INTEGRATING LOCAL KNOWLEDGE INTO GIS-BASED FLOOD RISK ASSESSMENT

The Case of Triangulo and Mabolo communities in

Naga City – The Philippines

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Content

To Rubiela, Beatriz and Alejandra
my loving Mother, Sister and Niece,
…the reason behind the reason.

To Flor for her earnest friendship.

The endless cycle of idea and action,
Endless invention, endless experiment,
Brings knowledge of motion, but not of stillness;
Knowledge of words, and ignorance of the Word.
All our knowledge brings us nearer to our ignorance,
All our ignorance brings us nearer to death,
But nearness to death no nearer to God.
Where is the life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?
The cycles of heaven in twenty centuries
Bring us farther from the stars and nearer to the dust.

T.S. Elliot

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Chapter 1: General introduction

1.1 Introduction

This study intends to provide a better understanding of the risk related knowledge that is present among urban communities settled in flood prone areas by incorporating geo-information technology. In the development of this research there are three fundamental issues related to:

1. The experiences and perceptions of people in flood-prone environments;
2. How these should be analysed and incorporated into Geographical Information Systems (GIS) -based flood risk assessments and
3. How to make this knowledge available to other actors in the risk-management arena.

Research on the first issue showed that in flood-prone environments, communities develop a profound, practical and resourceful local 'risk related' knowledge, and ways of perceiving, measuring and reacting to the threats posed by flooding. Consequently these findings guided the second issue of the study for which the researcher focused on the use of learning-based, participatory and spatial analytic approaches to introduce this local `risk related` knowledge into risk assessments.

Research on the third issue proves that local knowledge can broaden and improve the way in which disaster risks and threats are understood and assessed by external actors, such as municipal authorities. The results also demonstrate that local knowledge coupled with low-cost or free access geo-information software are important assets for local communities and authorities. This is particularly the case in developing countries where scarce budgets for municipal development are allocated to solve more immediate problems faced by poor communities rather than for geo-information acquisition.

1.2 Shifting the paradigm: from top down to collaborative risk assessments

During the past three decades a series of devastating disasters have caused human and economic losses spread all around the world. The years 2004, 2005 and 2008 have witnessed some of the most devastating natural catastrophes of recent decades. The Asian and Pacific region is one of the most vulnerable to disasters triggered by natural events such as floods, cyclones, earthquakes, drought, storm surges and tsunamis. In the last decades floods and storms were the major cause of disasters in terms of occurrence and impacts, and are becoming the second cause of deaths in South-East Asia (ESCAP, 2007).

The increasing trend in the number of disasters and their economic impact implies that communities, regions and nations can no longer afford to simply respond to and recover from disasters. Therefore, international initiatives such as the United Nations International Strategy for Disaster Risk Reduction (UN-ISDR) among others actively promote the implementation of more proactive approaches and advocate that managing the risk brings more benefits than dealing with the situation once the disaster has occurred.

Disaster Risk Management has been proposed as a broader and more proactive approach in which decision-making is supported by structured and systematic processes and procedures such as participatory, collaborative and community-based risk assessments. The overall shift advocated is to move from top-down, technological approaches that usually are based on models and measures established by experts and authorities to a more consultative approach which engages local knowledge of communities and implies sharing and transference of knowledge and expertise (UN, 2003).

Actors such as local communities, scientists, researchers, NGOs and authorities are now encouraged to be actively engaged and to work together from the initial phases of disaster and risk-related problem identification, through information gathering and analysis, until the development of a long-term management strategy and its implementation. Collaborative risk assessments are seen as a win-win situation even if (or because) the actors involved have different perceptions, values or goals and diverse cultural, socio-economic or political backgrounds that may enrich the process (Hordijk and Baud, 2006).

Another advantage of implementing participatory approaches for risk identification and analysis is that it requires disaster managers and consultants to engage with the communities and recognise their values and experiences as an integral part of effective disaster risk management (Buckle, 2000). As the UN (2003) emphasizes strategies based on public information, public relations and public hearings were previously deemed appropriate mostly in the context of informing citizens. Nowadays, however, there is a need to involve communities and groups of people, especially those settled in natural or man-made hazard-prone areas, who claim the right to have a say in the risk decision-making process and influence its outcome (Partner Re, 1997).

This community involvement, one of the chief priorities for action according to the UN-ISDR Hyogo Framework for Action (2005-2015) (ISDR, 2005), has led to the development and application of several tools that look for engaging communities, authorities and other actors and guide them through the process of disaster risk identification, analysis and implementation.

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, have proven their efficiency also in local risk assessment (Gilbert et al., 1980; Scoones and Thompson, 1994; Sedogo, 2002). Therefore these tools are being gradually incorporated into disaster risk management especially at grassroots levels. Several organizations, such as the International Federation of Red Cross and Red Crescent Societies (IFRC), have developed community-based assessment instruments for analysing disaster situations at the grassroots levels and for improving the community's expertise in identifying and articulating its needs and reducing its vulnerabilities. Examples of these are the *Capacity and Vulnerability Assessment* (CVA), *Hazards, Vulnerability and Capacity Assessment* (HVCA), and *Damage, Needs and Capacity Assessment* methods (DNCA) (Heijmans and Victoria, 2001).

Recent experiences have proven the valuable contribution of these methods not only for the assessment of the risk situation at the community level, but also for other aspects, like understanding of the root causes of vulnerability, 'learning' by the researchers or facilitators (and not just 'data extraction') and increasing community awareness about future disaster risks and how to reduce or mitigate them, , They also facilitated the promotion of local capacities and coping strategies and converted them into development action (IFRC, 2002; Cannon et al., 2003; Heijmans 2004).

1.3 Problem statement

It is clear that assessing risk in a more collaborative manner requires the participation of local communities and authorities. It also requires the utilization of new or adapted methodologies, with information and parameters tailored to the local context, resources and needs. Risk assessment as the starting point for further risk management processes should be a multifaceted activity aimed at integrating the potential occurrence and consequences of an event with the subjective interpretations of heterogeneous actors. Risk assessment should become the product of dialogue and negotiation between different actors, with their own perceptions, about what is 'harmful' for them (or not) (De Man, 2004). The use of adequate methods and skills that support what has been called 'community involvement and empowerment', has been explored by many institutions, organizations and disaster risk researchers and practitioners. By adopting participatory approaches the most vulnerable groups and the threats they face can be better identified (Buckle, 2000).

Nevertheless, the shift from top-down to more inclusive approaches is still more of a discourse within the circles of academics and experts rather than standard practice. Especially in developing countries, decision-making about risk related issues continues to be paternalistic, exclusive and based on the *decide-announce-defend* model, which intends to decide and inform the community and then justify the decision (UN, 2003). Very often the specialists diagnose problems, formulate alternatives and determine options without a meaningful consultation with communities. As a rule hazards, vulnerabilities and risk are assessed by experts who assume that disaster risk analysis and decision-making is too complex to involve the general public. Thus, at the end of the day, the authorities, technical staff, scientific advisors and other powerful actors are the ones who take decisions on behalf of at-risk communities (UNISDR, 2005).

This lack of community involvement is caused by several reasons. For instance it is often perceived that effective community participation is inherently hard to achieve. The benefits of participatory research are considered difficult to measure and monitor. Another reason is that participatory approaches often lack systematic analysis and documentation to be used as guidelines (Lilja N. et al., 2001; RAWOO, 2003) and, hence are considered less reliable. In comparison, the reliance on top down approaches has been attributed to their speed, lower costs, 'precision' and simplicity of results when compared to participatory studies (Twigg, 1999; Fordham, 1999; Parkes, 2000).

