COPING STRATEGIES AND MANAGEABILITY: HOW PARTICIPATORY GEOGRAPHICAL INFORMATION SYSTEMS CAN TRANSFORM LOCAL KNOWLEDGE INTO BETTER POLICIES FOR DISASTER RISK MANAGEMENT

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Abstract

The accumulated knowledge and perceptions of communities 'at risk' are recognized as key elements in ameliorating or managing disaster risk at local level, particularly in places where much of the crucial information as well as the technical and economic resources for risk assessments are not otherwise available.

The research behind this paper demonstrates that local community knowledge related to flooding can be systematically structured into spatial and non-spatial information compatible with a GIS (geo information systems) set-up. By means of descriptive and forecasting models and risk scenarios, these GIS technologies have the capacity on one hand to make the knowledge of at-risk people legitimated and accessible and on the other hand help to establish effective relationships for disaster risk reduction between at-risk communities, external actors (e.g. researchers or NGOs) and municipal authorities.

The paper focuses on the understanding of coping strategies and the 'manageability' concept as defined by communities. 'Manageability' expresses the way local communities experience flooding and perceive the hazard in relation to their capacity to deal with the situation, depending on their resources and a range of coping mechanisms. The research, in the Philippines, identified the significance of specific localised factors, including availability of socioeconomic resources and seasonality. The concept can be a powerful tool for managing preparedness at local and municipal level by providing local authorities with better indicators than just information on water depth and flood duration or population characteristics. It supports the understanding of flood as a threat, legitimises the 'inventiveness' of local coping strategies, and supports the monitoring of municipal policies' effectiveness in flood-prone areas.

Keywords: hazards, risks, vulnerability, coping strategies, manageability, preparedness, participatory GIS, local spatial knowledge, community participation

Introduction

Community involvement has become one of the chief priorities for establishing effective partnerships for disaster risk reduction according to the UN-ISDR Hyogo Framework for Action (2005-2015) (UN-ISDR, 2005).

Regarding disasters, identifying risk factors and understanding the way in which communities cope and adapt themselves to hazardous environments are considered

important determinants for risk reduction and decision-making at local and municipal level.

The understanding of mechanisms for coping and adaptation to flooding and other natural phenomena is not always straightforward to external actors such as researchers and policy-makers. Risk, and therefore the mechanisms for dealing with it or avoiding it are perceived differently by those that see flooding as a phenomenon to measure and model, those taking decisions for instance about urban development, public investment or land use change and those that have to deal with flooding in their everyday life and in consequence have to face and manage the threat.

Local knowledge can improve the way in which internal and external actors understand flood risk and take decisions about risk management and urban planning. Local people may know 'facts' not just about natural events, but also about the changes in their physical and socioeconomic situation which lead to variations of risk over time. Local people behave and develop mechanisms for coping, that if well understood can guide local authorities and communities to develop in partnership adequate measures for avoiding or decreasing people's vulnerability and expand their opportunities for managing floods.

In the last decade several tools for enhancing the inclusion of at-risk communities' knowledge into the decision-making process have been under development. Methods of participatory research, such as Participatory Rural Appraisal (PRA), Rapid Rural Appraisal (RRA), and Participatory Action Research (PAR) that were initially developed to analyze local knowledge and life conditions in fields such as anthropology and natural resource management (Gilbert *et al*., 1980; Scoones and Thompson, 1994; Lawas, 1997; Gonzales, 2000; Sedogo, 2002; McCall, 2003; Rambaldi *et al*., 2006), are proving their efficiency in the disaster risk field too (Heijmans and Victoria, 2001; Ireland, 2001; Bassolé *et al*., 2001; UNCRD, 2003; Dekens, 2007).

So far, the integration of geo-information systems and local community knowledge relevant to hazards, vulnerability and risk modelling is still at an embryonic stage (Maskrey, 1998; UN-ISDR, 2002; Ferrier and Haque, 2003; Zerger and Smith, 2003; IFRC, 2005). Nevertheless basic applications of GIS for hazard and vulnerability mapping as well as identification of coping mechanisms, overall risk, urban hazards and conflict mapping can be found (McCall, 2008).

Despite the increasing evidence that the combination of local knowledge with modern information systems (GIS, GPS, PGIS) and earth observation products (satellite imagery, aerial and oblique photography), can certainly enhance the way in which decisions are made by providing better information (O'Neill, 2003; IFRC, 2005): to date, the advantages of participatory collection of risk-related spatial information within a GIS context have not been widely explored. Very often the sketches, paper maps, historical profiles and other results obtained through participatory mapping are not kept or updated after a risk assessment project has finished, leading to a loss of valuable information. As Cannon *et al*. (2003) advise, these products need to be converted from raw data into useful spatial information that allows the community and other actors to develop analytical processes for risk analysis and exploration of risk reduction alternatives. This spatial and non-spatial information integrated in modern geo-information systems can be used to forecast flood hazards, estimate risk much more effectively, and moreover communicate local concerns and capacities to the 'higher ups'.

GIS used in a participative way can contribute to problem solving as it opens new ways for people to address issues. Participatory GIS (PGIS) helps to build capacity, improve the community's relationships with those in power, and promote learning among different actors by bringing new information and perspectives into decision-making processes.

The objective of this paper is to demonstrate that the use of PGIS can enhance the integration of local knowledge from communities which becomes a relevant and important asset for flood risk identification and reduction at local level. When the

authorities make proper use of the local knowledge existing among their people the feelings of 'ownership' and legitimacy of actions can be strengthened both at community and municipality level. On the other hand local actors can achieve lower cost in their disaster risk assessments and disaster management. Local knowledge is a resource that becomes particularly important for developing countries where much of the crucial information as well as the technical and economic resources for risk assessments are not available otherwise.

The paper demonstrates that by making use of participatory tools and GIS methods community-based concepts such as 'manageability' of flood threat through coping mechanisms, awareness of seasonality and timing of flood events can be spatially depicted and handled in such a way that their utility for planning and risk reduction is maximised. It can also become a powerful tool for decision-makers in order to enhance the adaptation capacities of at-risk communities, monitor the effectiveness of risk reduction policies and programmes and reduce disaster risk at local and municipal level.

Study Area

The study was carried out in two wards (locally known as barangays): Triangulo and Mabolo in Naga City, the Philippines (see Figure 1). The Philippines is considered one of the most disaster-prone countries in the world. The high frequency of earthquakes, volcanic eruptions, tropical cyclones and floods continuously trigger disasters which places an enormous burden on the numerous vulnerable communities on a continuous basis and constitutes a major constraint to much-needed development (World Bank, 2005).

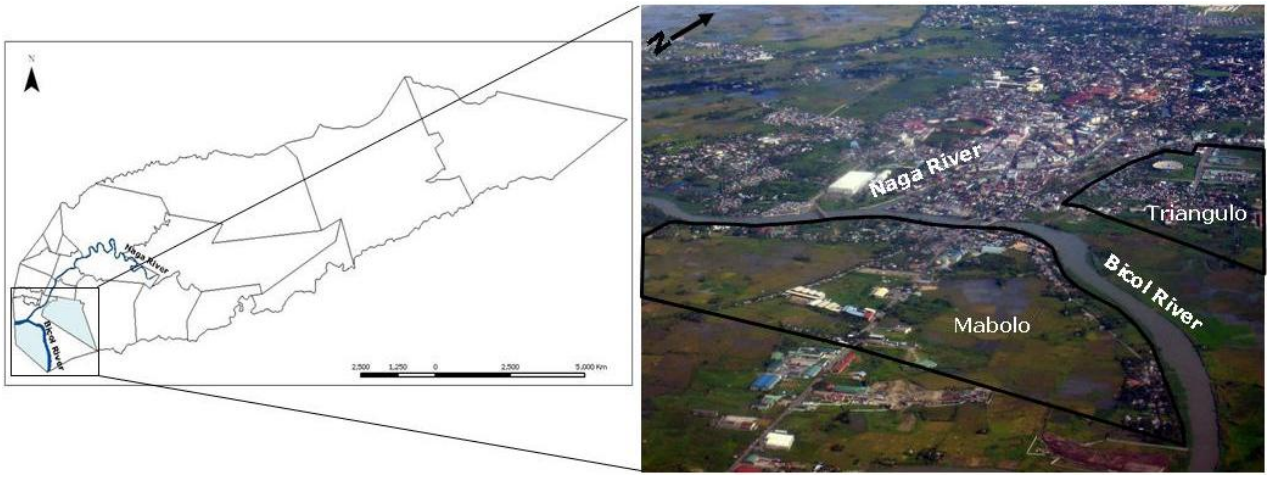

Figure 1. Location of the Mabolo and Trianguo barangays in Naga City

Naga City in the Bicol Province of the Philippines has been chosen for this case study because of its high susceptibility to climatic hazards such as typhoons and floods. Naga is a medium-sized city located in the floodplains of the Bicol River, in the so-called 'typhoon belt', and experiences two to five typhoons annually, accompanied by extremely intense rainfall.

