doi:10.1111/j.1467-7717.2011.01247.x

Coping strategies and risk manageability: using participatory geographical information systems to represent local knowledge

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The accumulated knowledge and perceptions of communities 'at risk' are key elements in managing disaster risk at the local level. This paper demonstrates that local knowledge of flood hazards can be structured systematically into geographic information system (GIS) outputs. When combined with forecasting models and risk scenarios, they strengthen the legitimacy of local knowledge of at-risk populations. This is essential for effective disaster risk reduction practices by external actors, local non-governmental organisations (NGOs) and municipal authorities. The research focused on understanding coping strategies and 'manageability' of flood hazards as defined by communities. 'Manageability' is how people experience flooding in relation to their household capacity and the coping mechanisms available. The research in the Philippines highlights the significance of localised factors, including socioeconomic resources, livelihoods, seasonality and periodicity, for understanding manageability. The manageability concept improves practice at the municipal level by legitimising local coping strategies, providing better indicators, and developing understanding of flooding as a recurrent threat.

Keywords: community participation, coping strategies, flood hazards, local spatial knowledge, manageability, participatory geographic information system, the Philippines, risks, seasonality, vulnerability

Introduction: mapping community knowledge of risk

It is recognised increasingly that community involvement needs to become a chief priority in establishing effective partnerships for disaster risk reduction, as in the Hyogo Framework for Action 2005–2015 (UNISDR, 2005).

Understanding how local people cope and how they adapt to flooding and other hazards is not always straightforward for external actors, such as policymakers and researchers. Flood risk, and mechanisms to deal with it, are perceived differently by those who know flooding as a phenomenon to measure and model, those who take

Published by Blackwell Publishing, 9600 Garsington Road, Oxford, OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

decisions on urban investment or land use change, and those who have to confront and manage the threat of flooding in everyday life.

Recognition of local knowledge can improve external actors' understanding of flood risk and risk management decision-making. Local people know the 'facts' about recurrent natural hazards, and are well-informed about the changes in their environmental and socioeconomic situations that result in their perceived risk varying over time. Local people establish mechanisms for coping that, if well understood, can guide the actors involved in planning and risk management and assist them in jointly developing adequate measures for decreasing people's vulnerability and avoiding or reducing risk.

Approaches and tools for integrating the knowledge of at-risk communities into decision-making processes have gained acceptance over the past decade. Methods of participatory research, especially participatory rural appraisal (PRA) and rapid rural appraisal (RRA), have been developed extensively to analyse local knowledge and life conditions in fields such as anthropology and natural resource management (see, for example, Gilbert, Norman and Winch, 1980; Kabutha et al., 1990; Chambers, 1994; Scoones and Thompson, 1994; Guijt, 1998; Gonzalez, 2000; FAO, 2001; Mukherjee, 2001). Such methods are now proving their effectiveness as well in the disaster risk field (see, for example, Heijmans and Victoria, 2001; Ireland, 2001; de Dios, 2002; UNCRD, 2003; Enarson et al., 2003; Abarquez and Zubair, 2004; Falk, 2005; Schaerer, 2006; Venton and Hansford, 2006; Dekens, 2007; van Aalst, Cannon and Burton, 2008).

The RRA and PRA approaches have been employed to collect vital spatial information from field observations and to determine local knowledge of hazard characteristics, the locations of vulnerable people and structures, and information on coping mechanisms, inter alia, and to distribute it via sketch maps. Too often, though, ephemeral and rough maps, photographs, historical profiles and other mapped outputs procured through participatory surveys are not valued or legitimated (Anderson and Woodrow, 1998; IFRC, 2002). Frequently, they are not even stored or updated, leading to a loss of valuable local information. As Cannon, Twigg and Rowell (2003) advise, these materials need to be converted from raw data into more flexible and sustainable spatial information to allow both the community and other actors to develop risk analysis and to plan risk reduction measures.

Meanwhile, the disaster risk reduction (DRR) sector has come to recognise the value of formalised geospatial information—such as aerial photography, satellite imagery, geographic information systems (GIS), and global positioning systems (GPS)—and is acquiring advanced techniques and competencies in this sphere, and using them to map vast quantities of geospatial information on physical hazards and their impacts, as well as environmental and, to a lesser extent, social vulnerability (Chen, Blong and Jacobson, 2001; Longley et al., 2001; UNISDR, 2004; IFRC, 2005; van Westen, Castellanos and Kuriakose, 2008). Increasingly, however, there are applications that include participatory information, as found in Williams and Dunn (2003), Bankoff, Frerks and Hilhorst (2004), Falk (2005), Peters-Guarin, van

Westen and Montoya (2005), Muňoz (2007), Kienberger (2008), Laituri and Kodrich (2008), Peters-Guarin (2008), and Marschiavelli et al. (2009) (see McCall (2008) for an overview).

Thus, on the one hand there have been advances in the application of remote sensing (RS)/GIS for hazard and vulnerability mapping, and on the other hand, developments in the PRA/RRA methodology have been applied to community risk assessment (CRA). Concomitantly, there is more than sufficient evidence from natural resource management and elsewhere that the combination of local knowledge and modern spatial information systems (GPS, GIS), participatory geographic information systems (PGIS), and earth observation products (satellite imagery, aerial and oblique photography) enhances planning and policy decisions by providing more reliable, empirical, detailed and convincing information (McCall, 2003; O'Neill, 2003; Chambers, 2006; Rambaldi et al., 2006a, 2006b).

Nevertheless, despite these advances and evidence of co-production of knowledge, the advantages of participatory collection of risk-related spatial information within a GIS context have not been widely harnessed for DRR to date (Maskrey, 1998; UNISDR, 2002; Ferrier and Haque, 2003; Zerger and Smith, 2003; IFRC, 2005).

PGIS utilised within a participatory risk assessment process brings together the spatial information components of DRR and local spatial knowledge. By making use of formalised systematic mapping and analysis of local spatial knowledge relevant to hazards, vulnerability and risk, PGIS provides the added value (to local capacities) of digital data in a GIS environment. The integrating of local spatial knowledge into PGIS can be used to forecast flood hazards, estimate risk much more effectively, and understand vulnerability and coping strategies (McCall, 2008). PGIS contributes to risk management by helping to build local capacity, improve a community's relationships with those in power, promote learning among the actors, and enhance risk communication of local concerns and capacities, for example, to the 'higher-ups'.

Participatory mapping and PGIS elicit, represent and validate local spatial knowledge, which is rarely available on official maps; the information is spatially specific, implying that it concerns local priorities, values and perceptions; the process itself is driven by local interests and priorities; it is socially inclusive, representative of the interests and values of communities as well as of individuals; feelings of 'ownership' and the legitimacy of actions can be strengthened at the community and municipality level; and it is capacity-enhancing, as communities and groups can be empowered by involvement in PGIS processes, thereby improving self–confidence and technical and political capacities. By forging communicability between outsiders and insiders, it not only legitimises the value of endogenous knowledge, but also makes the technical GIS tools more acceptable to local users. Furthermore, local actors can achieve lower costs in their disaster risk assessments and disaster management. These factors are particularly important in developing countries where much of the crucial spatial and non-spatial information and the technical and financial resources for risk assessments are not otherwise available to local authorities and planners.

The objective of this paper is to demonstrate that use of PGIS among communities at risk enhances the integration of local knowledge into risk assessments, making it an important asset for risk management at the municipal level. Furthermore, when the authorities make proper use of people's local spatial knowledge in a PGIS frame, multiple benefits materialise, as identified in the PGIS literature (Craig, Harris and Weiner, 2002; McCall, 2003, Rambaldi et al., 2006a, 2006b; Dunn, 2007; Sieber, 2006).

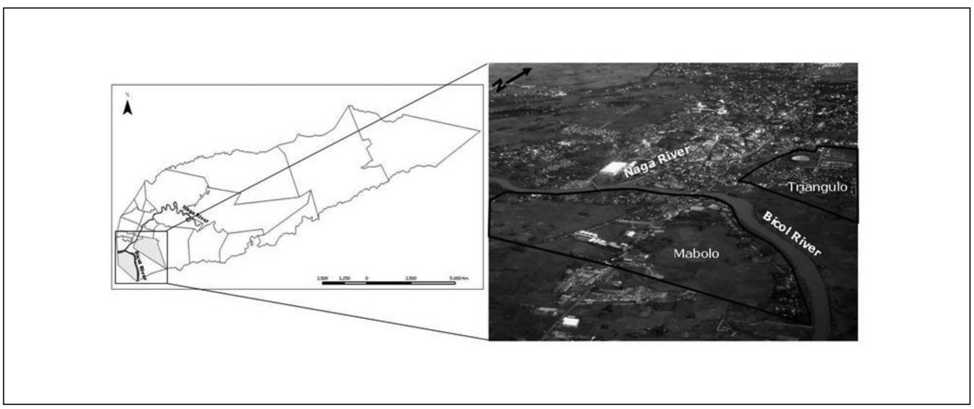
The paper argues that, by making use of participatory tools and GIS methods, community-based concepts such as 'manageability' of the flood threat through coping mechanisms, and awareness of seasonality and the timing of flood events, can be spatially depicted and handled. They are powerful tools to permit decision-makers to strengthen the adaptation capacity of at-risk communities and to assess the effectiveness of risk reduction policies and programmes across time.

