrigger boat harbour, deep wells and other water sources, sea walls, roads and trails. This was done with the use of yarns and pins to represent line features and points on the map respectively. The use of pins and yarns allowed the participants to discuss among themselves and agree on perceived geographic features and landmarks. After validation and consensus among all the participants, paint was applied to polygonal features of the map such as vegetation types and land use. The colours used to designate land use/cover and vegetation were pre-assigned by the facilitators in accordance with the legend or coding system of the map.

The last day of building entailed finalising the 3D model. With the use of white yarn, a geo-referenced grid was superimposed over the relief map, each grid square corresponding to 40,000 square metres on the map. The legend and orienting arrow pointing to the north was placed in the southern portion of the map. As a final touch, a plastic cover was put on top of the relief map as protection.

III. Incorporating P3DM into CBDRM

In parallel with the building of the model, CBDRM workshops and focus-group discussions (FGDs) were convened with members of the PO. FGDs were intended to list the hazards (not only natural) in everyday life, make profiles of those hazards, identify threatened infrastructure, resources and livelihoods and assess vulnerabilities and capacities. The methodology used followed the framework developed by Anderson and Woodrow (1989) and refined by Abarquez and Murshed (2004).

Once the model was ready, it was integrated into CBDRM workshops and FGDs. The P3DM first served as the basis for the identification of hazard-prone areas. Participants were asked to plot the areas they considered threatened by typhoons, storm surges and tsunamis using yarns and pins of different colours. Fishermen and male farmers were the most active in this activity. The neat divide between the island plateau and the low lying village surroundings facilitated the definition of hazard-prone areas. Participants

then identified the threatened assets within the community using markers, yarns and pins: houses solely made of palm, copra storage areas, fish pond, essential cultivated lands, the PO's karaoke and outrigger boat, cottages for tourists, etc. (Figure 3). The model helped participants to better identify the dangerous areas and the safe areas that might serve as a refuge in times of crisis.

Figure 3: Plotting of vulnerable infrastructure on the P3DM

The CBDRM workshop proceeded with the planning of measures that would enable the community to reduce vulnerabilities and raise capacities. Participants from the PO considered eight assets crucial to their everyday life: the PO multi-purpose hall and tourist cottages, the village houses, fishing, subsistence farming, cash crop agriculture, tourism activities, retail shops, transportation and boats. For each of these assets, they listed essential points of vulnerability and elements of capacity to face natural hazards, especially typhoons and storm surges. Then, they discussed how to reduce vulnerability and raise capacities (Table 1). Based on the model, people agreed, for example, upon an agricultural field that could be protected with the financial support of the PO. In return the PO would benefit from the vegetables and root crops harvested in times of crisis. On the other hand, areas identified as safe from major hazards turned out to be of little use because of a handful of large landowners reticent to get involved in CBDRM activities. The P3DM also turned out to be a very useful tool in the planning of structural measures such as the sea wall intended to protect the tourist cottages and the multi-purpose hall. Overall, it is noteworthy that most of the measures suggested and planned by the community aim at enhancing capacities rather than at reducing underlying vulnerability. Indeed, people's vulnerability is rooted in structural constraints that seem beyond the influence of the local community. As emphasised by Lewis (this issue), the underlying vulnerability is often derived from past or exogenous forces. On the other

hand, people's capacities to cope with a crisis rely on local and indigenous resources localised on the model. For example, it seems very difficult for poor fishermen to have an impact on the price of fish that is dictated by powerful boat owners and market dealers. On the other hand, mutual help and subsistence farming are indigenous ways of coping with fluctuating prices.