Owing to the city's location, the presence of flood has caused problems throughout its history. Communities in most wards have to cope with recurrent flooding, mostly related to typhoons and high intensity rainstorms. 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, the implementation of effective measures to counteract the negative effects of flooding is still lacking. Furthermore vulnerability and risk reduction are still not included as central components of the poverty reduction and development plans within the municipality.

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

The research behind this paper clearly showed that understanding the threat embodied by flooding and typhoons required not just determining aspects such as water depth, duration or velocity of the water and winds and their spatial distribution. It also involved understanding the role played by existing knowledge at community level; the awareness raised by official and community-based warning systems; and the efficacy of the social and economic coping strategies available at household, ward and municipal level. These elements determine the range of options that these actors may have for 'managing' the flood threat.

In this paper *manageability* is understood as the way local communities experience flooding and perceive the hazard from it in relation to their capacity to deal with the situation, depending on their resources and range of coping mechanisms.

The fact that flooding in the studied barangays occurs mostly as a gradual rather than a sudden event, coupled with official warnings and community-based mechanisms for self-awareness, determines that these communities are rarely unaware of the ongoing situation (except during flash floods). Once people are warned that a typhoon will strike the Bicol Region, and being conscious of their high vulnerability, several decisions start to be made and actions taken, particularly at family level. Existing local knowledge is thus transformed into self-defence mechanisms that seek to avoid or lessen the direct impact of flooding.

Through participatory activities carried out as part of the research it was revealed how, particularly at household and ward level, numerous coping mechanisms exist to deal with the disruption created by flooding, as shown in Tables 1 and 2.

The main aim of these strategies is to avoid or decrease the disruption that flooding may create in the family's daily life. Coping mechanisms performed to protect life, secure the minimal provision of food and other basic needs, procure the safety of

their residence and valuables and postpone evacuation until the last moment help people to feel that up to a certain point they can 'manage' the situation with their own resources.

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

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 intentions to evacuate and suggest precautions. -Households start packing and wrapping 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 the residents with trucks for potential evacuation . -Listen to radios/TV for forecasts. -Residents fix all valuables in elevated areas/ mezzanines. -Children, women and elderly people are evacuated to in-laws or neighbours in flood-free areas or evacuation centres.
NO. 3	Signal No 3 + Water at *Waist depth* + strong winds	-Ward and Municipal officers carry out rescue, usually by means of '*banca*' (wooden boat). -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 make roll calls to count the evacuees. -Some people still at their homes are evacuated.

Table 2. Households' coping mechanism to avoid disruption of some of the main aspects of daily life

Aspect of Daily Life	Before Flooding	During Flooding	After Flooding
Housing	-Reinforce wooden/ thatched houses by tying with wires (S). -Nail walls, windows and put heavy items (tyres, sandbags) on top to protect roofing (S). -Prepare second hand or scrap materials for repair later on (S). -Elevate part of the house/ build mezzanine ((L). -Build house in reinforced materials or 2 storeys (L).	-Secure housing access to avoid debris and waste intrusion (S). -Vacate the house to avoid life loss (S).	-Source relief materials (S). -Drying of walls with electric fan to avoid deterioration (S) -Repair damages to house by family members to avoid cost of labour (SM). - Repair the damages little by little (M). - Earth-filling to elevate room levels (L). - 'Leave as it is' (L).
Livelihood	-Look for additional sources of income (SL). -Stocking shops to have enough supplies to sell (S). -Increase working hours (SM). -Save money (ML). - buy items in stock for shops and purchase agriculture products (farmers) (S).	-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	-Ask for work or for assistance from other community members (S). -Look for alternative job (ML) -Sell stored items on credit (S). -Sell scrap material from damaged houses (S). -Labour for food (farms) (SM). -Borrow money from

	-Gather seeds for next planting season (SM). -Elevate shop buildings (L)	(SL).	relatives, moneylenders (loan sharks charging high interest) or from government (SL). -Pawn appliances and other valuables (SL). -work overtime (SL).
Food	-Buy food supplies to pre-empt scarcity and increasing prices (S). -Store basic non-perishable food items (rice, sugar, salt, canned goods) (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 place (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). -Decrease in food intake (ML)
Health/ Sanitation	-Purchase nutritious food (S). -Store drinking water to avoid diseases (S). -Do not buy perishable goods (S). -Buy first aid medicines (S).	-Prevent kids from going out/playing amidst floodwaters (S). -Dispose of human waste in plastic bags (SM) -Boil water to avoid illnesses (polluted water) (S). -Practice proper personal hygiene (S).	-Consult health workers for sickness or injuries (S). -Boil drinking water (S). -Avoid or thoroughly wash after direct contact with stagnated waters (S). -Avoid use of pumped water for consumption (S). -Ask Barangay or NGOs for medicines (SM). -Clean house/surroundings (SM
Safety of	-Arrange/improvise	-Place effects at	-Dry wet things with an

Belongings	storage (S) -Install metal hooks to hang items (S). -Prepare waterproof containers (S). -Pack and plastic wrap valuable items/ appliances to be put in safety (SM). -Fix things before evacuating (S). -Build stands for refrigerators and heavy items (SM). -Construct/install mezzanines (ML).	second floor, mezzanines or sealed containers (SM). -Take livestock, poultry and vehicles to elevated roads (S). -Guard the house to ensure safety of belongings (S). -Place appliances at relatives, neighbours or evacuation places (SM).	electric fan (S). -Clean flood dirt from items (S). -Repair minor damages to appliances (SL).
Mobilisation	-Assemble improvised floaters (S). -Get clothes ready for walking in the flooded area (S). -Prepare improvised walkways (SM). -Prepare *banca* (rustic boat) or knowing who owns one among neighbours (S)	-Place walkways (SM). -Wear flood-suitable clothes like shorts and waterproof boots (S). -Do not walk barefoot to avoid injuries (S). -Build makeshift raft or floaters (basin or cans) to carry heavy stuff (S). -Use boats for mobility within the ward (S)	-Do not go out unless necessary (S). -Do not walk barefoot in areas full of debris to avoid injuries (S). -Keep the walkways until it is dry again (SM)
Overall Safety	-Raise awareness during the typhoon	-Follow official safety instructions	- Clear surroundings of debris and dangerous

	season (June-Dec) (SM). -Follow PAGASA forecasts/ broadcasts through radio/TV (SM). -Ask in advance for temporary refuge at relatives or friends (S). -Proper waste disposal (SM). -Participate in community programs for cleaning the drainage system (RABUZ) (SM).	(S). -Stop sending children to school (S). -Evacuate children, women and elders to temporary shelter at neighbours, relatives or City Government evacuation centres (S).	materials (S). -Ask relatives, friends, or City Government for support (SL). -Help community members in repair works (S). -Participate in community recovery activities (S). -Clean canals (SM).

As mentioned, some of the strategies listed in both tables make people less dependent on external (uncertain/inadequate/deficient) assistance and speed the process of going back to 'normal' life after flooding has receded, making the whole episode less traumatic.

While some of these strategies were found to be temporary and practiced just for survival during the event or shortly in the aftermath (S), others become or have to be integrated in their daily life either in the medium (M) or long term (L).