The study area

The case study (Peters-Guarin, 2008) was carried out in two *Barangays* (wards): Mabolo and Triangulo in Naga City, Philippines (see Figure 1). The Philippines is considered to be one of the most disaster-prone countries in the world. The high frequency of earthquakes, floods, tropical cyclones and volcanic eruptions continuously trigger disasters, which place an enormous, ongoing burden on numerous vulnerable communities and constitute a major constraint to much-needed development (World Bank, 2005).

Naga City in the Bicol Province of the Philippines was selected for this case study because of its high susceptibility to hydro-meteorological events such as floods and typhoons. Naga is a medium-sized city situated in the floodplains of the Bicol River, in the 'typhoon belt', and experiences between two and five typhoons annually, accompanied by extremely intense rainfall.

Figure 1 Location of Mabolo and Triangulo Barangays in Naga City



Source: authors.

Owing to the location of the city, the frequency of flooding has caused problems throughout its history. Communities in most wards have to cope with high intensity rainstorms and recurrent flooding, mostly related to typhoons. The annual occurrence of these events has created a high level of awareness among the communities and the local government. However, despite the clear interest of the local authorities in improving their disaster response schema, implementation of effective measures to counteract the negative effects of flooding remains lacking. Furthermore, vulnerability and risk reduction are still not central components of poverty reduction and development plans within the municipality.

Manageability and coping strategies: people's ways of dealing with the flood threat

The research in Naga City revealed that understanding the threat embodied by flooding and typhoons requires not just determining physical aspects, such as water depth and duration or velocity of the water and winds as well as their spatial distribution. It involves also comprehending the role played by existing knowledge at the community level, the awareness raised by official and community-based warning systems, and the efficacy of the coping strategies available at the household, ward and municipal level. These elements determine the range of options available to actors for 'managing' the flood threat.

Manageability is understood in this paper as the way in which local communities and individuals experience flooding and recognise the hazard posed, in relation to their capacity to handle the situation depending on their resources and range of coping mechanisms. This capacity has accumulated over generations as a result of people's experience of dealing with floods with limited assistance from higher authorities. The coping and manageability capacities have been developed not as choice options, but as self-help necessities.

Manageability might be considered as an unavoidable behaviour or as a residual option—that is, it is composed of what people do when the authorities cannot fully relieve their hardships, and, how people react when they have no alternatives. Moreover, it may be seen as an illustration of the authorities' dereliction of their duty of care for the population. While accepting the reality of that interpretation, these authors also view manageability in a more positive light: it is the manifestation of people's resilience, creativity, intelligent strategies and accumulated learning. People may be victims of the hazards (human-made as well as natural) but they are not passive survivors helplessly waiting for government assistance.

The fact that flooding in these *Barangays* is mostly a gradual rather than a sudden event, coupled with official warnings and community-based self-awareness, determines that these communities rarely are unaware of the upcoming situation (except during flash-floods). Once people receive a warning that a typhoon will strike the Bicol Region several decisions and actions are taken. Participatory research revealed how, particularly at the household and ward level, numerous coping mechanisms are deployed to deal with flooding (see Tables 1 and 2).

The main aim of these strategies is to avoid or decrease the disruption that flooding can cause to a family's daily life. Coping mechanisms for protecting lives, ensuring a minimal supply of food, increasing the physical safety of the residence and securing valuables, and postponing evacuation until the last moment accord people with the feeling that, up to a certain point, they can 'manage' the situation using their own resources.

Some of these strategies were found to be temporary and employed just to survive the event or the immediate aftermath (S), whereas others were integrated into people's daily lives either in the medium (M) or long (L) term. Some of the strategies make people less dependent on external (perhaps uncertain and inadequate) assistance and speed up the process of returning to 'normal' life, thus making the episode less traumatic.

With regard to housing, the long-term strategies are specifically intended to avoid flood water entering the building. The preferred coping mechanisms to prevent exposure to flooding are to build concrete houses, to raise the terrain, or to construct houses on elevated stilts. The latter is so common as to characterise the landscape of these communities. When flooding or high winds cause more than 50 per cent

Table 1 Community-based warning levels and protective mechanisms against floods and typhoons found in the Barangays

Public storm signal	Community-based warning parameters	Precautionary measures taken by local ward officers and households
No. 1	Signal no. 1 + water at knee depth	• Local ward officers ask residents about their intention to evacuate and suggest precautions. • Households start to pack and wrap valuable items/ appliances in plastic to avoid damage. • Households should store water for drinking/domestic use. • Store food (rice + viands) and firewood/gas. • Livestock is moved to safety.
No. 2	Signal no. 2 + water rising above knee depth	• Local officials ask the municipality to assist residents by providing trucks for a potential evacuation. • Listen to radio/television for forecasts. • Residents move all valuables to elevated areas/mezzanines. • Children, women and elderly people are evacuated to the homes of relatives or neighbours in flood-free areas or to evacuation centres.
No. 3	Signal no. 3 + water at waist depth + strong winds	• Ward and municipal officers carry out rescue operations, usually by means of wooden boats (known locally as 'banca'). • Municipal authorities ask the electricity company to cut off light/electricity. • Local officials visit residents who are still in their houses. • Husband or eldest son stays behind to guard the house. • Local officers guide people to evacuation centres and conduct roll-calls to count evacuees. • Some people still in their homes are evacuated.

Table 2 Households' coping mechanisms to reduce disruption of daily life, before, during and after flooding

Aspect of daily life	Before flooding	During flooding	After flooding
Housing	• Reinforce wooden/ thatched houses by tying with wire (S). • Nail down walls and windows and put heavy items (sandbags, tyres) on top to protect roofing (S). • Prepare second-hand or scrap materials for future repairs (S). • Elevate part of the house/ build mezzanine (L). • Build house using reinforced materials or over two storeys (L).	• Secure access to the house to avoid intrusion of debris and waste (S). • Vacate the house to avoid loss of life (S).	• Source relief materials (S). • Dry walls with an electric fan to avoid deterioration (S). • Repair house with family members to avoid the cost of labour (SM). • Repair the damage 'little by little' (M). • Earth-filling to elevate room levels (L). • 'Leave as it is' (L).
Livelihood	• Look for additional sources of income (SL). • Stock up shops so there are enough supplies to sell (S). • Increase working hours (SM). • Save money (ML). • Replace stock in shops and purchase agriculture products (farmers) (S). • Gather seeds for next planting season (SM). • Elevate shop buildings (L).	• Stop working outdoors (S). • Use savings (S). • Temporary change in business location (second floor, roof or other safer place) (S). • Look for jobs in flood-free areas to meet family needs (SM). • Work overtime (SL).	• Ask for work or for assistance from other community members (S). • Look for alternative employment (ML). • Sell stored items on credit (S). • Sell scrap material from damaged houses (S). • Work for food (on farms) (SM). • Borrow money from relatives, moneylenders ('loan sharks', charging high interest) or from the government (SL). • Pawn appliances and other valuables (SL). • Work overtime (SL).
Food	• Buy food supplies to pre-empt scarcity and rising prices (S). • Store basic non-perishable food items (canned goods, rice, salt, sugar) (S). • Collect/store wood for fire and cooking (S).	• Buy items or food stocks in bulk (S). • Buy food items at nearby stores (S). • Bring enough food to evacuation site (S). • Purchase cheap food (SL).	• Collect relief items from local government unit and NGOs (S). • Place food stocks in containers to avoid damage by rats (SM). • Fetch wild edible foods (SL). • Change diet by eating cheaper food (ML). • Reduce food intake (ML).
Health/sanitation	• Purchase nutritious food (S). • Store drinking water to avoid disease (S). • Do not buy perishable goods (S). • Buy first-aid medicines (S).	• Prevent children from playing amidst floodwaters (S). • Dispose of human waste in plastic bags (SM). • Boil water to avoid illnesses (S).	• Consult health workers on sickness or injury (S). • Boil drinking water (S). • Avoid stagnant water, or thoroughly wash after coming into contact with it (S).