Yet, approaches based on local knowledge and experiences may be a useful resource particularly in developing countries where detailed information required for conventional model-based risk analyses facilitated by GIS is often not available. For instance, historical records on river discharges and rainfall are often missing, whereas knowledge about hazardous events is generally available within the local communities (Ferrier and Haque, 2003). Organisations such as the IFRC have found that there is a vast quantity of undocumented local knowledge on disaster occurrences in the field, which usually remains untapped because of the lack of funding for producing locally owned i, a format to systematically collect it and a low commitment to do so (IFRC, 2002; Hordijk and Baud, 2006). Anderson and Woodrow (1989) argue that much of the information that agencies need for risk assessment and mitigation can be easily obtained from local people who usually already know what the situation is but do not always have the skills for understanding and organizing what they know.

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, 2002a; IFRC, 2002; Ferrier and Haque, 2003; Zerger and Smith, 2003). 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 after a risk 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 management alternatives. This spatial and non-spatial information integrated in modern geo-information systems can be used to forecast flood hazards, and estimate risk much more effectively.

Most of the relevant data for flood risk assessment, such as the community-based reconstruction of past events as well as the essential social, demographic and physical data, have an important spatial context. These data can be efficiently collected and updated by combining several tools:

(a) Geographic Information Systems for the entry, storage, analysis, and retrieval of data generated together with communities in digital format.
(b) Global-Positioning Systems (GPS) for geo-referencing riskrelated information identified at local level in digital format.
(c) Aerial photography, satellite images and cadastral maps for displaying, on-screen digitising and visualisation of information. These provide the base maps for indicating the spatial distribution of the data on peoples' experiences and perceptions, hazardous events, physical exposure and socioeconomic conditions.

(d) Participatory approaches for diagnosing the community's flood risk problems. Tools such as small-scale surveys, participatory physical and social mapping, transect walks, semi-structured interviews etc. can be supported by GPS and mobile GIS tools.

There is a need to develop innovative approaches that integrate local knowledge with scientific and geo-spatial methods and tools, such as GIS, GPS and EO (Earth Observation) in order to capture and share information between scientists and communities about hazards, vulnerability and capacity. Communities can be assisted in capturing and documenting their own experiences from previous flood events in order to build capacity, and guarantee survival and sustainability (Ferrier and Haque, 2003). A learning-based method that brings together local communities and technical knowledge is useful for risk assessment and construction of risk scenarios. Making local knowledge widely accessible to other actors allows them to use it for risk disaster planning, prediction and decision-making.

1.4 Research objectives and questions

The objectives of the research have been formulated as follows:

1. To contribute to the ongoing development of knowledge about how risks and disasters are perceived, experienced and managed by communities at local urban level
2. To investigate how spatial analysis techniques available in geo-information systems can be combined with local flood-related knowledge and perspectives into risk assessment relevant for urban planning and disaster risk management

In addressing these objectives, this research particularly concentrates on three main issues, mentioned before:

a. Which flood-related knowledge and perceptions do communities living in a flood-prone environment have?
b. What types of spatial and non-spatial methods are required in order to integrate this knowledge into flood risk assessments?
c. How can geo-information technology help to make this knowledge relevant and usable to other actors for urban planning and disaster risk management decision-making?

To develop these main objectives the research focused on:

- Identifying and analysing the physical, seasonal and behavioural factors that transform inundations into threatening events for the people in the flood-affected communities.
- Analysing and converting the analysis of these factors into spatial information which can be used as inputs for spatial analysis of flooding.
- Spatially reconstructing the past flood events, based on memories and experiences of the affected communities.
- Using a combination of hydrodynamic modelling and community-based criteria to determine changes in flood behaviour and threats as a result of urban expansion processes.

- Developing GIS techniques for spatial analysis and representation of factors contributing to the vulnerability of the households in the study area.
- Developing GIS techniques for spatial analysis and representation of the risk derived from flooding using present, future and climate change scenarios.

1.5 Significance of the research

The increasing awareness on the importance of disaster risk management is leading to a growing demand for better approaches for risk identification and assessments particularly at the local level. One of the focal points is the need to take human and community dimensions of natural hazards into account (Anderson and Woodrow, 1989; Johnson et al., 1982; Messer, 2003; Wisner et al., 2004; Dekens, 2007).

This research develops an approach that recognises local knowledge as a crucial input in flood risk assessment. It seeks to understand the way in which people in flood-prone urban environments perceive and understand the threats that these increasingly 'human-induced' events represent to their everyday life. By learning from grassroots people and combining their experiences with the technical and GIS know-how the researcher's objective is to understand – in respect of flood risk-, **what** knowledge they have, **how** they apply it in their daily life and **how** it can be made available and become meaningful to other actors.

The researcher is convinced that 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 flood risk over time. Furthermore local people behave and develop mechanisms for coping that are not always straightforward to external actors.

The knowledge and experiences that people hold from facing continuous threats are not easy to acquire by means of earth observation products or spatial analysis. On the other hand, and given the fast changes that the natural and man-made environments are experiencing, it is probable that local knowledge can become outdated. Therefore GIS and spatial tools can help to envisage risk scenarios for future situations based on the communities' perceptions and points of view.

This research intends to demonstrate that the combination of technical methods with local experiences can help to present people's knowledge to other decision-makers by integrating the information and converting it in 'official formats' which they may be more familiar with (i.e. by adding geo-references, coordinates, legends, scale). Furthermore, the resulting information can help to improve the way in which decisions are taken, emergencies managed and local capacities improved. Finally it can also improve local self–confidence and build capacities for risk management as local actors appreciate local knowledge as an asset and therefore become less dependent on external human, technical and economic assistance.

1.6 The research in the SLARIM project

This research was integrated in the ITC-SLARIM project which stands for Strengthening Local Authorities in Risk Management. The project is now part of the overall Disaster Management (DMAN) research theme of the UNU-ITC School on Disaster Geo-Information Management.

The main objective of this research project, launched in 2002, was to develop generic methodologies for GIS-based risk assessment and decision support that can be beneficial for local authorities in medium-sized cities in developing countries, which do not yet utilise Geographic Information Systems in their urban planning, and which are threatened by natural hazards. The methodologies have been developed through several PhD and MSc researches and concentrate on the application of methods for hazard assessment, elements-at-risk mapping, vulnerability assessment, risk assessment, and the development of GIS-based risk scenarios. The methods applied for risk assessment depend on the availability of existing data within the study area, and range from simple loss estimations based on historic information to more complex methods based on modelling (Westen, 2004).

The current research was undertaken to determine the potentials of integrating local flood knowledge into GIS procedures for flood risk assessment for data-poor environments. The City of Naga fitted the objectives of the general project because of the recurrent flooding problem it has been experiencing during the last decades, the poor integration of flood risk issues and information into urban planning, the prevalence of land use changes and development plans, and the poor use made of an existing GIS platform for decision-making and problem-solving.

The aim is that the methods and procedures developed in this research could be used by the communities, municipality and other local actors in Naga City and be of use to other small and intermediate cities facing the same problems.

1.7 General overview of research methods

The methodology used for the study has followed a learning-based approach. During her fieldwork the researcher had the opportunity to get closer to the communities in their own context and attain a deep understanding of several aspects related to their ‘risk’ reality. Through dialogue, debate and joint activities it was possible to elicit their memories and experiences with past inundations, as well as the mechanism and strategies they use in order to cope with these events. Later on, this knowledge was incorporated and spatially modelled in a GIS environment.