Regarding housing, for instance, the long term strategies are specifically oriented to avoid contact of the flood waters with the main structure. By preventing the damage of structural elements such as walls, roofs and floors families try to avoid becoming homeless. The preferred coping mechanisms to avoid exposure to flood therefore are to build concrete houses, elevate the terrain or build houses on elevated stilts. This last strategy even characterise the landscape and life style of the communities in the wards studied. However it was found that once the houses, especially the wooden ones, have undergone around 50% of damage they are not

considered a safe refuge anymore. In this case the whole family has to seek refuge in safer houses (often concrete buildings) nearby or move to evacuation centres.

Nevertheless, building houses from strong materials and filling up the terrain to avoid flooding are coping strategies that require availability of funds; most of the time the money comes from people's own savings or from private loans. However, given the fact that most families in both wards have an income that falls below the poverty line (by 2005 66% of the households in Triangulo and 73% in Mabolo were earning less than US $3 a day) the likelihood of carrying out these mechanisms and providing safety and long-term refuge is low. Most of the time households need to make use of their limited savings or borrow small amounts from informal (lllegal) moneylenders (locally know as loan sharks) or pawn their few valuables, if any. The poorest families, however, can only repair the structural damage 'little by little', using scrap or second hand (weaker and inadequate) materials, or simply leaving the house 'as it is'.

Diversification of livelihood, extending working hours, changing of work or workplace or even trading work for food were found to be strategies that the households adopt in order to increase or extend their economic resistance. In this way they try to avoid to the maximum having to use their savings (if any), borrowing money or selling/pawning valuables such as their few appliances or livestock, as these constitute their reserves for other 'critical times' such as illness, unemployment or death. Most of these strategies are meant to last for shorter periods or at least until the situation returns to the pre-flooding status. Yet, given the precarious socioeconomic conditions of most of the families in these wards the 'recovery' can last for months, and even years, depending on the magnitude of the event and the level of damage experienced by each household.

The degree of disruption experienced and the availability of resources in the short and long term may also lead to several of the coping mechanisms initially meant to deal with a given flood event becoming permanently incorporated in the households' daily life. For instance, because vegetables and groceries become

scarce and expensive during inundations, then reaping wild edible crops is a strategy performed to complement the diet of the family. However, it was found that families experiencing severe losses or left in marginal status incorporate this mechanism into their normal life to decrease the risk of malnutrition and starvation (derived from the lack of budget for food). The same applies to strategies such as decreasing the food intake, missing meals and consuming poor-quality items. According to some of the households interviewed this risky mechanism may last for several months after flooding and even become part of peoples' life style, especially after consecutive floods and typhoons.

The research found how the continuous implementation of coping mechanisms without reducing the current situation of flood hazards and community vulnerability may lead to further marginalization and impoverishment in the long term. Decreasing the food intake, pawning or selling valuables and borrowing money at high interest rates increase the poverty and vulnerability of the people in these communities.

Especially in a situation where hazard events are happening at short intervals, people have increasing difficulty implementing the same coping mechanisms every time flooding takes place. Their resources are depleted, their resilience is reduced, and therefore their capacity to endure floods decreases. Many times it was found that despite the coping mechanisms available people are trapped in a cycle of poverty and marginality because of the recurrent losses they experience.

Characterising manageability ranges from the community's perspective

Owing to the fragile social and economic conditions present in these two wards there is no need for an 'extreme' magnitude event to become a serious threat to the wellbeing of the 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 or other external actors, to perceive, but well known by the local vulnerable groups.

In order to make the flood risk-related knowledge found in these communities accessible for municipal disaster risk planning and decision-making their awareness, coping strategies and perceptions of threat need to be translated into formats that outsiders, who are not familiar with the situation, may easily grasp. The use of participatory tools made it possible to elicit and understand how these two 'at-risk' communities perceive the threats from their flood-prone environment and how they behave accordingly. Afterwards this knowledge was structured into a number of qualitative classes defined in terms of water depth and duration, the disruption caused and the available resources and coping mechanisms they involve.

Figure 2 shows the results of the exercise in which depth and duration of flooding were used by the participants to explain the progressive hazardousness that a flood episode represents for them and their possibilities for managing the situation arising from its occurrence.

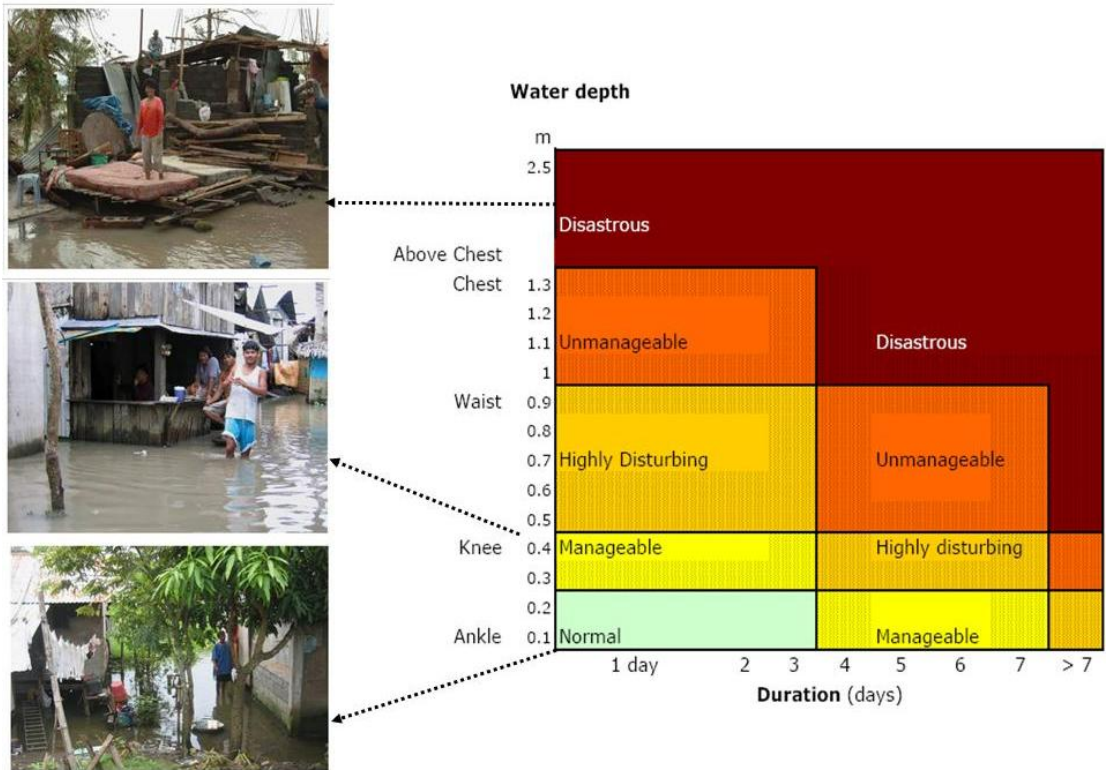

Figure 2: Graphic representation of the flood hazard and manageability perception by the two communities in relation to floodwater depth and duration

A general description and definition of each of the categories given by the participants in the exercises is as follows:

Normal

Defined as low flood levels below or slightly up to *ankle* depth but in any case less than 30 cm (or one foot) and lasting less than 2-3 days. According to the people this flood stage can occur during the dry season in the lowest lying areas, typically when isolated rain showers occur; each month during the full moon period when high tide takes place or during the wet season after several hours of continuous rainfall.

People in these communities consider this flood stage as 'normal' as it occurs numerous times particularly in the low lying terrains. They have become used to the situation and adjust their life style to the presence of some flood level, particularly during the wet season. Strategies for adaptation such as elevated houses and pathways help working people to carry on with their economic activities, students are able to attend school and likewise people are able to continue with what they call 'their normal life' (see Figure 2).

During these flood stages people carefully follow the official warnings; the coping mechanisms implemented are particularly intended to ease the mobilisation of the people and avoid direct contact with floodwaters (often polluted with rubbish and 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 stagnant water and water-borne diseases.