		• Follow proper personal hygiene routine (S).	• Avoid drinking pumped water (S). • Ask Barangay or NGOs for medicines (SM). • Clean house and surroundings (SM).
Safety of belongings	• Arrange/improvise storage (S). • Install metal hooks to hang items (S). • Prepare waterproof containers (S). • Wrap valuable items/ appliances in plastic for safe storage (SM). • Fix things before evacuating (S). • Build stands for refrig-erators and heavy items (SM). • Construct/install mez-zanine floors (ML).	• Place effects on second floor, in mezzanines or in sealed containers (SM). • Move livestock, poultry and vehicles to elevated roads (S). • Guard the house to protect belongings (S). • Place appliances at the homes of relatives or neighbours or at evacuation sites (SM).	• Dry wet things with an electric fan (S). • Clean flood dirt from items (S). • Repair minor damage to appliances (SL).
Mobility	• Assemble improvised floaters (basin or cans) (S). • Get clothes ready for walking in the flooded area (S). • Prepare improvised walkways (SM). • Prepare banca (rustic boat) or identify some-one owning one. (S)	• Set up temporary walkways (SM). • Wear suitable clothes, such as shorts and waterproof boots (S). • Do not walk barefoot, to avoid injury (S). • Build a makeshift raft or floaters to carry heavy objects (S). • Use boats for mobility within the ward (S).	• Do not go out unless it is necessary (S). • Do not walk barefoot in areas full of debris, to avoid injury (S). • Keep the walkways in place until the terrain is dry again (SM).
Overall safety	• Raise awareness of expected flooding during the typhoon season (June–December) (SM). • Follow forecasts/broad-casts from the Phillipines Atmospheric, Geophysi-cal and Astronomical Services Administration (PAGASA) via radio/ television (SM). • Ask in advance for temporary refuge in safer homes of relatives or friends (S). • Proper waste disposal (SM). • Participate in community programmes (that is, waste management, also known as RABUZ) to clean the drainage system (SM).	• Follow official safety instructions (S). • Stop sending children to school (S). • Evacuate children, women and elders to temporary shelter (neighbours or relatives or evacuation centres) (S).	• Clear surroundings of debris and dangerous materials (S). • Ask relatives, friends or city government for support (SL). • Help community members with repair work (S). • Participate in community recovery activities (S). • Clean canals (SM).

damage to houses, especially wooden ones, they are no longer considered as places of safe refuge. In this case the whole family has to seek shelter in safer houses (often concrete buildings) nearby or move to evacuation centres.

However, building houses from strong materials and raising the terrain to avoid flooding are coping strategies that require funds. Mostly this money comes from people's own savings or from private loans. However, since most families live below the poverty line—66 and 73 per cent of households in Triangulo and Mabolo, respectively, were earning less than USD 3 per day in 2005—the likelihood of implementing these strategies and providing long-term refuge is low. After damaging floods, households need to use their limited savings, borrow small amounts from informal moneylenders (known locally as 'loan sharks'), or pawn their few valuables. The poorest families, though, can only repair the structural damage 'little by little', using scrap (weaker and insufficient) materials, or simply leave the house 'as it is'.

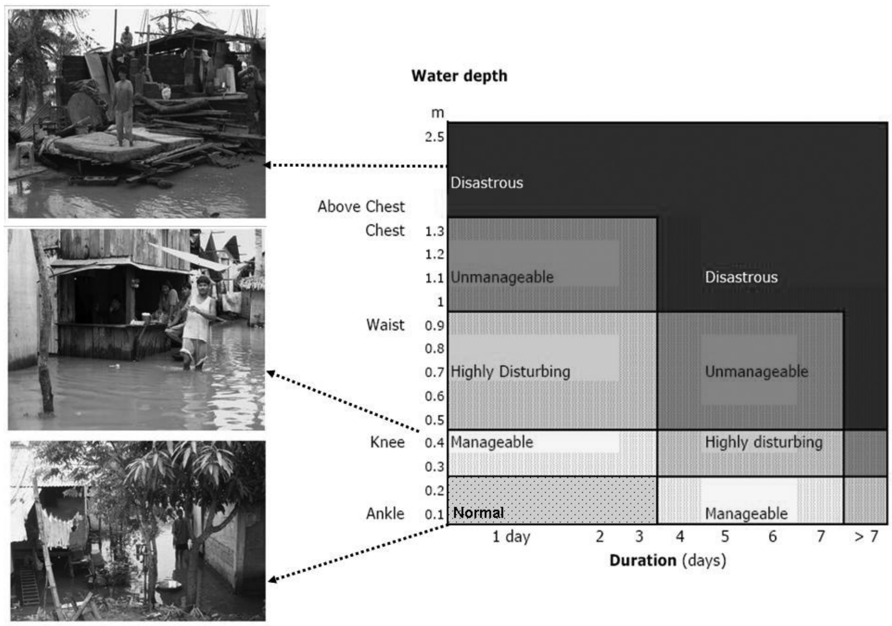
Diversifying livelihoods, extending working hours, changing employment or even trading work for food are strategies to prolong households' economic resistance and to avoid for as long as possible having to use savings, borrow money or sell/pawn valuables, since these constitute their reserves for other 'critical times'. Most of these strategies are meant to last for shorter periods or at least until the situation returns to pre-flooding status. Yet, given the precarious socioeconomic conditions of most families in these wards, the 'recovery' can continue for months or years. Risky strategies such as decreasing food intake, missing meals and consuming poor-quality items may last for several months after a flood and become 'normal', especially after consecutive typhoons. For instance, because vegetables become expensive or scarce during inundations, families supplement their diet by reaping wild edible crops; those families left in a marginal state after flood events incorporate this into normal life.

The continuous implementation of such coping mechanisms without reducing high levels of flood hazard and community vulnerability may lead to further marginalisation and impoverishment in the long term. Especially where there is a recurrence of threatening events at short intervals, people have increasing difficulty in implementing the same coping mechanisms every time flooding occurs. Their resources are depleted, their resilience is reduced, and hence their capacity to endure floods decreases. Despite the coping mechanisms available, people are trapped in a cycle of poverty and marginality because of recurrent losses.

Characterising manageability ranges from the community's perspective

Where social and economic conditions are fragile there is no need for an 'extreme' magnitude event to create a serious threat to households. Seasonal rains, small but repetitive flooding, high tides or strong winds have the capacity to disrupt the 'normal' life of these communities in ways not always easy for municipal or regional authorities and other external actors to perceive.

Figure 2 Graphic representation of the flood hazard and manageability perception of the communities in terms of floodwater depth and duration



Source: authors.

The participatory tools employed during this research project made it possible to elicit and understand how these 'at-risk' communities perceive the threats posed by their flood-prone environment and how they behave accordingly. This knowledge was then structured as a number of semi-quantitative classes defined in terms of water depth and duration, the disruption caused, and the resources and coping mechanisms (Peters-Guarin, 2008).

Figure 2 shows how depth and duration of flooding were identified by community participants and used to explain the progressive hazardousness of flood episodes.

The participants described the five hazardousness categories as follows:

Normal

This category is defined as low flood levels up to *ankle* depth, but in any case less than 30 centimetres (or one foot) and lasting less than three days. This flood stage can occur during the dry season in the lowest-lying areas with isolated rain showers, each month during the full moon period with high tide, or generally during the wet season after several hours of continuous rainfall.

People consider this flood stage as 'normal' as it occurs numerous times particularly in low-lying terrain. They are used to the situation and adjust their lifestyle to it, especially in the wet season. Adaptation strategies such as elevated houses and pathways help working people to carry on with their economic activities; students can attend school; and generally people are able to continue with their 'normal life' (see Figure 2).

During these flood stages people carefully follow the official warnings, and their coping mechanisms sustain their mobility while avoiding direct contact with flood-waters polluted with human and animal waste. This stage does not embody high levels of direct physical threat, but because of its high recurrence it increases the exposure of people, particularly children, to water-borne diseases.

Disturbing but manageable

According to the communities, this category comprises flood stages below or slightly above *knee* depth (40–60 centimetres or 1–2 feet) and which lasts less than three days, or flooding at *ankle* depth but which lasts between three days and one week (see Figure 2).

At this stage the incidence of flooding starts to be disturbing because of either the depth or the duration of the flood. However, by instigating some coping strategies at the family level, the situation is still found to be *manageable*. The disturbance comes from the interruption of normal activities, schooling, for example, such that working parents have to allocate time from economic activities to take care of their young.

In houses at ground level or not sufficiently elevated, domestic activities such as cleaning, cooking and sleeping are highly disrupted because of the intrusion of flood waters. Basic sanitary facilities and private and public faucets, toilets and pumps are mostly covered by flood waters. These disruptions to people's everyday activities represent extra stress in their already challenging daily lives.

Mobility difficulties arise as many roads and pathways are flooded and economic activities such as street vending and washing clothes, as well as the running of small 'in-house' shops and food stalls, have to cease. This interruption of income-generating activities may represent a cutback of up to 30 per cent of the daily revenue of many households in the lowest-lying areas. This stage also represents a higher exposure to diseases among people who still commute to work or perform tasks such as collecting potable water, for they have to wade amidst stagnant waters. In some sectors children are still allowed to swim and play in the polluted waters. In the case of low level but longstanding water, the disturbing aspects come from the presence of pooled (usually polluted) water that provides an ideal breeding ground for mosquitoes and water-borne diseases and foul smells.

Highly disturbing

This category—also referred to as 'hardly manageable' or 'intolerable'—occurs when flooding reaches below or slightly above *waist* depth (80–100 centimetres or approximately three feet) and lasts between one and three days, or when water levels are below or slightly above *knee* depth (40–60 centimetres or 1–2 feet) but last between three and seven days.