The tools used for this purpose included purely community-based techniques, participatory applications of GIS, and the implementation of GIS methods, such as hydrological modelling and multi-criteria evaluation. In all cases the methods and tools used (including the GIS) were means that both facilitated the process of eliciting the tacit flood-related knowledge found and helped to turn the oral descriptions and narratives into spatial and non-spatial inputs for the risk analysis and assessment. The methodology applied in the research will be presented in more detail in chapter 3.

1.8 Structure of the book

The structure and linkages between the theoretical and empirical chapters comprising the thesis are presented in Figure 1.1.

Part I (Chapters 2 and 3) is constituted by the conceptual and methodological approaches leading the research; chapter 4 gives the background of the two Barangays studied. **Part II** consists of empirical chapters that deal with the analysis of flood hazard, vulnerability and risk. It can be subdivided in two main components: chapters 5 and 8 present the conceptualisation of local knowledge, found in the studied communities. These chapters form the basis for the second component formed by Chapters 6, 7, 9 and 10 which contain the practical application and integration of local knowledge and experiences into GIS-based modelling.

A brief description of each chapter is given below:

Chapter 1: General introduction. This chapter presents the general introduction of the study with the statement of the problem, research questions and objectives, significance of the study, general methods and the structure of the book.

Chapter 2: Theoretical and conceptual framework of the research. The theoretical basis of the research and an overview of current trends in risk assessments are presented, focusing on local knowledge and collaborative ways to combine scientific and community-based procedures to improve the understanding of disaster risk. Furthermore, the chapter focuses on the occurrence and implications of inundations for communities settled in urban environments. It also provides a review of study cases, which have included participatory approaches and local knowledge into flood risk assessments. The chapter ends by presenting the conceptual approach applied in the research.

Chapter 3: Implementing the methodology for eliciting and modelling flood-related local knowledge. The proposed approach for integrating the local knowledge into GIS-supported flood risk assessment is presented in this chapter. The chapter shows how spatial and non-spatial components of the local knowledge are turned into information ready for integration with other more formalized means of analysis. It also shows how through the use of focus group discussions, open interviews, transects etc. local or 'place-based' knowledge can be converted into information for flood risk management. The chapter ends with a discussion on the limitations and constraints in the application of the method proposed.

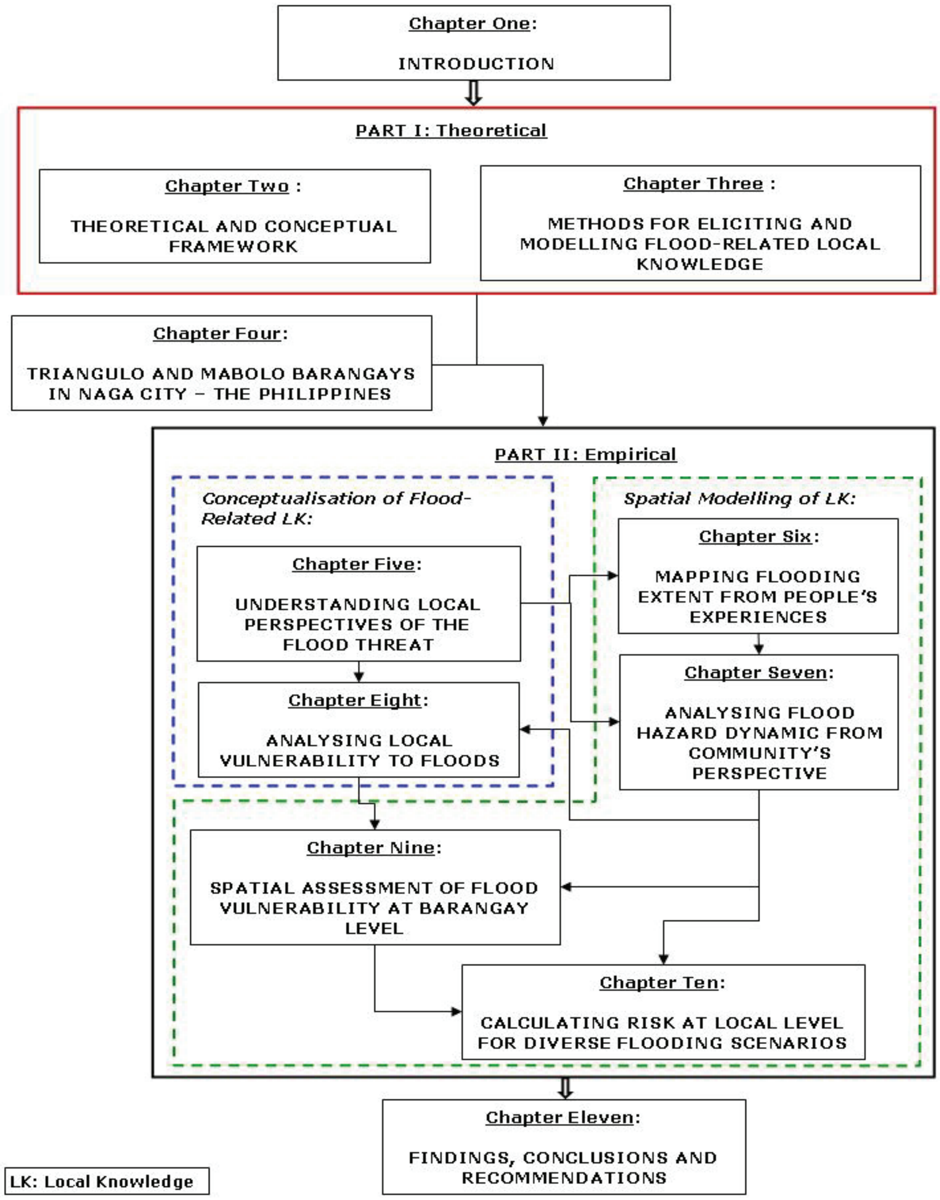


Figure 1.1: Flowchart of structure of the research and linkages between chapters

Chapter 4: The Triangulo and Mabolo Barangays in Naga City – The Philippines. This chapter describes Naga city and two of its Barangays as case study area. First a geographical and historical description of Naga city is provided together with a flood risk profile of the city. Local organizations related to flooding are described. The second part of this chapter offers a general geographical and socioeconomic profile of the communities in the selected Barangays.

Chapter 5: Understanding local perspectives of the flood threat. This is the first conceptual chapter directly derived from the local knowledge. The experiences of the flood-affected people are elicited and structured in such a way that they provide a picture of the flood problem at hand.

Chapter 6: Mapping flooding extent from people's experiences. This chapter presents the results of the data collection by means of GIS-assisted mini-survey of people's concrete experiences with water depth, duration and flood distribution of three events, which hit the communities in the past. The data were used for spatially reconstructing and analysing the hazard events. After applying some of the parameters derived in Chapter 5 it was possible to convert the hazard parameters in classes based on the community's point of view.

Chapter 7: Analysing flood hazard dynamic from community's perspective. In this chapter community's experiences and flood risk-related knowledge are used again as primary input, but this time combined with the outputs of flood modelling using hydrodynamic software (SOBEK). Past, present and future scenarios are modelled to reveal the influence of landscape transformation in aggravating the threat from flooding for communities in the study area. In addition, the community-based datasets and scenarios produced in chapter 6 were used to validate the outputs of the hydrodynamic model. The final section of the chapter presents the actual flood hazard assessment for the communities settled in the study area based on the analysis of three flood scenarios.