Disturbing but manageable

According to the participants in the workshops this category comprises flood stages below or slightly above *knee* depth (40-60 cm or 1-2 feet) lasting less than three days or flooding at *ankle* depth but lasting between three days and one week (see Figure 2).

This stage was characterised as one in which the incidence of flooding starts to be disturbing either because of the depth or the duration of the flood; however by performing some coping strategies, particularly at family level, the situation is still found to be *manageable*. In the first case the disturbance comes from aspects such as the interruption of normal activities (e.g. schooling). In this case working parents have to allocate time from their normal economic activities in order to take care of their young.

For people living in houses that are at ground level or not sufficiently elevated, domestic and everyday activities such as cooking, sleeping and cleaning are highly disrupted because of the intrusion of floodwaters. The use of basic sanitary facilities such as private and public faucets, toilets and pumps stops as the facilities are partially covered by floodwaters.

Difficulties for mobilisation arise as many roads and pathways are flooded. In addition economic activities such as street vending, washing clothes and small 'in house' shops and food stalls have to be totally or partially stopped. The interruption of income-generating activities may represent up to a 30% cutback in the daily revenue of many households, especially those settled in the lowest-lying areas. This stage also represents a higher exposure to diseases as the people that still continue commuting to work or performing some domestic tasks (e.g. collecting potable water from flood-free areas) have to wade amidst stagnant water. In addition it was found that in some sectors children are allowed to swim and play in the polluted water, increasing their chances of catching diseases.

In the second case (long-standing water) the disturbing aspects come from the presence of pooled (usually polluted) water as this provides an ideal breeding ground for mosquitoes and water-borne and skin diseases.

According to the participants in the workshops all the disruption created in their daily activities represents an extra load of stress to people's already difficult everyday life.

Highly Disturbing

Also referred to as 'hardly manageable' or 'intolerable', this category can take place when flooding reaches below or slightly above *waist* depth (80-100 cm or around 3 feet) lasting one to three days; by flood stages below or slightly above *knee* depth (40-60 cm or 1-2 feet) but lasting between three and seven days.

This category is associated with a stage in which the mechanisms meant to counteract the negative effects derived from inundations are nearly depleted. Especially in the first two circumstances, the disturbance created by this flood stage usually exceeds the resistance of the most vulnerable groups. Their flimsy residences do not constitute a safe shelter anymore and besides most of the economic activities from which they derive their daily income come to a halt.

During fieldwork it was found that, in both cases, this flood stage marks the boundary at which the poorest and more exposed families are forced to look for external physical protection and alimentary assistance. When evacuating, the first option for most of the families is to look for stronger buildings nearby in order to continue taking care of their residence and land plot. If such assistance cannot be provided by neighbours then people move to other friends or relatives or to official evacuation centres in flood-free but remote areas.

In the first case, this stage is also considered critical as almost all zones in both wards face the threat of an inundation with these characteristics. Moreover at this stage the threat from flood is not just related to secondary or tertiary effects such as diseases, disruption of economic activities, services, and basic facilities. This stage can cause severe damage and primary losses as a result of the direct and long-term contact of structures with floodwaters. It poses a serious threat for the wellbeing of the entire barangay.

Unmanageable

This category may take place when flooding reaches below or slightly above *chest* depth (130 cm or around 4 feet) in a single day and lasting a maximum of three

days; with flooding at *waist* depth (80-100 cm or around 3 feet) but lasting between three days and one week; or with moderate magnitude flooding below *knee* depth (40-60 cm or 1-2 feet) that lasts more than one week.

According to people these three possibilities for flood behaviour go simply beyond their resources to manage or cope with the situation; most of the households have to rely on external assistance to meet basic needs such as food, drinking water, shelter, sanitation and health care. At this stage most of the residents in low-lying areas have to leave their residences and move out of the ward, social and economic activities in the low lying areas have come to a halt and the community as such has nearly disintegrated, at least until the flood recedes to 'manageable' levels.

An additional threat during this stage is related to the fact that flooding is widespread in most of the flood-prone areas of the city which comprise 17 out of 27 wards. The disruption at this stage exceeds the capacity for response of most of the barangays and creates lots of pressure on the relief capacities and resources available at municipal level.

Disastrous

This category is the last and most feared by the people in these wards. It can take place when, regardless of the duration, flooding reaches above *chest* depth (>130 cm or >4 feet) or by flood stages below or slightly above *waist* depth (80-100 cm or around 3 feet) lasting more than three days and flood stages below or slightly above *hip* depth (70-90 cm or around 3 feet) but accompanied by strong winds (i.e. during a super-typhoon).

In the first two cases flooding is widespread in Naga City and nearby towns in the floodplain of the Bicol River. The 'calamity' or `disastrous' state is felt at all levels as half of the municipality is flooded including the City Centre where most commercial activities take place. The extent of the physical, social and economic dislocation is such that many people just fail to cope with the situation (see Figure 2). In this case extreme mechanisms are adopted such as family disintegration,

emigration (particularly of the head of household) to bigger cities or simply remaining in a state of marginalisation and destitution for years, which becomes their 'new' life style.

According to the people in both wards these circumstances had been experienced several times in the previous decade (Typhoon Rosing in 1995 and Loleng in 1998). During fieldwork, almost a decade later, the physical damage, threat to life and widespread disturbance caused by these typhoons were constantly recalled by the people in these communities and had become part of their collective memory.

Coping, timing and decision-making at household level

The moment at which to start performing most of the coping or self-defence mechanisms also plays an important role in the manageability of a given flood event.

Coping strategies start to be implemented depending on the severity of the official warnings, the current status of the weather and the household's knowledge of the potential evolution of the flood or typhoon in their sector. When a given flood stage is reached, for instance when the floodwaters are at *ankle* depth, the members of the family start a process of reasoning and decision-making, which depends mostly on the velocity at which the waters are rising. Their awareness of flood behaviour leads them to adopt one or several of the diverse protective mechanisms known or at hand.

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

The course of the previous decision-making by individual households is based on several factors, on what can be called as a subjective 'multi-criteria' judgement that includes:

- ***Flood behaviour in their own zone***: because of previous experiences the households know the potential depth and duration of a given type of flood in the surroundings of their house.
- ***Perceptions of their own spatial location in relation to flooding***: determined by the household's consciousness of the local variations in the topography of the zone in which their residence is built and the closeness to the paths of flooding.
- ***Awareness of their own levels of physical exposure***: determined basically by the safety that the house inhabited can provide to the family members and belongings.
- ***Perceptions of their own socioeconomic capacity*** or resistance to absorb the progressive losses and impact caused by the succession of flood stages.
- ***Awareness of potential environmental problems*** in their area associated with the presence of pollutants, human and animal waste.
- ***Perceptions of the state of affairs for the whole community*** determined by the levels of dislocation experienced by other households in their own zone and the whole ward.

By answering the questions in Figure 3 the family unit takes decisions about which self-protective strategies to perform and the moment to do it. During the Focus Group Discussions it was found that households usually try to delay the evacuation of family members and the shifting of belongings to flood-free areas until the last possible moment. This behaviour is understandable: while they stay in their own home they perceive the disruption can be kept at manageable levels. Moving to an evacuation centre means putting their life and decisions in other people's hands.