In this category the mechanisms to counteract the negative effects of inundations are nearly depleted. Especially in the first two stages that combine deep and long-lasting flooding, the disturbance created usually exceeds the resilience of the most vulnerable groups. Their flimsy residences do not constitute a safe shelter anymore and most of their daily economic livelihood activities come to a halt.

The field studies found that this flood stage marks the boundary at which the poorest and more exposed families are forced to seek external physical protection and food assistance. The first option for most families is to look for stronger buildings nearby to allow them to continue to protect their land plot. If neighbours cannot provide such assistance, people move to the homes of friends or relatives or to official evacuation centres in more remote areas.

At this stage almost all zones in both wards (Mabolo and Triangulo) are severely flooded and therefore the threat becomes more than just the secondary or tertiary effects of diseases and disruption of facilities, livelihoods and services. Flooding up to waist depth can cause severe damage to structures and poses a serious threat to the longer-term well-being of the entire ward.

Unmanageable

This category occurs when flooding reaches around *chest* depth (130 centimetres or approximately four feet) in a single day and lasts a maximum of three days, or, when flooding reaches *waist* depth (80–100 centimetres or about three feet) but lasts between three days and one week, or, moderate magnitude flooding below *knee* depth (40–60 centimetres or 1–2 feet) and which lasts for more than one week.

The community asserts that it does not have the resources to manage or cope with the situation at this stage; most households have to rely on external assistance to meet basic needs, including drinking water, food, health care, sanitation and shelter. At this stage most people in low-lying areas have to leave their residence and move out of the ward; social and economic activities in the low-lying areas come to a stop and the community as such nearly disintegrates, until the flood recedes to 'manageable' levels.

During this stage damage is widespread in most flood-prone areas of the city, comprising 17 of the 27 wards. This disruption exceeds the capacity for response of most of the *Barangays* and creates mounting pressure on relief capacities and resources at the municipal level.

Disastrous

This is the final category and is the one that is most feared by the people. It occurs when flooding, regardless of the duration, reaches above *chest* depth (more than 130 centimetres or more than four feet), or when flood levels are below or slightly above *waist* depth (80–100 centimetres or approximately three feet) and last more than three days, or when flood waters are below or slightly above *hip* depth (70–90 centimetres or around three feet) but accompanied by strong winds (that is, during a category four or five typhoon).

In the first two cases flooding is widespread in Naga City and nearby towns in the Bicol River floodplain. The 'calamity' or `disastrous' state is felt everywhere as one-half of the municipality is flooded, including the city centre, with its commercial activities. The extent of the dislocation is such that many people fail to cope with the situation (see Figure 2). In this case extreme mechanisms are adopted, such as family disintegration, migration (particularly of the head of household) to bigger cities, or simply remaining in a state of marginalisation and destitution for years, which becomes their 'lifestyle'.

According to people in the two wards these circumstances have manifested themselves several times over the previous decade (notably, Typhoon Rosing in 1995 and Loleng in 1998). During the fieldwork, almost a decade later, the physical damage, the threats to life and the widespread disturbance caused by these typhoons were recalled constantly by these communities; they are part of the collective memory.

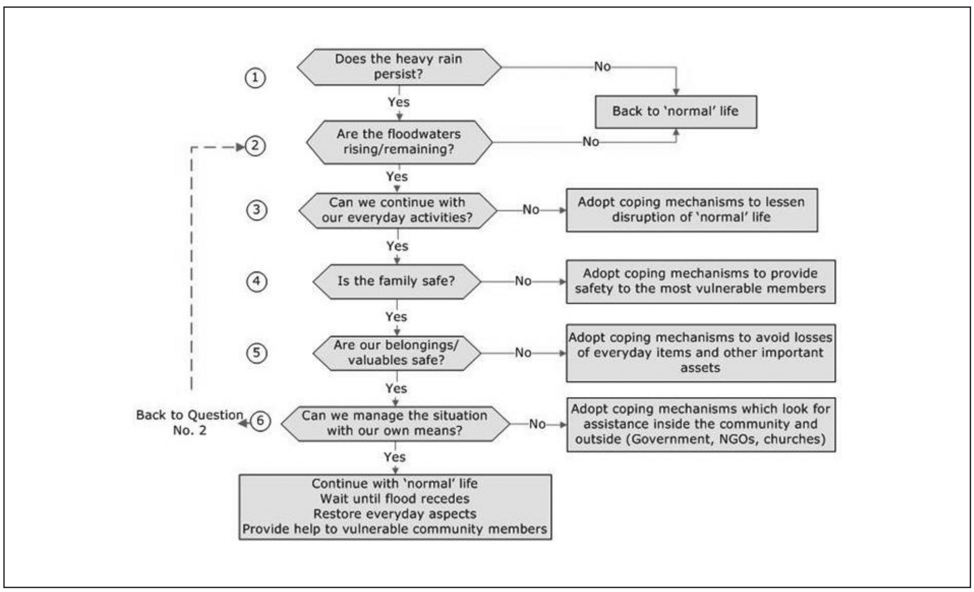
Coping, timing and decision-making at household level

Coping strategies are initiated depending on the official warnings, the current status of the weather and the household's own knowledge of the evolution of floods. Once a given flood stage, such as *ankle* depth, is reached, the family initiates a process of decision-making that depends mostly on the speed of flood-rising. Their awareness of flood behaviour leads them to adopt an assortment of the mechanisms listed in Table 2.

Figure 3 shows aspects of the decision-making process of households in the *Barangays* when flooding reaches consecutive stages (*ankle, knee, waist, chest* depth and above).

The course of household decision-making is based on what can be called a subjective 'multi-criteria' judgement that includes:

Figure 3 Decision-making by households when flooding reaches ankle, knee, waist depth and above



- ***Flood behaviour in their own zone:*** from previous experience the households know the potential depth and duration of a given type of flood in their surroundings.
- ***Perceptions of their own spatial location in relation to flooding:*** the household's consciousness of local variations in the topography around its residence, and its proximity to flooding paths.
- ***Awareness of their own levels of physical exposure:*** the security that their house can provide to family members and belongings.
- ***Perceptions of their own socioeconomic capacity*** or resilience for absorbing the progressive losses caused by the succession of flood stages.
- ***Expectations of potential external assistance*** from *Barangay* and municipal authorities, churches, local politicians and NGOs; based on their experience of previous floods.
- ***Awareness of potential health environmental problems*** in their area associated with the presence of pollutants, such as human and animal waste.
- ***Perceptions of the state of affairs for the whole community:*** the levels of dislocation experienced by other households in their own zone and ward.

By answering the questions in Figure 3 the family unit is able to take decisions about which self-protective strategies to implement and when to do so. The research (Peters-Guarin, 2008) found that households usually try to delay the evacuation of family members and the shifting of belongings until the last possible moment.

This reluctance to evacuate is understandable. While they stay in their own home they can protect their property and remain close to their livelihoods; moving to an evacuation centre means putting life and decisions in the hands of other people. Most of the official evacuation centres are located in faraway flood-free areas; thus people are compelled to stay away from their residence and place of work. Furthermore, evacuation centres are described as 'crowded', 'messy' and 'unhealthy'. People always hope the situation will 'improve' and that they can manage the situation easily and return to their livelihood and family activities without too much trauma and without reliance on external relief.

Clearly, though, the sequencing of questions 3 and 4 will depend on the speed at which the water is rising and its final depth. Most of the flooding in these areas is not sudden; therefore, at least during the initial flood stages, people perceive that the family is safe as long as members remain on the elevated mezzanines or floors (even in houses built of weak materials). However, if the water rises fast or reaches above *knee* depth then safety of the family becomes the primary issue and the order of questions 3 and 4 is reversed.

Converting local flood knowledge of manageability and coping mechanisms into spatial information for DRR

Disaster risk reduction is essentially about managing and coordinating a complex system of information resources. Disaster information is needed by decision-makers at different levels and at different scales. Municipalities, which need to plan, design, and coordinate, require information that is sufficiently detailed and meaningful for disaster risk management. An aim of any risk information model or programme should be to increase knowledge of the reality of 'risk' among communities and their everyday socioeconomic, physical and environmental circumstances. The shared awareness derived from adequate information should then encourage appropriate attitudes and actions by authorities and local communities, enhancing opportunities for decision-making in partnership.

Local flood risk-related information always has an important spatial component which can become useful for planners and municipal authorities. On the one hand the severity of flood events differs in space and the physical and environmental conditions change spatially across wards and municipalities. On the other hand individuals, households and communities have characteristics that vary spatially as well.

Much of these local spatial data can be generated through participatory methods and PGIS that represent satisfactorily the locational and social variation of hazard, vulnerability, coping and manageability capacities, risk and risk perceptions.

Employing participatory spatial analysis tools in the collection of risk-related local knowledge adds value to this information. First, many issues, such as flood nature and recurrence, manageability thresholds, seasonality, coping mechanisms at the household and ward level, the characteristics of vulnerable groups, and risk reduction measures, are discussed and assessed in the community participatory process. Second, the participation of several types of stakeholders—community leaders, local residents, socioeconomic groups (including farmers, shop owners and street vendors) and ward officers—generates discussion and understanding of other people's priorities. In addition, it can facilitate agreement on risk assessments and risk reduction measures, avoiding the conflicts that emerge when such evaluations are performed just by experts or official authorities.