Chapter 8: Analysing vulnerability to floods from a household perspective. In this chapter the results of a GIS-based mini-survey are used to identify and statistically analyse some of the elements that constitute the household 'resource band' against flooding. Through the use of indicators, tables, maps, pictures, case-descriptive boxes and narratives the analysis in this chapter demonstrates how the interaction among social, economic, physical, developmental and environmental factors present in the studied areas contribute to the impact of flooding on the households in the researched communities.

Chapter 9: Spatial assessment of Flood Vulnerability at Barangay Level. This chapter builds on the analysis of household vulnerability, presented in chapter 8, by up-scaling the vulnerability analysis to a spatial vulnerability assessment at ward level. The factors contributing to flood vulnerability, identified by the communities, were integrated using Spatial Multi-Criteria Evaluation, with weights derived from the local people. The elements contributing to the vulnerability of the households are spatially represented.

Chapter 10: Calculating risk at local level for diverse flood scenarios. This chapter provides a methodology for analysing and quantifying the consequences derived from the occurrence of different floods at local level. Several flood risk scenarios are used to determine how the losses derived from inundations impact on the socioeconomic wellbeing of the communities in the two wards. Flood events with different return periods (2, 10 and 20 years) are analysed under varying hydrological, climatic and developmental contexts.

Chapter 11: Findings, Conclusions and Recommendations. The final chapter presents a summary of findings, conclusions and recommendations derived from the results of the methodology applied and the analysis and assessments performed according to the three main objectives of the research.

Chapter 2: Theoretical and conceptual framework

This chapter presents the theoretical framework used in this research. It draws from some of the contemporary theories on risk derived from the occurrence of natural events and conceptual debates on hazard, human vulnerability and coping mechanisms as factors to take into consideration when analysing the impact of disasters on society. The chapter addresses how various forms of knowledge are included in current risk assessments and explores collaborative ways to combine scientific and community-based procedures in the understanding and management of disasters.

2.1 Disaster Risk Assessment: a theoretical framework

The general framework of this research is based on the Disaster Risk Management (DRM) approach promoted by the United Nations through the International Agency for Disaster Reduction – ISDR. One of the key premises in this approach is that disasters are not seen as events of nature by itself but the product of intricate relationships linking the natural and organizational structure of a society (UN-ISDR, 2005). Given the strength of the physical forces involved and the human socioeconomic interdependence on climate and the environment, it is unlikely that adverse impacts from climate events will ever be totally eliminated (UNDP, 2002). Still, efforts to understand and dig in the root causes of disasters clearly indicate that there is considerable scope, both at a macro and household level, to handle the extent and nature of disaster occurrence.

Disasters could, in fact, be reduced, if not prevented, their impact on peoples and communities' mitigated, and human action or inaction to high risk and vulnerability to natural hazards could spell the difference (Birkmann, 2006). Human societies have, therefore, the responsibility to identify the risks and factors leading to disasters and decide on the appropriate interventions to control or manage them.

Risk assessment is then a central stage that, more than a purely scientific enterprise should be seen as a collaborative activity that brings professionals, authorized disaster managers, local authorities and the people living in the exposed areas together (Fischhoff et al., 1983; O'Brien, 2000; Montague, 2004; UN-ISDR, 2005; Plapp and Werner, 2006).

2.1.1 Evolving concepts on collaborative Disaster Risk Management

The past decades have witnessed a shift in focus from 'disaster recovery and response' to 'risk management and mitigation'. From 1990-2000 the

International Decade for Natural Disaster Reduction (IDNDR) and now its successor the International Strategy for Disaster Reduction (ISDR) stress the need to move from top-down management of disaster and a cycle that stresses rehabilitation and preparedness, towards a more comprehensive approach that tries to avoid or mitigate the risk before disasters occur and at the same time fosters more awareness, more public commitment, more knowledge sharing and partnerships to implement various risk reduction strategies at all levels (UN-ISDR, 2005). This more positive concept has been referred to as 'risk management cycle', or 'spiral', in which learning from a disaster can stimulate adaptation and modification in development planning rather than a simple reconstruction of pre-existing social and physical conditions (DFID, 2005).

Disaster risk management can be described as an array of measures involving public administration, decentralization, organizational and institutional development (or strengthening), community-based strategies, engineering, settlement development and land use planning. It also takes into consideration environmental issues as part of the risk mitigation and reduction strategies (UN-ISDR, 2002). A general strategy for disaster risk reduction must firstly establish the risk management context and criteria, and characterize the potential threats to a community and its environment (hazard); secondly it should analyse the social and physical vulnerability and determine the potential risks from several hazardous scenarios in order to, finally, implement measures to reduce them (see Figure 2.1). The final goal, reduction of disaster risk in the *present* and control of *future* disaster risk, should be achieved by combining structural and non-structural measures that foster risk management as an integrating concept and practice which are relevant and implemented during all stages of a community's development process and not just as a post-disaster response (Lavell, 2000; UN-ISDR, 2002; UNDP, 2004). Disaster risk management requires deep understanding of the root causes and underlying factors that lead to disasters in order to arrive at solutions that are practical, appropriate and sustainable for the community at risk (UN-ISDR, 2005).

Evidently, managing risk in this manner requires a consensual and collaborative approach. The UN-ISDR has widely advocated for new ways in which authorities, communities, experts and other stakeholders jointly diagnose problems, decide on plans of action and implement them. In other words, a new ethic of disaster risk management is emerging, based on 'informed consent' as opposed to paternalism. Risk assessment as the starting point for further risk management processes should in turn be a multifaceted activity aimed at integrating the likelihood and potential consequences of an event with subjective interpretations (perceptions) of interacting, heterogeneous actors (De Man, 2004). Risk management therefore will become the product of dialogue and negotiation between different actors, with their own perceptions about what is 'harmful' for them or not.

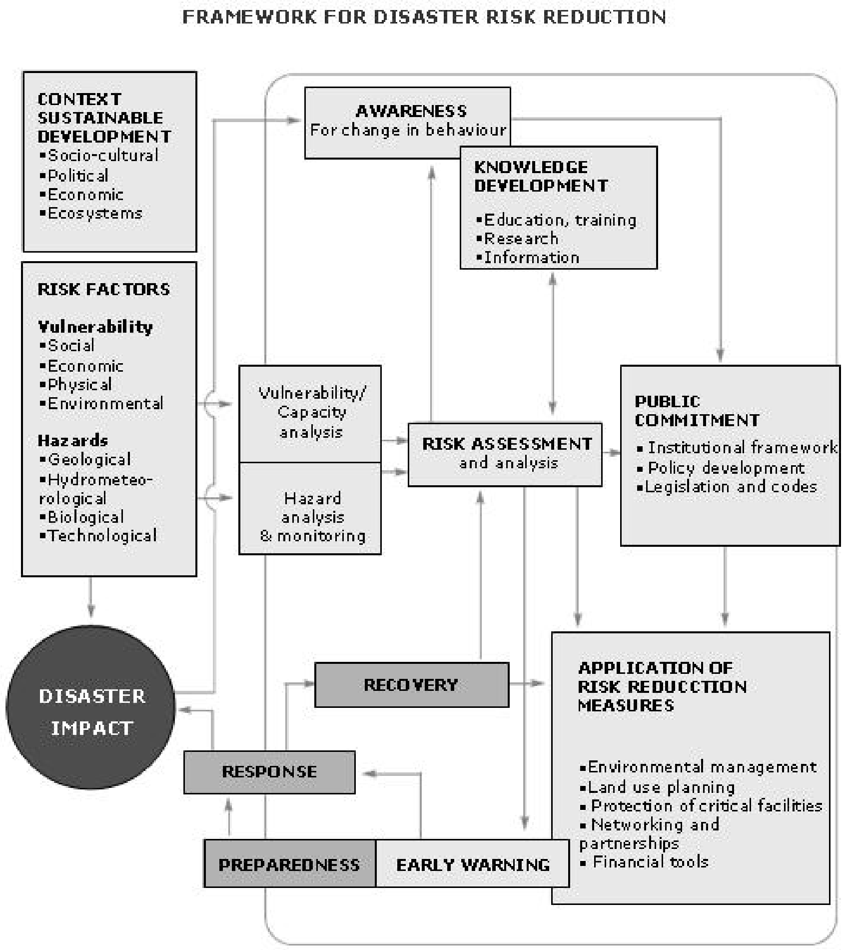


Figure 2.1 Framework for implementing the Disaster Risk Reduction strategy (UN-ISDR, 2002)