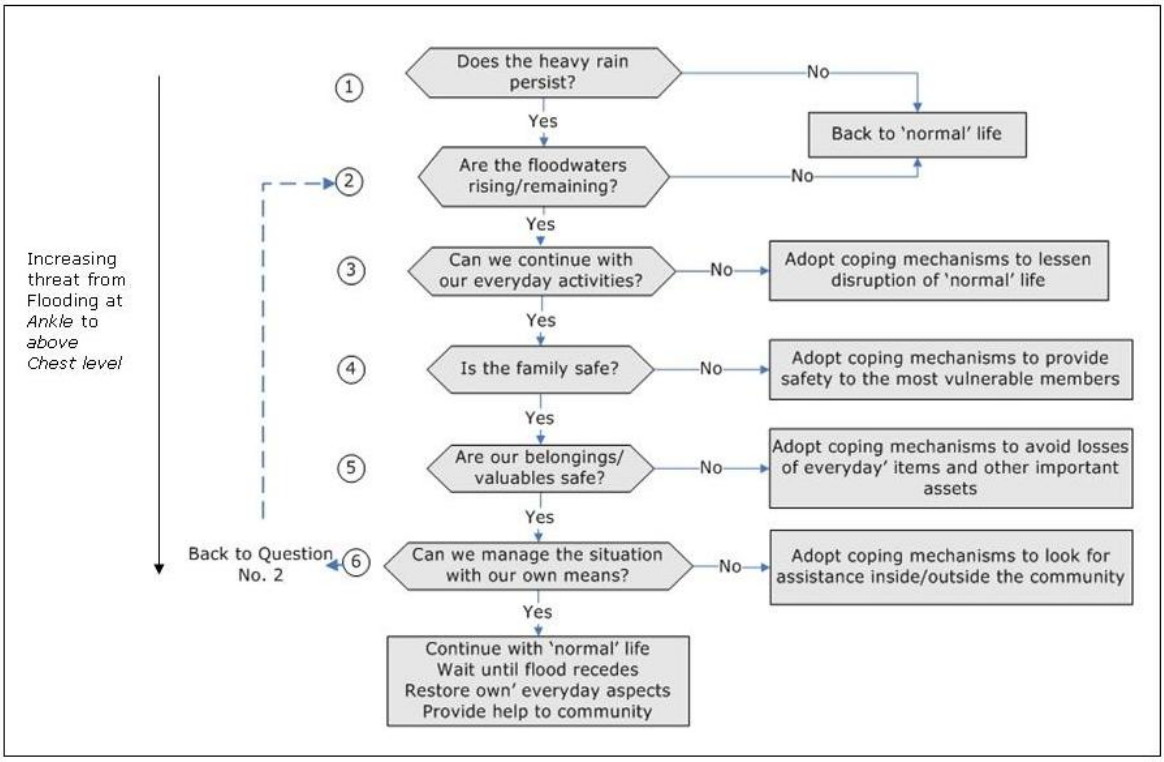

Figure 3. Decision-making process performed by the households while flooding reaches ankle, knee, waist depth and above.

This reluctance to evacuate is related on the one hand to the fact that most of the official evacuation centres are located in the flood-free areas far away from these communities; thus people are compelled to stay away from their residences and work places. Furthermore evacuation centres are described as 'messy', 'crowded' and 'unhealthy'. On the other hand people always hope the situation will 'improve' and therefore they can easily manage the situation and get back to their activities (especially those related to their livelihood) without causing too much trauma to their 'normal' life and without having to rely on external assistance.

It is clear however that the order in which questions 3 and 4 are answered will depend on the velocity at which flood is rising and the depth of the floodwaters. As previously explained, most of the time flooding in these areas is not sudden; therefore at least during the first flood stages, *ankle* and *knee* depth, people perceive that at some point the family is safe as long as they remain in the elevated

mezzanines or stories of their houses (even those built of weak materials). Yet if the water rises fast or reaches further than *knee* depth then family safety becomes the first issue to be resolved and the order of questions 3 and 4 is reversed.

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

Disaster risk management is essentially about managing and coordinating a complex system of information resources. From a disaster risk point of view the lack of data may lead to poor risk reduction and management strategies because of the lack of information for making informed management decisions. Disaster information is needed by decision-makers at different levels and at different scales. Municipalities need information that is sufficiently detailed and meaningful to be useful in all aspects of disaster risk reduction.

The final aim of any risk information models or programmes (using GIS or not) should be to increase knowledge and understanding about the 'risk' reality in which communities perform their everyday life. This shared awareness should in turn facilitate decision-making and encourage appropriate attitudes and actions by authorities, local communities and decision-makers, enhancing their opportunities for working in partnership.

Local flood risk related information has an important spatial component. The severity of flood events differs in space, the households have different characteristics in different parts of the barangays, and environmental conditions also change spatially. In data-scarce environments, typical of developing countries, much of these local data can be generated through PGIS and participatory methods that satisfactorily represent the spatial variation of hazard, vulnerability, coping and manageability capacities, risk and risk perceptions among other factors.

The incorporation of spatial analysis tools in the collection of risk-related local knowledge offers a number of advantages that give this information an added

value. First of all issues such as flood nature, distribution, recurrence, manageability thresholds, seasonality, coping mechanisms at household and barangay level, characteristics of more vulnerable groups, factors determining vulnerability and risk reduction measures are discussed and assessed as part of a participatory process. Secondly the participation of several types of stakeholder such as barangay officers, community leaders, socioeconomic groups (e.g. farmers, small scale vendors, shop owners) and lay people generates debate, discussion and understanding of other people's points of view. Finally it allows agreements on risk assessment and identification of risk reduction measures preventing conflicts emerging from such evaluations when they are performed in isolation by experts or authorities.

This paper demonstrates how local knowledge elicited from the communities was incorporated into community-based GIS mapping and hydrodynamic modelling (using SOBEK software) in order to analyse the spatial distribution of flood manageability and the seasonal distribution of flood hazard.

In the research most of the elements, relationships or processes required to spatially represent the risk factors were elicited through a learning-based approach in which the researcher gets closer to the communities in their own context and gains a deep understanding of the several aspects related to their 'risk' reality. Most of the spatial and non-spatial data about the phenomena under analysis (flood risk in this case), was collected and analysed 'on-site' with the participants.

Flood hazard and the spatial distribution of manageability

The categorisation of the stages in which the occurrence of a flood event is perceived and managed by the community provided an important entrance point for the spatial representation and analysis of flood risk. By knowing the spatial distribution of people's vulnerabilities and capacities the challenges faced by different groups of people because of flooding can be identified.

As explained in the previous section, increasing water depth and duration of flooding combined with lack of availability of resources at household and barangay level can create differentiated levels of disruption. The people in the communities under research established categories for this ongoing disruption that range from *Normal,* via *Manageable, Highly disturbing* and *Unmanageable* to *Disastrous*. This classification was found useful for portraying the differential threats that families can face according to their own socioeconomic resources and coping mechanisms.

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

In this paper the scenario of a minor inundation is analysed in order to demonstrate the importance of including in the first place analysis of the so-called 'small magnitude-high recurrence' flood events which are neglected (by experts and modellers) in flood risk analysis and often perceived as innocuous by municipal and regional authorities. Secondly the spatial analysis performed herein also aims to demonstrate the importance of including the spatial dimension for the analysis and distribution of flood risk, as it was found that, regarding flooding, location plays an important role in the type of coping mechanism that needs to be implemented as well as the time at which these strategies need to be performed.

The event on which the current analysis is based took place as a tropical depression (named as Labuyo) which hit the Bicol region, including Naga City, from September 19 to 23, 2005. 'Normal' heavy rains brought by tropical storms may cause significant levels of flooding in the lowest lying areas of Naga, particularly when they coincide with the high tide period. The presence of small but perennial flooding in these two Barangays is mostly the result of natural water retention associated with wetlands in the Bicol and Naga rivers floodplain. This situation has been worsened by poor planning and lack of implementation of risk reduction measures such as drainage systems and infrastructure that help to drain the runoff from the impervious areas created by urban expansion.

The water depth and duration maps reconstructed for these events are shown in Figure 4. From these maps it can be observed how the lowest-lying areas experienced deep flooding (*waist* deep at 70-90 cm) even during events categorised as 'small' or 'normal'. During tropical depression Labuyo communities in zones 3 to 6 in Triangulo and 4 to 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 the aforementioned 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.