In the study (Peters-Guarin, 2008), knowledge elicited from the communities was incorporated into community-based GIS mapping and hydrodynamic modelling using SOBEK software (WL|Delft Hydraulics, 2001, 2006) to conduct an integrated analysis of the spatial distribution of flood manageability and the seasonal distribution of flood hazard. Most of the elements and processes related to the risk factors were elicited through a learning-based approach whereby the researcher meets the communities in their own context and gains a deeper understanding of aspects of their ('risk') reality (Hordijk and Baud, 2006). Most of the spatial and non-spatial data on the phenomena (flood risk in this case) was collected and analysed 'on-site' with the participants.

Flood hazard and the spatial distribution of manageability

Local people's categorisation of the stages by which a flood event is perceived and managed provided an important entrance point for the spatial representation and analysis of flood risk, for it introduced the spatiality of vulnerabilities and capacities.

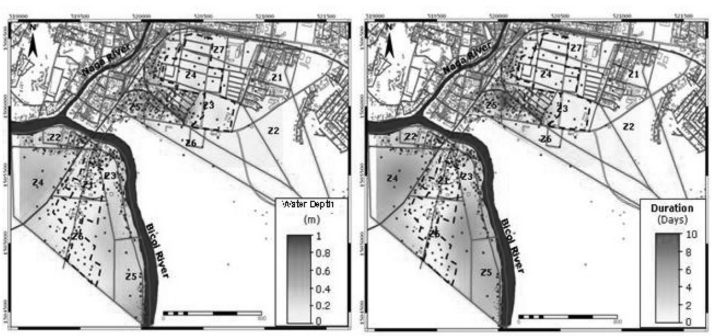
Rate of flooding, depth and duration, in combination with the availability of resources at the household and *Barangay* level, created differentiated perceived levels of disruption. People established categories for this disruption that ranged from *Normal,* via *Manageable, Highly disturbing* and *Unmanageable* to *Disastrous*. This classification was useful for analysing the threats that families face according to their resources and coping mechanisms.

The spatial analysis performed here made use of community-based reconstructed flooding scenarios for which households' remembered data on water depth and duration of past events were collected and manipulated in a GIS.

The scenario of a minor inundation is examined here to demonstrate the importance of including the 'small magnitude–high recurrence' flood events that usually are neglected by flood risk experts and modellers and often are perceived as innocuous by municipal authorities. The analysis also demonstrates the importance of including the spatial and seasonality dimensions in the evaluation as well as the distribution of flood risk, because location and time play an important role both with regard to the threat, and the availability of coping mechanisms (Chambers, Longhurst and Pacey, 1981).

The event on which the analysis is based took place as tropical depression Labuyo hit the Bicol region, including Naga City, on 19–23 September 2005. 'Normal' heavy rains brought about by tropical storms triggered significant levels of flooding in the lowest-lying areas of Naga, particularly as they coincided with the full moon/high tide period. The existence of small but perennial flooding in these two *Barangays* (Mabolo and Triangulo) is mostly the result of natural water retention associated with wetlands in the Bicol and Naga Rivers floodplain. This situation has been worsened by a lack of planning and poor implementation of risk reduction measures, such as drainage infrastructure for the runoff from the impervious areas created by urban expansion.

Figure 4 Reconstructed water depth (left) and duration (right) maps of the flood episode of tropical depression Labuyo in 2005



Notes: Z1 etc. denotes the zones in the two *Barangays* (wards).

Source: authors, community-based survey.

Figure 4 shows the water depth and duration maps reconstructed for these events. From these maps one can observe how the lowest-lying areas experienced *waist*-deep flooding (70–90 centimetres) even during events categorised as 'small' or 'normal'. During tropical depression Labuyo, communities in zones 3–6 in Triangulo and 4–6 in Mabolo faced flooding at *knee* and *hip* depths that lasted for almost one week. While flooding was a serious issue for people settled in these sectors, those living in elevated areas in zones 1, 2, 4 and 7 in Triangulo and zones 1 and 6 in Mabolo did not experience any flooding at all.

To map the spatial distribution of 'manageability' of this flood, a GIS-based procedure was carried out in ILWIS® software (ITC, 2005). The maps in Figure 4, representing the water depth and duration experienced by the communities, were combined by means of conditional ('if') rules based on the 'manageability' stages elicited from the community respondents and characterised above. Table 3 provides the set of classification rules used for the combination procedure in ILWIS.

Figure 5 illustrates the multiple and diverse impacts of the flooding episode in 2005, which encourages a closer look at the spatial differences in flood threat and manageability produced by this event. Figure 5 demonstrates that the big variations in the socioeconomic conditions of the people in these communities create a variegated pattern of damage and disruption even within a single *Barangay*.

The areas classified as unmanageable and disastrous in Mabolo (zones 3, 4, 5 and 6) correspond to areas where the households experienced greater damage because of the destruction of harvestable rice crops. The losses caused by this flood damaged the investments and income of the farmers. Because of the small size and tenurial character of the plots, the crops were not insured; furthermore, numerous labourers, earning their livelihood from marginal activities related to the harvesting, drying and packing of rice also lost their daily income.

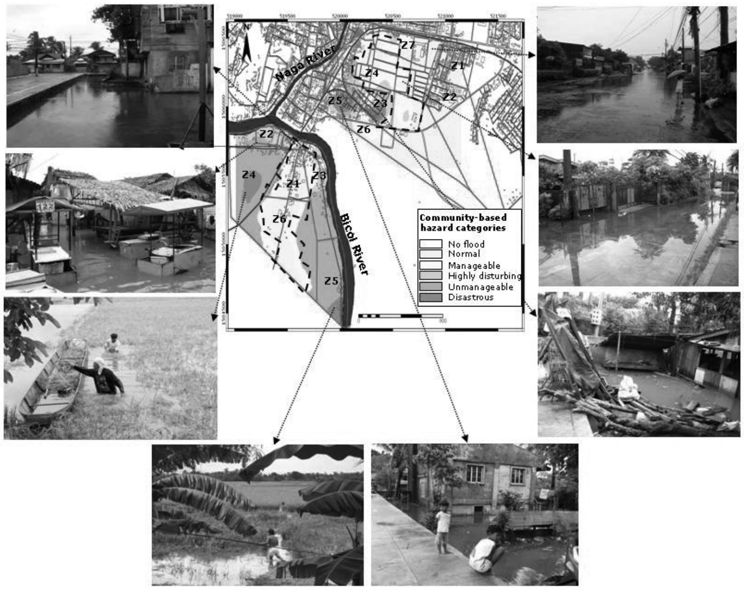
In Triangulo, the areas where the households faced unmanageable circumstances were those where flooding was deeper. Families had to leave the house, seek refuge in safer buildings, and hence lose several days' income from work.

The prevalent socioeconomic conditions are such that the poorest of the poor feel that they are unable to manage the situation with their own resources, even without the impact of a large flood, as well illustrated in Figure 5. For them, even the occurrence

Table 3 Community-based criteria used for flood hazard perception classification in ILWIS®

- If water depth < 20 centimetres and duration < 3 days then **'Normal'**.
- If water depth < 20 centimetres and duration > 3 days then **'Manageable'**.
- If water depth in range 20–40 centimetres and duration < 3 days then **'Highly disturbing'**.
- If water depth in range 20–40 centimetres and duration in range 3–7 days then **'Unmanageable'**.
- If water depth in range 20–40 centimetres and duration > 7 days then **'Disastrous'**.
- If water depth in range 40–90 centimetres and duration < 3 days then **'Unmanageable'**.
- If water depth in range 40–90 centimetres and duration > 3 days then **'Disastrous'**.
- If water depth in range 90–130 centimetres and duration < 3 days then **'Disastrous'**.
- If water depth > 130 centimetres and duration ≤ 1 day then **'Disastrous'**.

Figure 5 From 'Normal' to 'Disastrous': illustration of the hazard and disruption embodied by the flooding episode triggered by tropical depression Labuyo



Source: authors.

of heavy rains or high tides constitutes an indirect threat. After consecutive downpours or low-level flooding, these households cannot continue with their normal life anymore and the only outcome of the decision-making process in Figure 3, particularly in relation to questions 3 and 6, will be to ask for external assistance, a situation perceived by many families as 'nearly a calamity' (disastrous).