	Vulnerabilities	Capacities	Mitigation measures
PO's cottages	- Location - Basement - Palm roofs - Source of incomes for the PO - No seawall	- Continuous presence of watchers - People used to secure goods and strengthen the rooftop - Mutual help between PO members - Important papers are in the PO president's house	- Build a seawall - Purchase a strong net to cover the roof - Need for a communal cell phone - Save some income to foster resilience - Use a shell as warning tool
Houses	- Housing materials	- One two-storey house in the village - Some cemented houses - People are used to strengthening their roofs with nets	- Need for permanent nets to strengthen the roofs
Fishing	- Small and fragile boats - Source of incomes - Define the capacity to buy rice - Define the capacity to send children to school	- Pawning of assets (boats) - Loan to purchase gas - Mutual help between fishermen - Farming and fish pond - Fishermen are used to securing their boats	- The PO may loan money to the fishermen for the purchase of gas - The PO may enter into negotiation with the National Food Authority to purchase discounted rice during rainy season - Secure the PO boat in the event of a tsunami - Harvest milkfish from the pond
Subsistence farming	- Source of food - No protection - Long recovery	- Fishing	- Nets and bamboo for the protection of one field owned by the son of a PO member. The PO would provide the materials to protect the field. In exchange the owner would sell part of his harvest at a cheap price to the PO
Cash crop agriculture	- Define the capacity to buy rice - Define the capacity to send children to school - Existing debt among farmers - No protection - Long recovery	- Fishing	- The PO may engage in copra dealing. Copra may be stored at the PO president's house and secured in the event of a warning

Tourism	- Location of assets - Source of income - Dependent on transportation	- Do not depend entirely on infrastructure	- Develop tourism activities which do not rely on infrastructure (eg turtle watching)
Retailing shops	- Dependent on fishing / transportation / agriculture / electricity for storing fish	- Sideline resources (craft, laundry, etc.)	- Look for a sponsor to purchase a freezer to store fish and vegetables - Need to locate the freezer in a safe place - Look for a sponsor to buy a generator - Develop craft activities
Transportation /Boats	- Sea based - Source of incomes - The decision to go out is within the hands of the boat owner, not the fishermen - Access to doctor and schools	- Some boats are more resistant - Traditional knowledge of the sea - Children stay at school during the rainy season	- The PO may enter into negotiation with gas stations to purchase discounted gas during rainy season and after typhoon or storm surge periods.

Table 1: Vulnerabilities and capacities of threatened assets and associated mitigation measures suggested by the community of Divinubo in August 2007

The last part of the CBDRM process entailed the definition of measures to be taken in times of crisis. The P3DM was the focal point of the discussions. It better enabled the dialogue concerning warning signals to reach the whole village, and facilitated the plotting meeting points, evacuation routes and evacuation areas. Since the PO was already organised into four gender and age-balanced sub-groups for its regular activities, it was decided that each group would take care of one critical social and economic asset for the community. One group was tasked to converge on the karaoke machine, which is a major resource should tourists visit the island. In the event of a warning signal, this group would take the karaoke machine to a higher and wind-sheltered point on the island. Another group would take care of disassembling the outrigger boat and carry it to a refuge. A third group would go to the copra storage area of the PO and transport the coconut shells to safety. The fourth group would harvest fish from the pond and take them to the evacuation area. The fastest, easiest and safest routes of evacuation were identified on the model.

Conclusions

The use of P3DM for effective CBDRM is very promising. The Divinubo experience emphasises several assets:

1/ P3DM facilitates the participation of the population through direct involvement in the construction of a concrete, long-lasting tool. If facilitated well it can bring together the different sectors of the community, even the usually marginalised children, elders, women, the disabled and so on. All can have a concrete role in the construction of a P3DM or in its use for CBDRM.

2/ P3DM raises people's awareness of their territory. Building a P3DM is indeed a collective learning experience that stimulates the exchange of information and its tangible visualisation. Except for a few men who are used to crossing and navigating around the island for farming and fishing, people did not have a complete and tangible appraisal of Divinubo. Most of the participants actually discovered the real shape, terrain and land use of the island when building the model. Furthermore, hazard, vulnerability and risk are abstract concepts that materialise only when hazardous phenomena strike and cause damage. Mapping hazard-prone areas and vulnerable assets on a 3D model allows people to concretely appraise disaster risk in their immediate environment.

3/ P3DM allows 3-dimensional mapping of natural and other hazards, threatened assets, vulnerability and capacities. In the future, it will be important to ask people to further plot vulnerable social groups or families on P3DM. The model may be critical when the mapping and comprehension of hazard-prone areas requires topographic and elevation references, for flooding, tsunami, landslides. Similarly, when refuge and evacuation areas have to be located, P3DM may be of valuable importance as it may enable people to immediately identify threatened and safe areas.