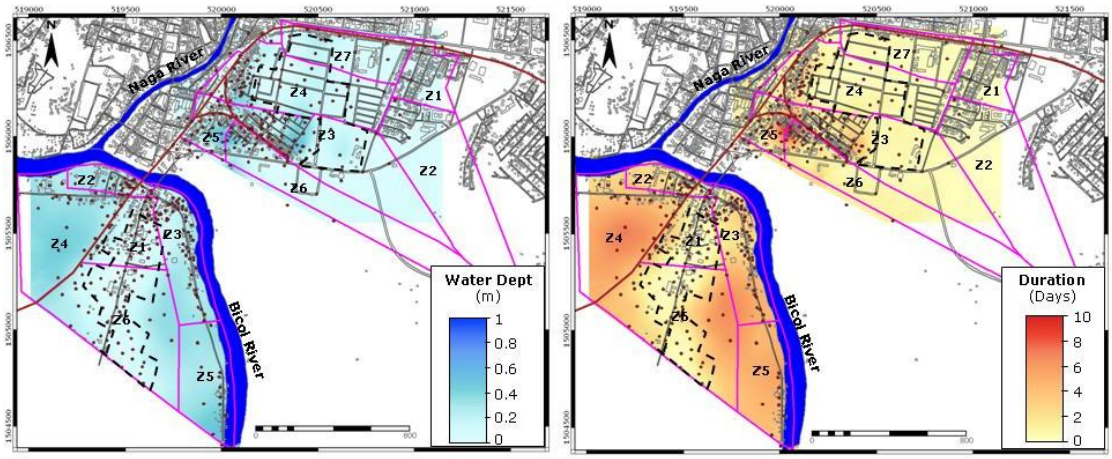

Figure 4: Reconstructed water depth (left) and duration (right) maps of the flood episode of tropical depression Labuyo in 2005 (data source: community-based survey).

In order to determine the spatial distribution of 'manageability' of this flood, a GIS-based procedure was carried out in ILWIS® software. 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 characterised in the previous section. Table 3 provides the set of classification rules used for the combination procedure in ILWIS.

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

- If water depth < 20 cm and duration < 3 days then **'Normal'**
- If water depth < 20 cm and duration > 3 days then **'Manageable'**
- If water depth (in range 20-40 cm) and duration < 3 days then **'Highly Disturbing'**
- If water depth (in range 20-40 cm) and duration (in range,3,7 days) then **'Unmanageable'**
- If water depth (in range 20-40 cm) and duration > 7 days **'Disastrous'**
- If water depth (in range 40-90 cm) and duration < 3 days then **'Unmanageable'**
- If water depth (in range 40-90 cm) and duration (> 3 days) then **'Disastrous'**
- If water depth (in range 90-130 cm) and duration < 3 days then **'Disastrous'**
- If water depth >130 cm and duration <= 1 day then **'Disastrous'**

A set of illustrations of the multiple and diverse circumstances taking place during the flooding episode in 2005 is presented in Figure 5. This arrangement provides a closer look at the differences in the spatial distribution of flood threat and manageability embodied by this event. It can be seen how the diverse socioeconomic conditions of the people that were affected create a differential pattern of damage and disruption within the same administrative area (the barangay in this case).

The areas classified as unmanageable and disastrous particularly in Mabolo (Zones 3, 4, 5 and 6), correspond to areas where the households experienced larger damage because of the destruction of ready-to-harvest rice crops. The losses caused by this flood did damage the investments and potential gains of the farmers. Most of their losses could not be minimised as, because of the small size of the plots and the tenure character of the land, the crops were not insured. Numerous labourers and workers, earning their livelihood from marginal activities

related to harvesting, drying and packing of rice also lost their daily income as very little of the harvest could be saved.

In Triangulo the areas where the households faced mostly unmanageable circumstances were those where flooding reached deeper levels and therefore families had to leave the house, seek refuge in safer buildings, lost several days' income as they could not commit to work.

Households settled in flood-free areas in both barangays were interviewed during that week; in their opinion they considered the inconvenience as 'normal' as only a few social and everyday activities were disrupted as a result of the heavy downpours.

The map in Figure 5 also helps us to understand how the prevalent poor socioeconomic conditions in these barangays determined that for instance the poorer of the poor do not require the occurrence of a large flood event to perceive that they are not able to manage the situation with their own resources. For them even the occurrence of heavy rains or high tides constitutes an indirect threat. After consecutive downpours these households may find themselves in a situation where they cannot continue with their normal life anymore and thus the only outcome of the decision-making process presented before in Figure 3, particularly for questions 3 and 6, will be asking for external assistance, a state perceived by many families as 'nearly a calamity' (Disastrous).

Figure 5: From Normal to Disastrous: Illustration of the hazard and disruption embodied by the flooding episode triggered by tropical depression Labuyo in both wards.

Manageability and the seasonal distribution of flood hazard

Another finding of this research was that the threat embodied by flooding and the manageability of flood events depends greatly on the period of the year in which a given inundation takes place. Figure 6 illustrates perception of the flood hazard depending on timing and its relationship with the manageability of flooding based on the community-based categories previously explained.

As can be seen, during the first third of the year, equivalent to the dry season, people's perceptions of the flood threat remain low. This low awareness is based on the low probability that significant flooding will occur during this period. In addition

during the dry season economic opportunities are more abundant and therefore people are able to absorb the minor disturbance that occasional and small floods may bring. During the rest of the year, however, the perception of threat from the same flood stages (in water depth and duration) increases.

The feeling of a higher threat at the end of the year arises partly because the arrival of the wet season brings more recurrent flooding. In addition, economic opportunities start shrinking with the arrival of the rains and coping mechanisms are more likely 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. 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 were described as partly originating in the end of the growing season (when many people are engaged in rice farming-related duties), the reduction in demand for manpower in the construction sector and a widespread decrease in earnings until the next dry season, when chances of stabilising their economic situation start again. During this difficult period, however, some breaks or 'windows of opportunity' do exist. The first of them is the celebration of a religious festivity ('Our Lady of Peñafrancia') that brings together lots of tourists and devotees and therefore economic opportunities to Naga; the other is related to the second main harvest of rice (palay) that occurs during late September- early October (see Figure 6).

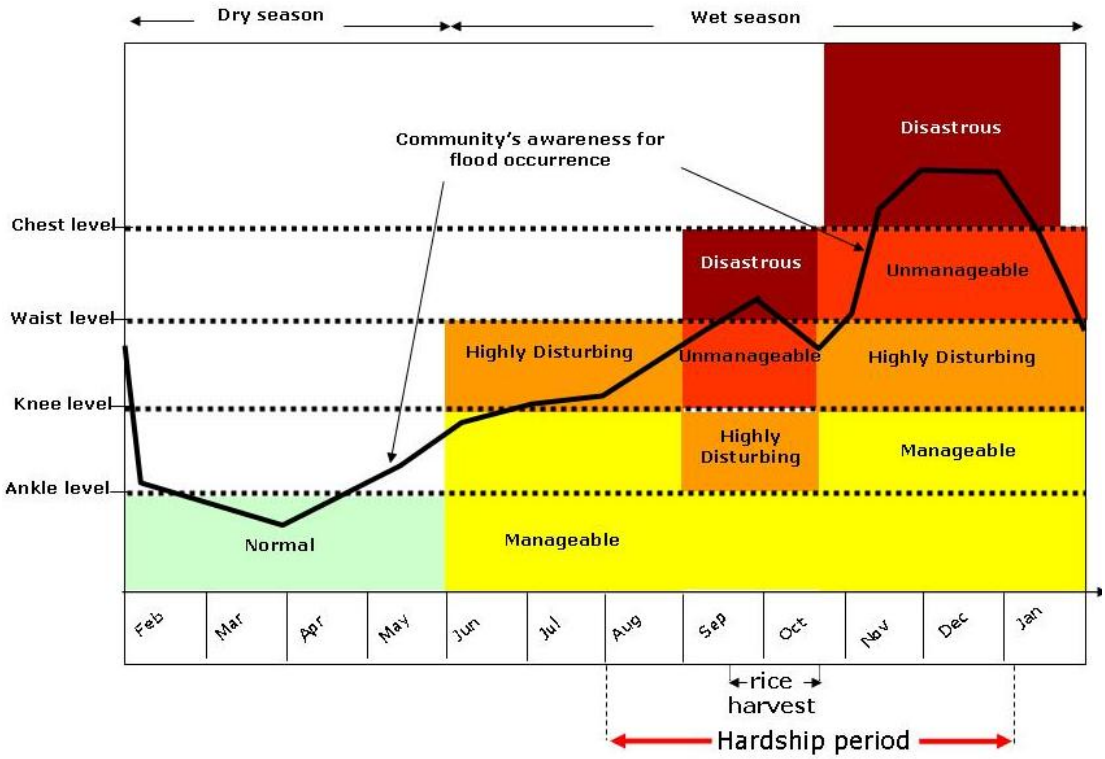

Figure 6. Community perception of the threat and manageability of flood depending on the time of the year

If rainstorms or inundations coincide with these periods then these chances are missed too. Losing the rice harvest as a result of flooding has a very negative repercussion for both communities for it constitutes a staple food for the families and also because in semi-rural areas such as Mabolo Ward many households still make their living from this agricultural activity.