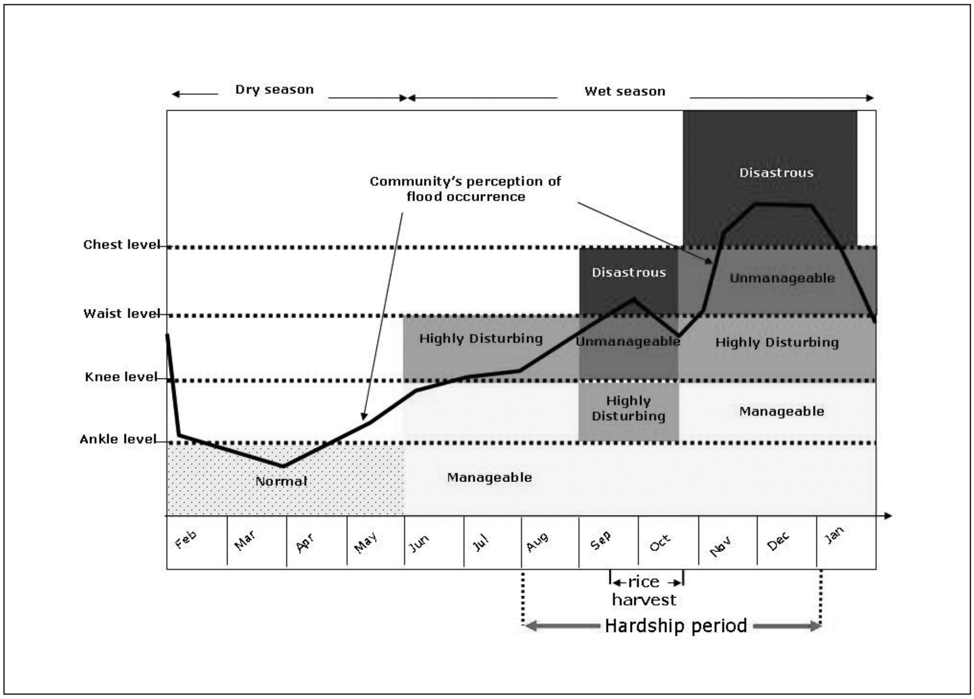
However, interviews with households settled in flood-free areas (Peters-Guarin, 2008) in both *Barangays* revealed how they considered the situation as 'normal'. Only a 'few' social and everyday activities were disrupted as a result of the heavy downpours.

Manageability and seasonal distribution of flood hazard

Another finding of the study (Peters-Guarin, 2008) was that the flooding threat and the manageability of flood events depend greatly on the period of the year in which inundation takes place. Figure 6 illustrates perceptions of the flood hazard depending on seasonality and its relationship with the manageability of flooding in terms of the community-based categories.

As can be seen, during the first four months of the year, equivalent to the dry season, people's perceptions of the flood threat remain low. This is based on the perceived low probability that significant flooding will occur during this period. In addition, during the dry season economic opportunities are more abundant and people are able to absorb the minor disturbances wrought by occasional small floods.

Figure 6 Community perception of the threat and manageability of flooding depending on the time of year



Throughout the rest of the year, however, the perception of threat from similar flood stages (in terms of water depth and duration) increases. Concern about a higher threat at the end of the year arises partly because the arrival of the wet season brings with it more recurrent flooding; besides, economic opportunities start to shrink with the onset of the rains and coping mechanisms are more prone to be insufficient.

In fact, the wet period is known in these communities as the 'hardship period', characterised by poorer health conditions, an increase in weather-related and water-borne diseases, reduced economic opportunities and overall poverty (Chambers, Longhurst and Pacey, 1981). Some of the interviewees consider that '*poverty starts with the rainy season*' and that from August to early January, life becomes '*even tougher*'. Difficulties during the last part of the year originate in the end of the growing season (many people are engaged in rice farming), the reduction in demand for manpower in the construction sector, and a widespread decrease in earnings until the next dry season.

During this difficult period, though, some 'windows of opportunity' are open. One is the religious festivity of 'Our Lady of Peñafrancia' (September), which attracts tourists and devotees and therefore economic opportunities to Naga. Another pertains to the second main harvest of rice (palay) in late September–early October (see Figure 6). If rainstorms or inundations coincide with these periods then these opportunities are not realised, of course. Losing the rice harvest because of flooding has very negative repercussions for both communities as it constitutes a food staple, and in semi-rural areas such as Mabolo, nearly 40 per cent of households still make a living from this.

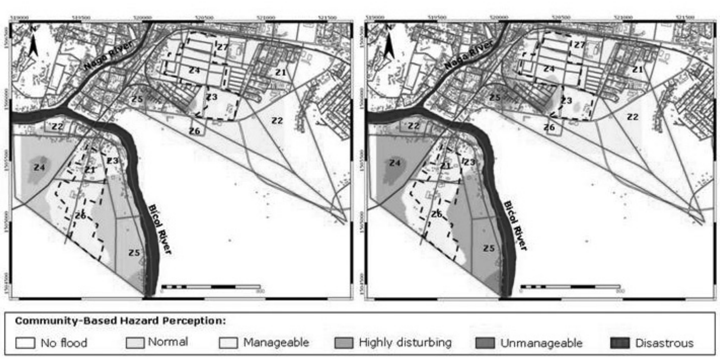
The relationship between seasonality, or timing, of flood events and manageability options becomes clear from Figure 6. Flooding at *knee* depth, which for most of the year is considered as a '*Manageable*' stage, during September to late October is perceived as '*Highly disturbing*' because flooding at this stage drastically affects the few economic opportunities that are available.

Figure 7 visualises the space–time differences in flood manageability levels due to seasonality factors. The same water levels and duration have different implications for households during September–October than in the wet season, in terms of hazards and manageability options.

According to the manageability concept, flooding triggered by tropical depression Labuyo embodied a particular high threat for some groups, because it occurred during the weeks when rice farmers, field labourers and small vendors were involved in significant moneymaking and social activities and *palay* (rice) harvesting. Flood stages that at other times would be regarded as *'Normal'* or *'Manageable'* turned into *'Highly disturbing'* and *'Unmanageable'* because crucial economic opportunities during the hardship period were at stake (see lower-left pictures in Figure 5).

Manageability of flood events is variable and influenced by the cumulative effects of previous floods. The losses experienced during a particular wet period reduce the manageability of later flood events in the same typhoon season or in later seasons. The research found that after typhoon Unding/Yoyong passed in November 2004, nearly 90 per cent of the affected households had not been able to restore fully their livelihoods by the time tropical depression Labuyo struck in September 2005. The general feeling of the people in these communities was that they felt poorer than in the previous year. Households that had been unable to rebuild or repair their houses with stronger materials perceived themselves not just as poorer, but also

Figure 7. Community perceptions of flood threat (of a two-year return period flood) in two different seasons



Left: normal wet season; right: September–October.

Source: authors.

as 'more exposed and less safe'—so, less able to manage typhoons and floods—as compared to the same season before. It is evident that when socioeconomic resources and coping strategies have been seriously affected by earlier flooding, people's perception is that their capacity to withstand the next wet season also will decrease.

Integration of local knowledge into flood risk management practices at the municipal level

Designing and implementing adequate policies and programmes for DRR requires improved information and understanding of risk factors derived from collaborative assessments as well as effective partnerships between at-risk communities and municipal authorities, via NGOs or researchers. PGIS can be effective in providing municipalities and planners with much needed data for risk analysis and it can assist them in strengthening the participation and involvement of local people.

Knowing the coping mechanisms and flood manageability of people in flood-prone areas may help municipal authorities to design better practices for disaster risk management, and to monitor their effectiveness. Naga City has established a reputation for being a model local government unit with regard to participatory processes and strong democratic traditions. Three municipal programmes directly linked to flood risk that can benefit further from local knowledge are presented below:

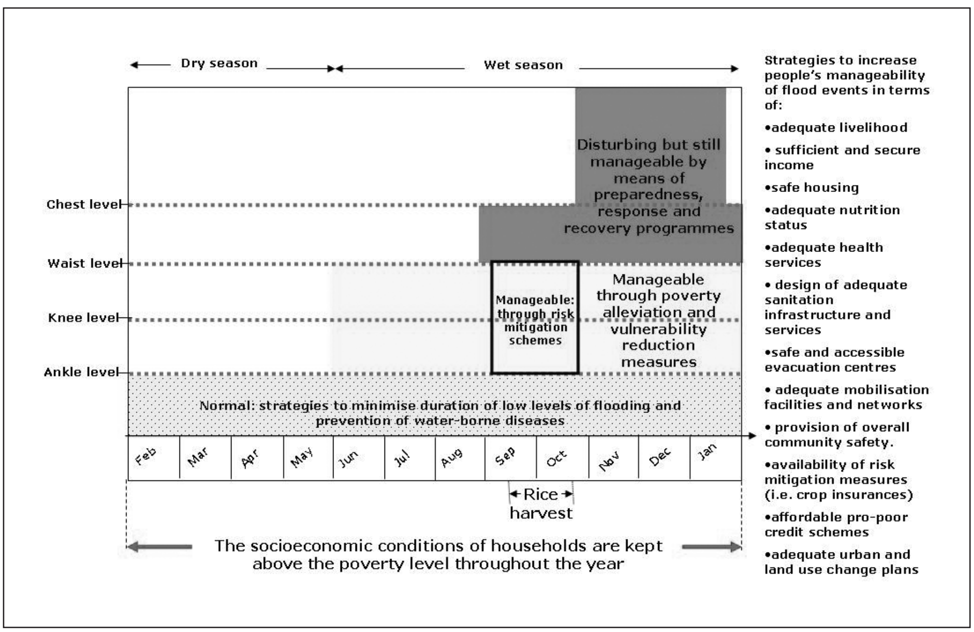
a. The city's campaign against child malnutrition distributes food supplements with high nutritional value to 4–11-month-old infants regardless of nutritional status in order to provide additional weaning food. This could be targeted specifically at areas where small flood events are highly recurrent.
b. The city's disaster relief assistance initiative distributes relief goods to evacuation centres, provides housing materials to families whose homes have been very severely damaged, and offers counselling to people emotionally and psychologically disturbed by disasters. This assistance should be extended to livelihood reconstruction and insurance for different economic sectors.
c. The city's urban poor programme (dubbed as *Kaantabay sa Kauswagan* or 'Partner in Progress') aims to address the perennial problem of squatting, particularly in hazard-prone areas. It provides relocation sites, relocation assistance and basic infrastructural development. Wherever possible, relocation sites should be situated in hazard-free areas near beneficiaries' sources of livelihood.