Disaster experts and researchers believe that by adopting a collaborative approach and through the use of community-based methods, geo-information techniques and earth observation products, among others, they can better define which events are threatening a given community and identify who the vulnerable are. Moreover, this enables them to determine which are the risks faced and which possibilities exist for managing these (Buckle, 2000; UN-ISDR, 2005). Nevertheless, adequate methods and skills that support community's involvement' (regarding DRM) are still in its infancy and currently explored by institutions, organizations and disaster management researchers and practitioners.

2.1.2 Role of risk assessments in the DRM framework

Disaster Risk Management involves three basic stages: risk assessment, risk reduction and disaster management. The first one is considered as the basic step; hence it needs to be multifaceted, multilevel and multidisciplinary. It also must combine different perspectives, criteria and knowledge systems in order to arrive at realistic and context-sensitive risk management measures.

According to the ISDR a risk assessment process should be based on a review of both the technical features of hazards (location, intensity, frequency and probability) and the physical, social, economic and environmental dimensions of people's vulnerability and exposure, while taking particular account of their coping capabilities to deal with the risks envisaged (ISDR, 2007).

The scheme for Risk Assessment presented in Figure 2.2 suggests that origin and severity of risk from natural events should be defined through two primary steps:

1. Risk identification which focuses on three tasks:
   (a) Identifying potential hazards
   (b) Assessing the physical, economic social and environmental factors leading to vulnerability to the potential hazard scenario and
   (c) Constructing potential risk scenarios based on (a) and (b)
2. Risk analysis which looks at the significance of identified risks on the community's capability to achieve defined goals and objectives.

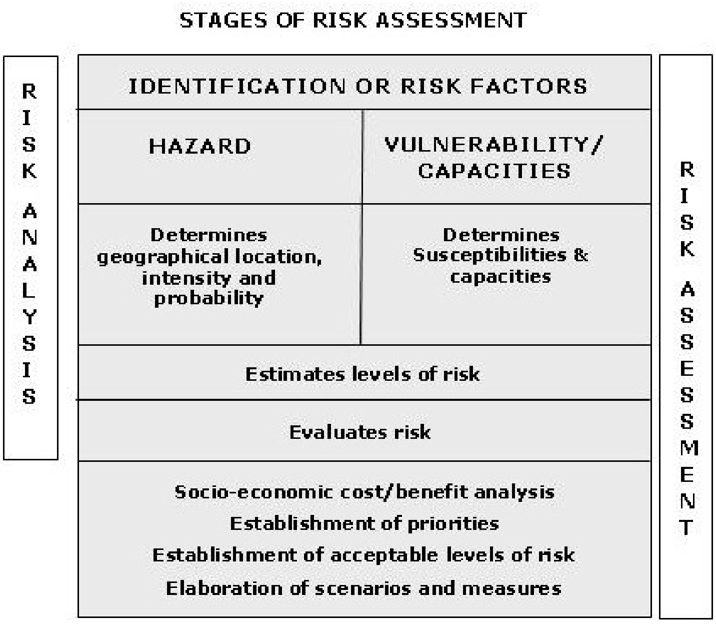


Figure 2.2 Basic stages undertaken in a risk assessment process according to UN-ISDR (2002).

In essence the risk identification process needs to evaluate the mutuality condition posed by both the hazard (which becomes the exogenous factor) that threatens an exposed system or individual, and the vulnerability (as the endogenous factor of the system) which expresses the possibility that the system or individual exposed is affected by the hazardous event (Cardona

2001). Additionally risk assessment has to acknowledge that hazards and vulnerabilities (and therefore risk) are not static, neither in space nor time. Hence it should incorporate some of the following factors for risk identification and analysis:

(a) Spatial and temporal variations of economic and social processes leading to risk.
(b) Spatial and temporal variations in the hazard and vulnerability factors.
(c) Spatial and socio-economic distribution of disaster losses and
(d) Connection between social risk (every-day risk) and disaster risk.

Introducing these elements into risk analysis, for example through scenarios, requires the utilisation of new or adapted methodologies, tools, information and parameters tailored to the context as well as to the community's situation, resources and requirements. These tailor-made methods should consider not only the use of existing spatial and non-spatial data but also combining such information with local (traditional and indigenous) knowledge, which could be important for understanding community behaviour. Thus, inputs to be used as a basis for community planning can be generated not only by so-called scientific inquiry and modelling but also by involving communities in hazard, vulnerability, capacity and resource assessment (Ireland, 2001; UNCRD; 2003).

Local knowledge has been recognized as an important complement to scientific approaches for risk assessment (Maskrey, 1989; Sadler and Boothroyd, 1994; Cutter, 1998; Buckle, 2001; Marsh, 2001; Wisner et al., 2004). Local people usually demonstrate a broad knowledge of their surroundings. Often they are used to deal with recurrent events and have developed their own way of understanding disasters and capabilities, skills and technologies to deal with them. These constitute essential inputs for risk identification, analysis and management (Heijmans, 2004).

Currently many communities are the end-users of information. However, they have particular expertise and knowledge different than, but equally important to, that of the researcher (Sanoff, 1990; 1991). Hence, assessing disaster risk in a participatory way reduces the danger of excluding the public from decision-making by using only scientific procedures. In this way the chance that attitudes, parameters and estimations of researchers will clash with those of the local population is decreased and the risk assessment is enriched as 'risk perceptions' of both groups may complement each other (Pellerano, 2004a, b, Heijmans, 2004). Crucial in participatory risk assessment it that the community is involved in the analysis and not just in data collection, and that it is empowered to make decisions about future activities as a result (Benson and Twigg, 2004).

From purely community-based techniques until the use of Geo-information Systems (GIS) and Geo-information Technology (GIT) this blend of methods may ultimately look for the inclusion of communities' perception in problem's solution and assist them to take decisions accordingly (Craig et al., 2002; Weiner et al., 2002).

2.1.3 Risk factors: hazard, vulnerability and capacity and their assessment

In the DRM framework risk assessment has evolved to a level of understanding that includes the human component in the risk equation. Risk is expressed by the notation:

$$\text{Risk} = \mathbf{H} \times \mathbf{V}/\mathbf{C}$$

Risk is understood here as made up by *hazard (H), vulnerability (V)* and *capacity (C)* factors, the latter being based on the ability of the individual or community to cope with the impact of hazardous events (ISDR, 2007).