The relationship between seasonality, or timing, of flood events and manageability options become clear then. From Figure 6 it can be seen how flooding at *knee* depth, which for most part of the year is considered as a '*Manageable*' stage, during September to late October is perceived as '*highly disturbing*' owing to the possibility that flooding at this stage will harm the few economic opportunities available during the wet period.

The maps in Figure 7 help to spatially visualise the differences in the distribution of flood hazard and manageability levels as a result of timing or seasonality factors.

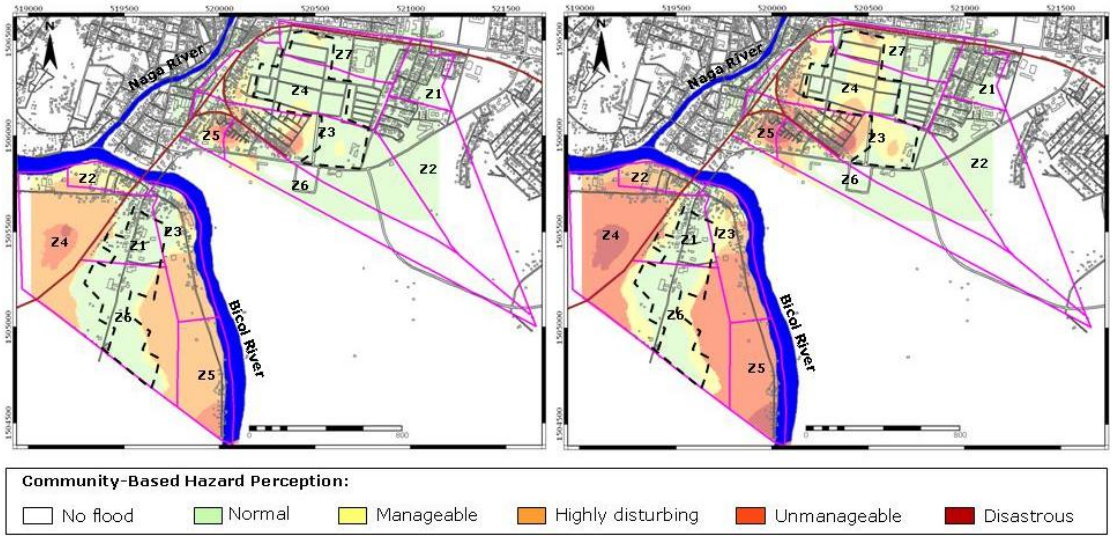

Figure 7: Two classifications of the flood threat depending on the time of the year in which inundations occur. Left: community perception during normal wet season, Right: community perception of threat during September-October for a two-year return period flood.

From the map on the side it can be seen how during the period September-October the same water levels and duration have different implications for the households in terms of hazards and manageability options.

According to this criterion the episode triggered by tropical depression Labuyo embodied a particular high threat for some groups in the communities studied, for it occured during the specific weeks of the year when farmers, labourers in the rice fields and small vendors were involved in significant money-making and social activities and palay (rice) harvesting. Flood stages that at other moments in time would be regarded as *'Normal'* or *'Manageable'* turned into *'Highly Disturbing'* and *'Unmanageable'* simply because people had their economic opportunities during the hardship period at stake.

Manageability of flood events was also found to be dynamic and influenced by both the seasonality of the hazard and the occurrence of previous floods. The losses experienced during a particular wet period reduce the manageability of other flood events that can happen during the same typhoon season and most probably the ones in the coming years. During the research it was found that after the pass of typhoon Unding/Yoyong (November 2004) nearly 90% of the affected households had not been able to fully restore their livelihood to previous standards when they were hit again by tropical depression Labuyo (September 2005). The general feeling of the people in these communities was that they felt poorer than the previous year. On the other hand, the households that had not been able to rebuild or repair their houses with stronger materials perceived themselves not just as poorer but also as more exposed and their dwellings less safe, in other words less able to manage typhoon and flood events, when compared with the same period the year before. It is evident that when the socioeconomic resources and coping strategies have been seriously affected, reduced or even depleted by flooding in the previous wet season, their own perception is that their capacity to withstand and manage the next wet season will also decrease.

Implementation of local knowledge into flood risk management policies at municipal level

The results of the research show that the flood-related knowledge of local communities can be structured and systematically organised in a GIS environment. Geo-information tools can be effective in the formalisation, collection, storage, manipulation and integration of local knowledge of communities at risk for the analysis and spatial modelling of flood risk. Yet to establish effective partnerships between at-risk communities and municipal authorities, via researchers or NGOs, the improved understanding and information resulting from collaborative assessments need to be translated into policies and programmes that increase the manageability of flooding for the households in these communities.

The concept and categories of 'manageability' of the flood threat derived from the community's own perception as well as the influence of seasonal and repetitive events, which are rarely taken into consideration for risk analysis, need to be considered in the design of risk reduction measures. It is evident that knowing the coping mechanisms that people implement in order to increase the manageability of flood hazard can help municipal authorities to better design their policies and programmes. It can also help them to monitor the effectiveness of these programmes and policies for the urban poor residing in flood-prone areas. It gives them a better indicator than using information on water depth and duration or on population distribution and characteristics separately.

Knowledge of the periods in which the risk for certain groups (farmers for instance) is higher will help authorities to design adequate risk mitigation measures, such as: insurance schemes for the specific months when harvesting takes place, accessible loans at low interest rates and provision of staple food such as rice in order to avoid scarcity and speculation. The fact that flooding happening in specific periods decreases the manageability options in these communities and can lead people to adopt risky coping mechanism for survival also needs to be taken into consideration by authorities and decision-makers. The lack of mechanisms that assist households to recover, and, moreover improve, their pre-flooding conditions leads to increased poverty and marginalisation. This in turn represents a higher load for the municipality as they will depend more on the services and aid provided by the government.

As can be seen from Figure 8 the main aim of the risk reduction measures should be to increase the manageability of flooding stages through the whole year. Initially the small but repetitive and long standing flood levels should be ameliorated/mitigated/managed by minimising the risk of diseases and pollution of superficial waters and improving the nutritional status of the whole family. These measures will ensure that during the wet season the working members of the family have adequate health conditions for work and providing a livelihood to the

family, and that children will be able to study throughout the year without interruptions due to low nutritional status and flooding of their schools.

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 be done either by structural measures that help to drain the floodwaters so that they do not stagnate (which is one of the main problems created by flooding in these areas), by urban planning measures that relocate urban poor households to elevated areas within the barangay, and by implementing best construction practices and systems for safe housing. Above and beyond this, of course, is the general need for measures that alleviate poverty, reduce vulnerability to flooding and elevate the socioeconomic level of all the households above the poverty level throughout the year.