4/ P3DM enables CBDRM to integrate into the larger development framework. It is now critical to encourage the local community to extend the use of the model for resource management, land-use planning and resolving land conflict issues. For example, the Divinubo exercise raises issues regarding access to land in hazardous and safe areas, which may be part of the larger development agenda.

5/ P3DM proves very useful in marginalised areas like small islands (Lewis, 2009). Rambaldi and Callosa-Tarr (2002: 3) note that in such areas “the tendency for most people... is to learn via concrete sensorial experiences, rather than abstract concepts”.

6/ P3DM is cheap to set up and easy to reproduce. The Divinubo project did not cost more than US$ 200 in materials and food for the local participants. The cost of materials may further be cut by the use of indigenous paints, local glue and scrap materials.

7/ Beyond its primary use for CBDRM, P3DM may provide valuable data for scientists interested in disaster research. As demonstrated by Rambaldi and Callosa-Tarr (2002), P3DM data may indeed be directly integrated into GIS. In the case of the Divinubo project, the model has been geo-referenced but not yet integrated into a GIS.

8/ The P3DM process could better facilitate the collaboration between scientists, NGOs, POs and local authorities. It is thus a powerful tool to bridge the gap between the academic realm and the NGO sector that has prevented scientific inputs from being integrated into these valuable initiatives.

However, there are several limits to the proposed methodology and some issues that seem to be instrumental in the effective integration of P3DM in CBDRM:

i) One of the major limits of P3DM is that it only partially covers social vulnerability/capacities and better applies to physical vulnerability/capacities. It turns out to be easier to plot infrastructure, houses and farmlands than gender-related inequalities or social capital. Further work is needed to integrate such social indicators and factors of vulnerability/capacities on the model.

ii) The Divinubo P3DM is a large-scale model adapted for a small island community of

700 people. It enabled locals to plot detailed features such as houses and deep wells. Mapping those details would not be possible on a small-scale model for larger communities or group of communities living in a common watershed or on a larger island. The methodology is thus still to be tested and adapted in different contexts.

iii) Similarly, the Divinubo P3DM was helpful because the terrain was contrasted. It enabled locals to clearly distinguish low-lying areas and higher points. A similar project will soon be implemented in a deltaic area of the Philippine archipelago and will test the use and contribution of P3DM in different environments.

iv) The Divinubo project demonstrated that scientists are well able to convene the building of the 3D model and FGDs to assess hazard-prone areas, people's vulnerability and community capacities. Yet their ability to fully organise the target community and implement the previously designed risk mitigation strategies for effective and long-lasting CBDRM is doubtful. There is a need to involve a local NGO in the organising of the community and the monitoring of the project in the longer term. This emphasises the collaboration and coordination between the scientific realm, the NGO sector and beneficiary communities. In the case of the Divinubo project, the risk assessment component organised by scholarly facilitators worked well but the crisis management module largely relied on the existing structure of the PO and its partition into four sub-groups. Possible changes or turnover within the organisation may complicate emergency management in the event of a crisis. Some further difficulties arose regarding responsibilities among members of the PO for the implementation of measures intended to enhance local capacities. Scholarly facilitators obviously lacked skill to address these issues.

v) P3DM will be maximised if updated regularly. In the case of the Divinubo project, the lack of NGO partners forced the facilitators to rely on the PO to ensure that the model will be stored properly and updated. However, a turnover in political leadership occurred on the island during the latest local election in October 2007. The incumbent president of the PO was removed and the fate of the P3DM is in danger. Collective lessons learnt during the building of the model and accompanying workshops remain.

vi) The long-term confidence-building stage before the implementation of the project is critical to anticipate the needs of the local community and to avoid misunderstanding regarding the expectations of all involved parties. All stakeholders of the project must work together towards the same agreed goals. For the Divinubo project, several visits to the island have been conducted during the last three years and one facilitator had been living on the island for two weeks before the implementation of the project. Yet, some members of the PO were expecting compensation in cash or kind from the facilitators.

In conclusion, the P3DM is a powerful tool with promising applications to improve CBDRM if careful initial groundwork is conducted and the right stakeholders are involved. Presently, the methodology is being refined through different projects elsewhere in the Philippines. Hopefully, further guidelines will emerge for a wider use of P3DM in disaster risk reduction and management in the future.

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