Hazards, the intrinsic factor, in its more widely accepted definition (given by the ISDR) are considered as those potentially damaging physical events, phenomena or human activities that may cause loss of life, injury, property damage, social and economic disruption or environmental degradation. Hazard analysis has dominated risk assessments until recently. The association of disasters with natural 'extreme events' emphasized the notion that once the aspects of the physical phenomena were known (i.e. magnitude, frequency, extension, intensity) then the assessment was completed. Probabilistic scenarios of hazard occurrence as well as expected damage and losses were usually presented as risk assessments (Cardona, 2004). Yet, nowadays it is accepted that the hazard analysis should be performed not just as a mere exercise of collecting information on hazard frequencies, magnitudes, areal extents and the like but also as an activity that integrates the varied dimensions of the hazard for the threatened community in relation with their environment, sustainability, equity and development context (White *et al.,* 2001).

This look to hazardous events has several important implications for disaster risk assessment. Firstly it should be addressed that the hazardousness of a natural event is determined by the susceptibility of the element exposed. While a natural phenomena can be characterized in its potentially damaging aspects (location, intensity, frequency and probability) the hazard level must also be attributed in function of the vulnerable element. In a collaborative assessment this implies that the evaluation of the hazardousness embodied by different events should reflect the perspective of the vulnerable communities concerned. Consequently, the common approach to hazard analysis based on 'the historical worst-case scenario' or the adoption of preset levels of protection associated with a specific probability of occurrence (e.g. the 100-year flood) needs to be complemented with the understanding of how events of different magnitudes interact with the human environment and how communities cope with them. Less severe but recurrent small events represent a permanent threat for communities located in hazard-prone areas and more often than not their analysis is overlooked in 'conventional' hazard assessments (Pelling, 2003; UN-ISDR, 2004).

Another issue is related with the increasing evidence that human-induced global warming is creating new or future weather-related hazards. There is a great level of uncertainty among scientist with regard to the exact modification of magnitude, rate and regional patterns of hazardous events.

Therefore probabilistic analysis based on historical records will become uncertain to some extent (IPCC, 2001; IFRC, 2003). Consequently, in several regions it will be necessary to address whether the communities will have to face the effects of climate change superimposed to already existing hazards or whether they should expect that 'events not previously reported' are likely to threaten them (Munich Re, 2006).

From the awareness that **Vulnerability** is a key factor determining the impact of hazardous events risk analysts have significantly improved their understanding of this notion. This means less emphasis is being placed on quantifying and measuring the potential structural damages and losses towards a more comprehensive analysis of the various, and usually complex ways in which social, economic and political systems interact to make people vulnerable and, hence, do generate disasters (Wisner et al., 2004).

Vulnerability is generally understood as configured by a set of long-term social conditions and processes that were already present by the time the hazardous phenomena took place. Some of these factors directly contribute to the suffering caused by the impact, while some others do not relate directly to the danger but do affect the ability of the community to respond to and recover from crisis. Factors contributing to vulnerability precede disasters, contribute to their severity, impede effective disaster response and continue afterwards. Understanding the conditions by which someone's life, livelihood, property and other assets are put at risk by a hazardous event, in other words why people become 'vulnerable' in 'specific situations', is now seen as key for this way of understanding risk and disasters, and their management (Wilches Chaux, 1988, 1993; Alexander, 1997; Alwang et al., 2001; IFRC, 2000; UN-ISDR, 2002; Bankoff, 2003; Cannon, 2003; Wisner et al., 2004).

Currently a wide range of effective methods for identifying and analysing the different facets of human vulnerability and capacity are available for a variety of disaster and development contexts (Cannon et al., 2003).

- *The Vulnerability and Capacity Assessment tool (VCA)* is a practical and diagnostic method mostly used by NGOs for planning and evaluating projects (Anderson and Woodrow, 1998; IFRC, 2002a; Davis, Haghebaert and Peppiatt 2004). The VCA is aimed to help practitioners to understand the nature and level of risk that communities face, where the risk comes from; what and who will be worst affected; what assets are available at different levels to reduce the risk; and what capacities need to be further strengthened. Some authors argue that VCA practices still need to strengthen their assessment of the social, economic and political factors that are the root causes of vulnerability for specific groups (Twigg, 2001; Davis, Haghebaert and Peppiatt 2004).
- *The Sustainable Livelihoods (SL)* method is a holistic and multi-disciplinary analysis which recognizes that poor families commonly suffer more than one problem at a time and often have to make significant sacrifices to meet their basic needs (CARE, 2002). A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (CARE, 2003;

DFID, 1999–2003). Sustainable livelihoods (SL) approaches have evolved out of shifts in thinking on poverty, sustainable development, participation and vulnerability and have now been consolidated into a number of basically similar methods (Carney, D. et al., 1999, Ashley and Carney, 1999; DFID, 1999-2005; CARE, 2003; Brocklesby and Fisher, 2003). The SL framework analyzes the vulnerability context in which people live their lives and the diverse livelihood assets (human, natural, financial, social and physical capital) that they hold. A central feature of the SL approach is that it views people as living and working within a context of vulnerability, which has a direct impact upon their assets and the livelihood options that are open to them (DFID, 1999–2003). Although this context often lies outside people's control, it can be managed by supporting poor people to build up their assets and thereby become more resilient. This emphasis on vulnerability, from a developmental standpoint, makes SL as a potential model for integrating risk into development programming (Twigg, 2001; Cannon et al., 2003). According to Ashley and Carney (1999) the Sustainable Livelihood methods provides an approach and framework for analysis that helps to represent the complex reality from a holistic point of view. Though SL approaches can support vulnerability and capacities analysis, they are widely regarded as a distinct methodology (Twigg, 2001; Cannon et al., 2003).

- The *Pressure and Release (PAR)* and *Access* models elaborated by Blaikie et al., (1994) conceptualise the relationship between hazard, vulnerability and livelihoods in a disaster context (Twigg, 2001). The Pressure and Release model is used as a tool for identify how disasters occur when natural hazards affect vulnerable people. In this model people's vulnerability is rooted in social processes and underlying causes which may take place far away from the disaster-affected area itself (Blaikie et al., 2004). Root causes, dynamic pressures and unsafe conditions are seen as set of factors that generate vulnerability. Understanding of disasters is helped by tracing the connections that link the impact of a hazard with these factors. PAR is a framework used to outlining a hierarchy of causal factors that together constitute the pre-conditions of disaster. The Access Model in turn is aimed at understanding complex and varied sets of social and environmental events and long-term processes that may be associated with a specific event that is called *disaster*. This model is set out to explain, at micro-level, the establishment and trajectory of vulnerability and its variation between individuals and households. It deals with the impact of disaster as it unfolds. It looks at the role and agency of people involved, how they cope, develop recovery strategies and interact with others actors (Blaikie et al., 2004).
- Finally, the *vulnerability indicators approach* is used to assess change over time of processes or phenomena that are difficult to measure directly (Hammond et al., 1995). Indicators are widely used to study phenomena such as environmental degradation, vulnerability, human development and sustainability by involving the use of proxy data to represent factors such as environmental stress, poverty, inequality, health status and various aspects of governance (Adger et al., 2004). Rather than measures of vulnerability itself, the use of indicators seeks to

capture the physical and/or social determinants or drivers of vulnerability (Kelly and Adger, 2000). Multi-criteria evaluation based on indicators or indices allows the involvement of different perspectives and has been recently recommended and applied by different specialists for the purpose of reformulating public policies regarding prevention, vulnerability and risk reduction (Maskrey, 1998; Comfort, 2003; ECLAC-IDB, 2000; Wisner, 2002; Briguglio, 2003; Davis, 2003; Lavell, 2003a, b; Masure, 2003; Cannon, 2003; Benson and Twigg, 2004; UNDP, 2004). The purpose of multi-criteria modelling is to identify the status of the system before the hazardous event occurs. This status is characterized by the instabilities or the 'vulnerability' that may lead the system to crisis. It represents the risk of the human settlement that may be interpreted as the initial conditions on which the response of the system depends when it is perturbed by any hazard (Barbat, 2003).