This paper has shown that flood-related knowledge of local communities can be formalised, collected, stored and manipulated in a GIS environment and incorporated in analysis and spatial modelling of risk. The use of PGIS improves understanding and integration of the concept and categories of 'manageability' of flood threats derived from the community's own perceptions. At the same time, it helps to model and spatially depict the influences of seasonal and repetitive events—two factors rarely taken into consideration in risk analysis and risk management. The visual impact of the community-structured maps and of the photographic images of people's coping mechanisms delivers the reality of the situation direct to the authorities. They provide better stimuli than just information on water depth and duration, or simply on population distribution.

Knowledge of the periods in which risk is higher for certain groups (farmers, for instance) enables authorities to design adequate risk mitigation measures, including insurance schemes for the specific months when harvesting takes place, accessible loans at low interest rates, and seasonal provision of staple foods, such as rice, to avoid scarcity and speculation. Flooding in specific periods decreases manageability options, and can lead people to adopt risky coping mechanisms for survival. The lack of formal and contextualised mechanisms that help households to recover or improve their pre-flooding conditions leads to increased poverty and marginalisation, which in turn is likely to place a greater burden on the municipality.

The main aim of municipal risk reduction measures should be to increase the manageability of flooding stages throughout the whole year (see Figure 8). In Naga municipality the authorities have recognised already that small but repetitive and longstanding flood levels should be ameliorated. Consequently, they are implementing programmes to minimise the risk of disease and pollution of surface waters and to improve the nutritional status of children, in particular. These measures could be extended to ensure that the working members of the family have adequate access to health services and medicines to support their livelihood throughout the wet season.

Figure 8 Increasing the manageability of flooding through poverty alleviation, vulnerability reduction and risk management measures



During the wet season, flood manageability needs to be increased to such an extent that households are able to manage flooding at *knee* and even *waist* level. This can occur through structural measures that help to speed up drainage of floodwaters so that they do not stagnate (one of the main problems caused by flooding) and urban planning measures that relocate poor households, public schools and public basic services to elevated areas within the *Barangay,* as well as by implementing construction practices that improve the safety of new and existing housing. Beyond this, of course, is the general need for initiatives that reduce vulnerability to flooding by enhancing the year-round socioeconomic level of all households so that it is above the poverty level. Naga has recognised already the need to decentralise the main commercial business district, away from one of the most flood-prone areas of the city to satellite markets in less flood-prone or flood-free areas. This means that even during less extreme events, formal and informal workers such as street vendors can continue to make a daily income.

Conclusion

The employment of perceptions, parameters and measures developed with at-risk communities broadens understanding of flood as a threat. This paper has developed concepts and categories of 'manageability' of the flood threat derived from the community's own perceptions. It raises opportunities for communities and *Barangay* and municipality officers to apply understanding of manageability when designing mitigation responses, so as to make them more sensitive and responsive to the difficult conditions experienced by the people.

When structured and spatially visualised, the categorisation of flood threats based on community perceptions also improves communication of the concerns of people and officials about the flood problem to outsiders. The mapping and imagery of manageability help authorities to identify those areas with the most vulnerable households in order to determine the levels of flooding they can 'manage' and when external assistance may be required. The more fragile the status of the family, and the smaller its resources, the fewer coping mechanisms it can depend on, and the earlier the stage at which it may need external support (the *Unmanageable* to *Disastrous* categories).

The information provided in this paper will be more helpful to local and municipal authorities than that provided by water depth and duration maps alone. Knowing in which areas the situation may become '*Unmanageable*' or even '*Disastrous*' should help authorities to focus on the coping capacities of the most vulnerable households, and thus address better their 'duty of care' for their citizens. It is apparent that many community members are being socially and psychologically empowered by their knowledge, skills and ability in coping with flood situations. Notwithstanding this fact, the authorities need to know if the strategies of the most vulnerable groups are sufficient to cope with the situation and return to 'normal' life soon; or if not, when they require external aid, and whether risk reduction strategies need to be designed for the short, medium or long term.

The paper demonstrates that spatial representation of local knowledge assists outsiders in gaining awareness of flood risk issues. On the one hand the dialogue and interaction between local communities, external actors and local authorities, facilitated by GIS and participatory tools, is an effective way to strengthen risk reduction partnerships among these actors. On the other hand the implementation of PGIS and participatory initiatives can benefit local governments as they provide accurate and contextualised information for the much-needed risk assessments and decision-making. Mapping and working with local knowledge develops technical and analytical skills at the local and municipal level that are needed to understand both the risk context of households in flood-prone areas and its complex relationships with other processes, such as livelihood provision, patterns of urban poverty and urban development. Participatory GIS-based risk analysis enhances the capacity of the community to communicate its concerns and to negotiate access to vulnerability and risk reduction measures.

Acknowledgements

The authors would like to highlight the important inputs to this paper of Georg Frerks of Wageningen University, Netherlands, and of John Twigg of the Aon Benfield Centre, University College London, United Kingdom.

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References

Abarquez, I. and M. Zubair (2004) *Community-based Disaster Risk Management. Field Practitioners' Handbook.* Asian Disaster Preparedness Center, Bangkok. http://www.adpc.net/pdr-sea/publications/12Handbk.pdf (accessed on 17 May 2011).

Anderson, M.B. and P.J. Woodrow (1998) *Rising from the Ashes: Development Strategies in Times of Disaster.* IT Publications, London.

Bankoff, G., G. Frerks and D. Hilhorst (eds.) (2004) *Mapping Vulnerability: Disasters, Development and People.* Earthscan, London

Cannon, T., J. Twigg and J. Rowell (2003) *Social Vulnerability, Sustainable Livelihoods and Disasters.* Department for International Development, London.

Chambers, R. (1994) 'Participatory rural appraisal (PRA): challenges, potentials and paradigms'. *World Development.* 22(10). pp. 1437–1454.

Chambers, R. (2006) 'Participatory mapping and geographic information systems: whose map? Who is empowered and who disempowered? Who gains and who Loses?' *The Electronic Journal of Information Systems in Developing Countries.* 25(1). http://www.ejisdc.org/ojs2/index.php/ejisdc/article/view/238 (accessed on 17 May 2011).

Chambers, R., R. Longhurst and A. Pacey (eds.) (1981) *Seasonal Dimensions to Rural Poverty.* Frances Pinter, London.

Chen, K., R. Blong and C. Jacobson (2001) 'MCE-RISK: integrating multi-criteria evaluation and GIS for risk decision making in natural hazards'. *Environmental Modelling and Software.* 16(4). pp. 387–397.

Craig, W.J., T.M. Harris and D. Weiner (eds.) (2002) *Community Participation and Geographic Information Systems.* Taylor and Francis, London.

de Dios, H.B. (2002) *Participatory Capacities and Vulnerabilities Assessment: Finding the Link between Disasters and Development.* Oxfam Great Britain—Philippines Programme, Quezon City. http://www.proventionconsortium.org/themes/default/pdfs/CRA/PCVA_2002_meth.pdf (accessed on 17 May 2011).

Dekens, J. (2007) *Local Knowledge for Disaster Preparedness: A Literature Review.* International Centre for Integrated Mountain Development (ICIMOD), Kathmandu.

Dunn, C.E. (2007) 'Participatory GIS – a people's GIS?' *Progress in Human Geography.* 31(5). pp. 616–637.

Enarson, E. et al. (2003) *Working with Women at Risk: Practical Guidelines for Assessing Local Disaster Risk.* International Hurricane Research Center, Florida International University, Miami, FL. http://www.ihrc.fiu.edu/lssr/workingwithwomen.pdf (accessed on 17 May 2011).

Falk, K. (ed.) (2005) *Preparing for Disaster – A Community-based Approach.* Second edition. Danish Red Cross, Copenhagen. http://www.proventionconsortium.org/themes/default/pdfs/CRA/PNRC_CBDP_2005.pdf (accessed on 17 May 2011).