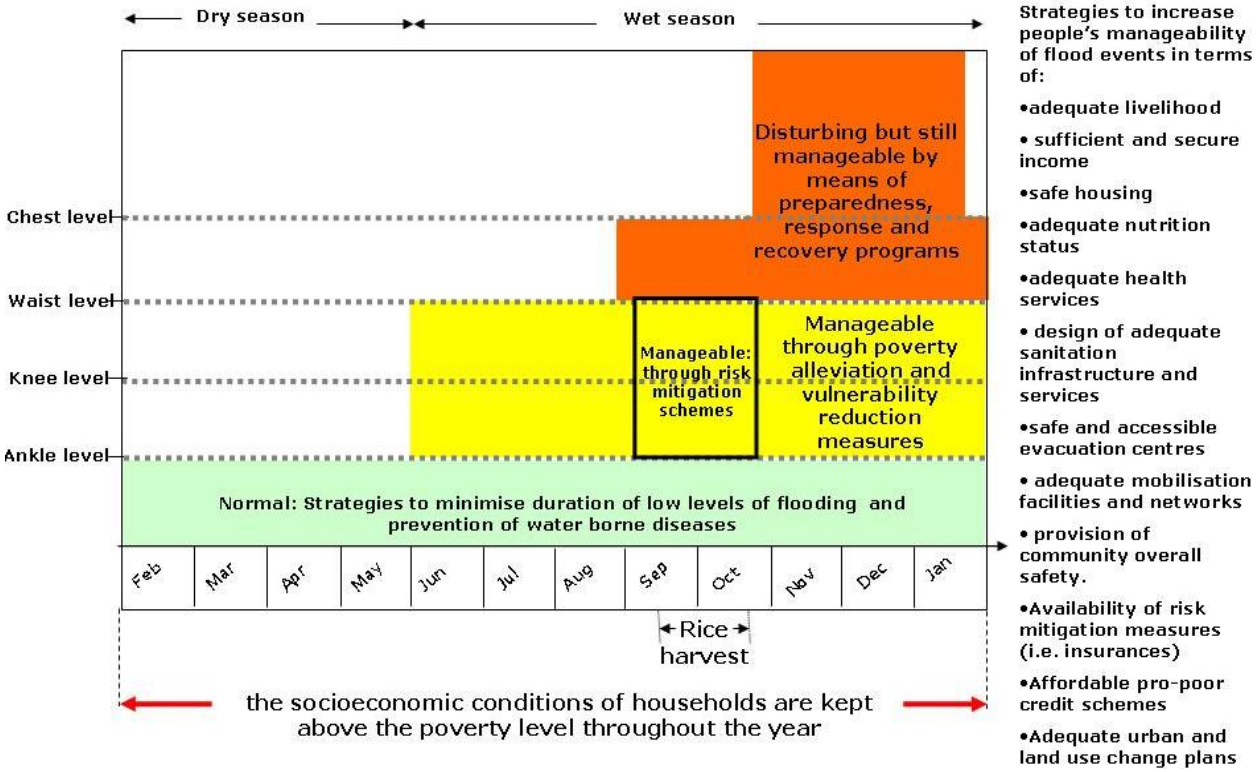

Figure 8: increasing manageability of flooding through poverty alleviation, vulnerability reduction and risk management measures.

Conclusions

The use of parameters and perceptions developed with at-risk communities may help to broaden the general understanding of flood as a threat. The concepts and categories of 'manageability' of the flood threat derived from the community's own perception can help to improve understanding of the flood problematic among the municipal authorities and other external actors. The communities and local barangay officers can make use of such type of tools to communicate their perceptions and concerns about the flood problematic to higher-ups and outsiders. When structured and portrayed in such a comprehensive way the categorisation of flood threat from the community's perception can foster discussions and debates on how to enhance the capacity for manageability for different types of flood events in these communities.

The mapping of manageability also helps authorities to recognise those areas where most vulnerable households can be found in order to determine the levels of flooding they can manage and at which point external assistance may be required. The more fragile the status of the family the smaller its resources and therefore the fewer the coping mechanisms it is able to perform and the earlier the stage at which they may need external support (*Unmanageable* to *Disastrous categories*).

The current classification, based on manageability, can be refined by clearly addressing the differences between households with strongly varying socio-economic levels. However, it is evident that the information provided by the current approach is more helpful for the local and municipal authorities than that provided by water depth and duration maps alone. Evidently knowing in which areas the situation may become 'Unmanageable' and even 'Disastrous' may better help authorities to focus on the coping capacities of the most vulnerable households. They may also know if the strategies of the most vulnerable groups are enough to cope with the situation and return to 'normal' life sooner or if, on the contrary, they will need external aid before, during and after the flood and whether the 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 to gain awareness of flood risk issues. On 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 partnerships for risk reduction between 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 enhances community capacity to communicate their concerns and negotiate access to vulnerability and risk reduction measures. It develops technical and analytical skills at local and municipal level 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.

Bibliography

Bassolé, A., Brunner, J., Tunstall, D. (2001). GIS: supporting environmental planning and management in West Africa. A report of the joint USAID/World Resources Institute Information Group for Africa.

Cannon, T., Twigg, J. and Rowell, J. (2003). Social vulnerability, sustainable livelihoods and disasters. Greenwich, DFID: 63 p.

Dekens, J. (2007). Local knowledge for disaster preparedness: a literature review. Kathmandu, Nepal: International Centre for Integrated Mountain Development.

Ferrier, N. and Haque, E. (2003). Hazard Risk Assessment Methodology for Emergency Managers: A Standardized Framework for Application. Natural Disasters in Canada as a Guide for Disaster Preparedness. Kluwer Academic Publishers, 28: 271-290.

Gilbert, E. H., Norman, D.W, and Winch, F.E. (1980). Farming System Research: A Critical Appraisal. In MSU Rural Development Paper, Vol. 6. (East Lansing, Michigan State University).

Gonzales, R. (2000). Platforms and Terraces. Bridging participation and GIS in joint-learning for watershed management with the Ifugaos of the Philippines. PhD Thesis. ITC Dissertation No. 72. Wagenigen University.

Heijmans, A. and Victoria, L. (2001). Citizenry-Based and Development-Oriented Disaster Response. ADCP. [on line Aug 21, 2004]. http://www.adpc.net/pdr-sea/cbdo-dr/cover.html

International Federation of Red Cross and Red Crescent Societies (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, JCU. Australia. 57 p.

Lawas, C. (1997). The resource users' knowledge, the neglected input in land resource management. PhD. dissertation, ITC- Wageningen University.

Maskrey, A. (1998). Navegando entre brumas. La aplicación de los sistemas de información geográfica al análisis del riesgo en América Latina. ITDG-Peru. LA RED.

McCall, M.K. (2003). Seeking good governance in participatory-GIS. Habitat International 27 (2003) 549-573.

McCall, M.K. (2008). Participatory Mapping and Participatory GIS (PGIS) for CRA, Community DRR and Hazard Assessment. Available at http://www.proventionconsortium.org/?pageid=48#action

O'Neill P. (2003). Developing an Effective Risk Communication Model for Vulnerable Communities. NSW State Emergency Service.

Rambaldi, G., Kwaku Kyem P. A., McCall M., and Weiner D. (2006) Participatory spatial information management and communication in developing countries. Electronic J. on Information Systems in Developing Countries 25 (1) 1-9.

Scoones, I., and Thompson, J. (1994). Knowledge, power and agriculture: towards a theoretical understanding. In Beyond farmer first: rural people's Knowledge, agricultural research and extension practice. (Ed) I. Scoones, and J., Thompson. Intermediate Technology.

Sedogo, L.G. (2002). Integration of local participatory and regional planning for resources management using remote sensing and GIS. Wageningen University, 2002. ITC Dissertation 92, 177 p.

United Nations Centre for Regional Development (UNCRD) (2003). Sustainability in Grass-Roots Initiatives: Focus on Community Based Disaster Management. 103 pp.

United Nations International Strategy for Disaster Risk Reduction (UNISDR). (2005). Hyogo Framework for 2005-2015: Building the Resilience of Nations and Communities to Disasters. [on line 22 June 2005]. http://www.unisdr.org/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf.

United Nations-International Strategy for Disaster Reduction (UN-ISDR) (2004). Living with risk. A global review of disasters reduction initiatives. Geneva. Switzerland. 387 pp.

World Bank (2005). Natural disaster risk management in the Philippines: enhancing poverty alleviation through disaster reduction. Available at: http://go.worldbank.org/EBABBUE0F0

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