Irrespective of which approach is used to analyse vulnerability, it needs to go beyond the likelihood of buildings collapsing and infrastructure being damaged. The leading concept of including social and human issues in vulnerability analysis should in any case shed light on the influence of various issues such as social inequalities (i.e. in income, age, gender) as well as characteristics of the susceptible communities and the aspects of the natural and built environment that contribute to human exposure (Cutter et al., 2003).

According to Vogel and O'Brien (2004) any collaborative vulnerability analysis needs to recognize, at least, the following aspects:
(a) Multidimensionality and heterogeneity among physical space and within social groups
(b) Scale-dependence with regard to time, space and units of analysis such as individual, household, region, system.
(c) Dynamism as characteristics and driving forces of vulnerability change over time.

The analysis of the **Coping Capacity** factor within the risk analysis process is triggered by the acknowledgement that communities affected by disasters, however vulnerable they may be, still demand resources crucial for their recovery. Coping capacity is the manner in which people and organisations use or manage available resources in unusual, abnormal, and adverse situations (Brahmi and Poumphone, 2001). The purpose of the capacity or coping assessment therefore is to understand people's previous experiences with hazards that enabled them to develop coping strategies, and to look into available resources (material, organizational and attitudinal) that the community uses to prepare for and to mitigate the negative effects of the disaster. The coping capacity analysis should also find how some strategies might undermine, weaken and eventually increase people's vulnerability. In order to perform capacity analysis people's resources are generally grouped according to: a) physical/material; b) social/organizational, and c) motivational/ attitudinal.

The evaluation of a community's organizational capacity is also considered as an integral part of the capacity assessment. Coping capacity analysis is mostly performed using the above mentioned Vulnerability and Capacity Assessment framework. Any capacity analysis should consider that different groups of people have different capacities helping to understand how and why people react, have reacted or will react to a threat. VCA has been also used after a disaster happened to identify rehabilitation measures, but it offers also possibilities to assess pre-disaster situations in at-risk communities and to identify long-term disaster risk mitigation measures (Heijmans and Victoria, 2001; Cannon, 2003).

There are a variety of different conceptual frameworks which have been used to categorise and analyse coping strategies. Kieffer (1977) sees coping mechanisms as *Structural Mechanisms (SM)* classified as either internal or external that include social units, religious institutions, political organizations and economic systems. *Functional Mechanisms* refers to different strategies according to broad function: (a) Preventive strategies, or mitigation strategies, (b) Impact-minimizing strategies, or preparedness strategies, (c) Post-event strategies or response, (d) Recovery strategies. Walker (1989) developed what was called *Sequential Mechanisms* for analyzing coping mechanisms. His framework identifies four distinct stages on which communities mobilize diverse resources to face disasters following a set of sequences based on their experiences and their level of vulnerability and capacity. This model analyzes how people tend to adopt strategies which secure the sustainability of their livelihood as much as possible.

2.1.4 Role of information and local knowledge in risk management

Risk information management refers to an interactive process of exchanging information and opinions between diverse actors regarding the nature and associated risks of a hazard on the individual or community and the appropriate responses to minimize the risks (O'Neill, 2003; IFRC, 2005). It is evident that accurate and relevant information can significantly reduce the loss of life and financial costs of a natural disaster. Disaster risk management 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 need information that is sufficiently detailed to be useful in all aspects of disaster risk management, e.g. with regard to land ownership, detailed hazard and risk maps and the location of utility lines, disaster response teams and emergency supplies. Governmental officials need regional and nation-wide data for program design, planning, and response to major disasters.

Risk assessment has been usually supported by modern technology which in the last decades has advanced considerably. Hazard mapping and prediction of future events is currently easily performed through techniques such as satellite imagery, production of high-resolution maps and computer modelling. The use of earth observation (EO) products and geo information systems (GIS) has become an integrated, well developed and successful tool in disaster risk management. New GIS mapping techniques, in particular, are revolutionising the potential capacity to analyse hazards, risks and vulnerability, and plan for disasters. GIS software packages are used for information storage, situation analysis and modelling. These types of software work basically with spatial data and enable different kinds of data (i.e. contour lines, forests, watercourses and other geophysical phenomena, roads and other physical structures, demographic and social factors) – to be overlaid in map formats (Twigg, 2004). Disaster risk management benefits greatly from the use of GIS technology because spatial methodologies can be fully explored throughout the assessment process. One of the key advantages of using GIS-based tools for the risk decision-making process is the possibility to use 'what if' analysis by varying parameters and generating alternative scenarios in a spatial context (Longley et al., 2005).

Modern information systems can certainly enhance the way in which decisions are made by providing better information, but this is not enough. The United Nations Committee for Risk Reduction states that 'the advantages of modern technology, such as those provided by GIS or access to satellite weather forecasts should not diminish the values of traditional wisdom' (UNCRD, 2003). Local knowledge transmitted through beliefs, taboos and oral history had greatly helped to preserve the environment through generations and should be central to technology-based methodological solutions (Bassolé et al., 2001). Macro-level data from EO products and techniques, social and economic surveys and census and GIS can be effectively complemented with local, community-based data for risk assessment. Much local indigenous knowledge has spatial associations and components. This type of local knowledge (also termed local spatial knowledge - LSK), 'describes home and action space; is innate and sustained knowledge about the land, identifies issues of immediate significance, and encodes the information about the environment in a language a region's inhabitants understand' (Duerden and Kuhn, 1996; Lawas, 1997; Gonzales, 2000; Sedogo, 2002; McCall, 2003).

Regarding flood risk assessment, several authors have found that local communities are indeed the primary sources of information for instance flood depths, time of occurrence, severity measured in terms of damage, and the like (Whitehouse, 2001; Ahmad and Warrick, 2004; Alcantara-Ayala, 2004; Rautela, 2005; Luna, 2006). Systematic collection and collation of data from significant events using public participation can provide a very useful complement for the development of data-sets to be used as input for risk studies at municipal level and as a basis for risk management and community planning (Ireland, 2001; UNCRD, 2003; Dekens, 2007). Information from local communities can also be useful in calibrating and verifying risk and disaster scenarios (Bassolé et al., 2001).

The final aim of any risk information models or programmes (using GIS or not) should be to increase knowledge and encourage appropriate attitudes and actions of at-risk communities. These models should recognise that local communities and other actors have different knowledge and perceptions about hazards and associated risks. Programs that recognise this and take an integrated approach that emphasizes community partnership will be more successful in risk reduction.

2.2 Flood risk identification and assessment

Compared with other natural events, floods and the type of damages they cause are relatively well known. Yet, nowadays it is understood that while floods can occur anywhere, they are much more potent and create a greater urgency when happening in an urban setting (Wisner et al., 2004). Hence, identifying flood risk in urban environments requires a special effort. This includes the understanding as to how and why urban communities become vulnerable, and are able to respond to floods within their specific built-up environment.