FAO (Food and Agriculture Organization of the United Nations) (2001) *Field Level Handbook.* Socio-Economic and Gender Analysis Programme, FAO, Rome. http://www.fao.org/sd/seaga/downloads/En/FieldEn.pdf (accessed on 17 May 2011).

Ferrier, N. and E. Haque (2003) 'Hazard risk assessment methodology for emergency managers: a standardized framework for application'. *Natural Hazards.* 28(2–3). pp. 271–290.

Gilbert, E.H., D.W. Norman and F.E. Winch (1980) *Farming Systems Research: A Critical Appraisal.* MSU Rural Development Paper. No. 6. Michigan State University, East Lansing, MI.

Gonzales, R. (2000) *Platforms and Terraces. Bridging Participation and GIS in Joint-Learning for Watershed Management with the Ifugaos of the Philippines.* PhD Dissertation No. 72. International Institute for Geo-Information Science and Earth Observation, Enschede, and Wageningen University, Wageningen. http://www.itc.nl/library/Papers/phd_2000/gonzales.pdf (accessed on 17 May 2011).

Guijt, I. (1998) *Participatory Monitoring and Impact Assessment of Sustainable Agriculture Initiatives.* SARL Discussion Paper. No. 1. Sustainable Agriculture and Rural Livelihoods Programme, International Institute for Environment and Development, London.

Heijmans, A. and L. Victoria (2001) *Citizenry-based and Development-oriented Disaster Response.* Asian Disaster Preparedness Center, Bangkok. http://www.adpc.net/pdr-sea/cbdo-dr/cover.html (accessed on 17 May 2011).

Hordijk, M.A. and I.S.A. Baud (2006) 'The role of research and knowledge generation in collective action and urban governance: how can researchers act as catalysts?' *Habitat International.* 30(3). pp. 668–689.

IFRC (International Federation of Red Cross and Red Crescent Societies) (2002) *Toolbox for Vulnerability and Capacity Assessment Disaster Preparedness.* IFRC, Geneva.

IFRC (2005) *World Disasters Report 2005: Focus on Information in Disasters.* IFRC, Geneva.

Ireland, D. (2001) Disaster *Risk Management from a Remote Shire's Perspective.* Centre for Disaster Studies, James Cook University, Townsville.

ITC (International Institute for Geo-Information Science and Earth Observation) (2005) *ILWIS 3.3 User's Guide.* ITC, Enschede.

Kabutha, C. et al. (1990) *Participatory Rural Appraisal Handbook: Conducting PRAs in Kenya.* National Environment Secretariat, Nairobi, Egerton University, Njoro, and Center for International Development and Environment, World Resources Institute, Washington, DC.

Kienberger, S. (2008) *Toolbox & Manual. Mapping the Vulnerability of Communities. Example from Búzi, Mozambique.* Version 1.0. Centre for Geoinformatics, Salzburg University, Salzburg, and Munich Re Foundation, Munich. http://projects.stefankienberger.at/vulmoz/wp-content/uploads/2008/08/Toolbox_CommunityVulnerabilityMapping_V1.pdf (accessed on 17 May 2011).

Laituri, M. and K. Kodrich (2008) 'On line Disaster Response Community: People as Sensors of High Magnitude Disasters using Internet GIS'. *Sensors.* 8. pp. 3037–3055. http://www.mdpi.net/sensors/papers/s8053037.pdf (accessed on 17 May 2011).

Longley, P., M. Goodchild, D. Maguire and D. Rhind (2001) *Geographic Information Systems and Science.* John Wiley, New York, NY.

Marschiavelli, M.I.C., P. Hadi, M.K. McCall and N.C. Kingma (2009) *Flood Risk Perception Analysis in Urban Areas, Case Study: Kampung Melayu, Jakarta, Indonesia.* Proceedings of the second International Conference on Geoinformation Technology for Natural Disaster Management and Rehabilitation, Bangkok, Thailand, 30–31 January. http://e-geoinfo.net/NDM2008/conference.html (accessed on 17 May 2011).

Maskrey, A. (1998) *Navegando entre Brumas. La Aplicación de los Sistemas de Información Geográfica al Análisis del Riesgo en América Latina.* La RED, Lima.

McCall, M.K. (2003) 'Seeking good governance in participatory-GIS: a review of processes and governance dimensions in applying GIS to participatory spatial planning '. *Habitat International.* 27(4). pp. 549–573.

McCall, M.K. (2008) *Participatory Mapping and Participatory GIS (PGIS) for CRA, Community DRR and Hazard Assessment.* ProVention Consortium, Geneva. http://www.proventionconsortium.org/themes/default/pdfs/CRA/PGIS_Sept08.pdf (accessed on 17 May 2011).

Mukherjee, N. (2001) *Participatory Learning and Action, with 100 Field Methods.* Concept, New Delhi.

Muňoz, G. (2007) *Folklore Meets Geographical Information Systems for Risk Reduction in Venezuela.* Young Researcher's Project Brief. ProVention Consortium, Applied Research Grants Programme, Geneva. http://www.proventionconsortium.org/themes/default/pdfs/AG/097VENMunoz.pdf (accessed on 17 May 2011).

O'Neill, P. (2003) *Developing an Effective Risk Communication Model for Vulnerable Communities.* New South Wales State Emergency Service.

Peters-Guarin, G. (2008) *Integrating Local Knowledge into GIS-based Flood Risk Assessment: The Case of Triangulo and Mabolo Communities in Naga City, The Philippines.* PhD Dissertation No. 157. International Institute for Geo-Information Science and Earth Observation, Enschede, and Wageningen University, Wageningen.

Peters-Guarin, G., C.J. van Westen and L. Montoya (2005) 'Community-based flood risk assessment using GIS for the town of San Sebastian, Guatemala'. *Journal of Human Security and Development.* 1(1). pp. 29–49.

Rambaldi, G., P.A. Kwaku Kyem, M.K. McCall and D. Weiner (2006a) 'Participatory spatial information management and communication in developing countries'. *The Electronic Journal on Information Systems in Developing Countries.* 25(1). pp. 1–9.

Rambaldi, G. et al. (eds.) (2006b) *Mapping for Change: Practice, Technologies and Communication.* PLA Notes 54. International Institute for Environment and Development, London.

Schaerer, M. (2006) *Community Risk Assessment Methodologies and Case Studies.* Provention Consortium, Geneva. http://www.proventionconsortium.org/?pageid=43 (accessed on 17 May 2011).

Scoones, I. and J. Thompson (1994) 'Knowledge, power and agriculture: towards a theoretical understanding'. In I. Scoones and J. Thompson (eds.) *Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice.* Intermediate Technology, London. pp. 16–31.

Sieber, R.E. (2006) 'Public participation geographic information systems: a literature review and framework'. *Annals of the Association of American Geographers*. 96(3). pp. 491–507.

UNCRD (United Nations Centre for Regional Development) (2003) *Sustainability in Grass-roots Initiatives: Focus on Community Based Disaster Management*. UNCRD, Nagoya.

UNISDR (United Nations International Strategy for Disaster Reduction) (2004) *Living with Risk: A Global Review of Disaster Reduction Initiatives*. Inter-Agency Secretariat of the International Strategy for Disaster Risk Reduction, Geneva. http://www.unisdr.org/eng/about_isdr/bd-lwr-2004-eng.htm (accessed on 17 May 2011).

UNISDR (2005) *Hyogo Framework for 2005–2015: Building the Resilience of Nations and Communities to Disasters*. International Strategy for Disaster Risk Reduction, Geneva. http://www.unisdr.org/eng/hfa/hfa.htm (accessed on 17 May 2011).

van Aalst, M., T. Cannon and I. Burton (2008) 'Community level adaptation to climate change: the potential role of participatory community risk assessment'. *Global Environmental Change*. 18(1). pp. 165–179.

van Westen, C.J., E.A. Castellanos and S.L. Kuriakose (2008) 'Spatial data for landslide susceptibility, hazard, and vulnerability assessment: an overview'. *Engineering Geology*. 102(3–4). pp. 112–131.

Venton, P. and B. Hansford (2006) *Reducing Risk of Disaster in Our Communities*. Tearfund, Teddington.

Williams, C. and C.E. Dunn (2003) 'GIS in participatory research: assessing the impact of landmines on communities in north-west Cambodia'. *Transactions in GIS*. 7(3). pp. 393–410.

WL|Delft Hydraulics (2001) *SOBEK Rural: Managing your Flow. Manual*. Version 2.07. WL|Delft Hydraulics, Delft.

WL|Delft Hydraulics (2006) *SOBEK-Rural: Hydrodynamics*. http://delftsoftware.wldelft.nl/index.php?option=com_docman&task=doc_view&gid=74 (accessed on 17 May 2011).

World Bank (2005) *Natural Disaster Risk Management in the Philippines: Enhancing Poverty Alleviation through Disaster Reduction*. World Bank, Washington, DC. http://go.worldbank.org/EBABBUE0F0 (accessed on 17 May 2011).

Zerger, A. and D. Smith (2003) 'Impediments to using GIS for real-time disaster support.' *Computers, Environmental and Urban Systems*. 27(2). pp. 123–141.