2.2.1 Floods in the urban context

Storms, heavy rains and floods are part of what is known as atmospheric or hydrological-related phenomena and are not always problems in and of themselves. To the contrary, floods are critical in sustaining many ecosystems such as river-delta, wetlands and the like (Prowse et al., 2001). Floodplains and low-lying areas for instance have been often preferred for settlements because of their accessibility, transport facilities, fertility and ample space for growth even if, from time to time, floods may pose a threat to their occupants.

In short the occurrence of floods was mostly seen as beneficial by traditional (often rural) societies whose development was adapted to their cycles (Smith, 2004). Floods used to have a positive connotation as they replenish aquifers, clean pollutants, remove sediments, fertilize fields, and create economic opportunities (Parkinson and Mark, 2005). Even today, for many communities whose economy depends on agriculture, floods are an essential component as they provide irrigation, basic nutrients to regenerate the soil, and help sustain livelihoods derived from them (Wisner et al., 2004).

Over the last decades, however, the increase in urbanization and industrialization has led to radically different land-use patterns, economic structures and livelihood bases. In many developing countries accelerated growth and unplanned redistribution of space and people have led to a boom in urbanization with little regard for the environmental functions and services provided earlier by these areas. To contemporary urban societies, especially in the developing world, the benefits brought by floods and the idea of preserving the hydrological and regulatory functions of floodplains are less evident or completely ignored or considered irrelevant when compared with the potential opportunities brought by expansion and growth of urban functions (Manuta and Lebel, 2005). Beck (1992) recognises how modern urban societies usually accept or trade off social and environmental side-effects brought about by development against the improving material quality of life. Urban planners have satisfied the growing demand for space and zones for new development at the expense of delicate ecosystems, agricultural livelihoods and rural areas in general. In addition the conversion of these areas is performed mostly by making use of harmful techniques, such as desiccation and filling up of wetlands or by occupying floodplains and blocking natural creeks and small tributaries with new buildings and infrastructure. Without the adequate provision of services and infrastructure (drainage, runoff, sewage systems and the like) all these modifications are progressively transforming floods, once seen as natural, rural phenomena, in socio-natural hazard and a persistent urban problem (Lavell, 2000).

Harmful practices associated with piece-meal development (typical of fast expanding cities) such as drastic changes in land use, land filling and segregation within low-lying areas deeply modify the natural absorption and regulation capacity of the terrain. These changes in turn transform the natural behaviour of floods and runoff with the consequent increase in frequency and duration of flood events with highly differentiated impacts. Patchy distribution, stagnating waters and isolated flooding affect some urban communities and sectors, while others are less affected or not at all. Usually these harmful practices contribute to the transference of the flood hazard from more developed and well-off sectors towards the lowest lying areas and less wealthy communities which cannot afford levelling up their neighbourhoods. These processes are depicted in Figure 2.3 .

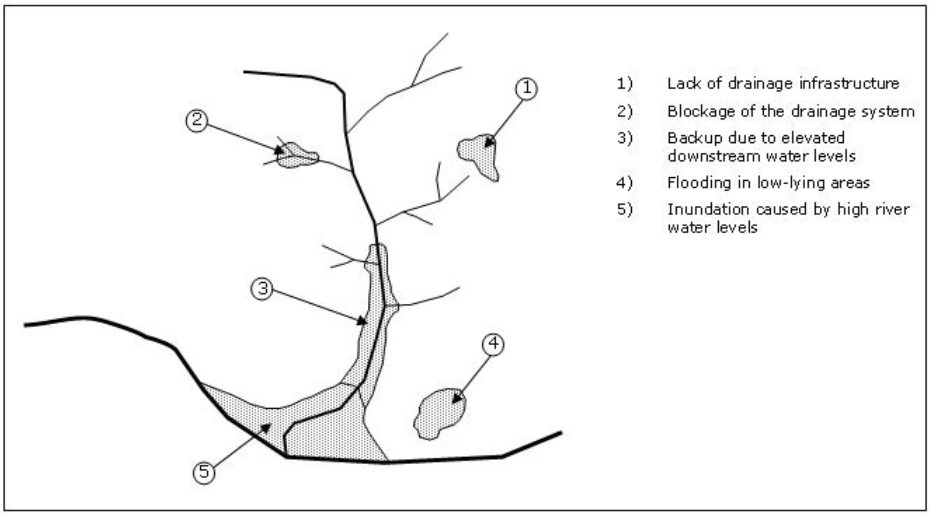


Figure 2.3: Causes and types of urban flooding (Parkinson and Mark, 2005).

In a similar vein UN-HABITAT (2004) argues 'there is little doubt that urban areas are increasingly becoming sites of environmental risk for their residents'. Many floods represent a larger threat for urban populations than for rural environments, because cities, particularly those in developing countries, often have a higher concentration of activities, goods, services, critical infrastructure, and population and poverty levels in a comparatively, smaller space (IFRC, 1999).

These factors combined with the lack of a prevention culture and weak regulatory capacities of local authorities result in higher disaster risk levels for urban areas once floods arrive. Particularly rapidly expanding cities in developing countries face increasing risk levels, as unplanned growth rarely takes account of physical hazards while there are no effective control and sanction regimes (Sanderson, 2000).

Rapid expansion, illegal status and piece-meal development combined with a deficient or lacking information management culture make it difficult to trace the ongoing changes in the natural environment. Most planning offices in medium and small cities simply lack records about how expansion takes place, especially towards peripheral and semi-rural zones, and how they modify the occurrence and behaviour of floods and floodwaters. Many small floods are not even noticed or registered as such by municipal authorities and the local media, since the influence of those changes is often localised or only noticeable in the long run. The consequences of filling-up and blocking small creeks only become noticeable for local people during heavy downpours when the rainwater tries to find its way to the river. Isolated or patchy-distributed small inundations, caused by the lack of an adequate drainage system, are hardly defined as a 'hazard' by others than the affected local people. Stagnated rain or small flood waters as result of earth filling practices and raised individual buildings, are mostly perceived as an 'inconvenient' by the local communities who have to endure the consequences in the form of water-born diseases and a overall unhealthy environment.

2.2.2 Perceptions of urban flooding as a threat

Floods, once perceived and regarded as beneficial for rural areas, are increasingly seen as hazardous or even disastrous by parts of the urban population. Rapidly expanding and poorly managed cities create complex interconnections with the surrounding environment and harbour multiple risks factors. This makes it difficult to identify when an event, such as a localized flood or even a heavy downpours, may become a 'hazard' for some of their inhabitants. As Few et al., (2004) advice, when talking about 'hazardous' events, in an increasingly human-modified environment, it is becoming of crucial importance to be explicit about whose perspectives define a given episode.

The adaptation to hydrological cycles found in many rural communities and the levels of structural protection found in developed societies (i.e. dikes, dams, drainage systems) have led to the prevalent perception that disasters are just triggered by 'extreme' or unforeseen flood events. This perception was well represented by the ecological framework proposed by Hewitt and Burton (1971). According to this framework, societies in their process of adaptation to weather events create a 'tolerance band' made of socioeconomic, political, institutional and similar resources within which a range of variation in the magnitude and frequency of these events can occur without major disruption (see Figure 2.4 A). Average floods can cause some level of damage but as long as they fall within the 'tolerance' range their effects are absorbed or coped with by the society. In this framework the threshold or *normal band of tolerance*, is considered applicable for the society as a whole and constant through time. Only extreme floods can exceed it, triggering disasters.

The disaster risk framework adopted in this research however, emphasises that, especially at urban level, the society creates differentiated conditions in which people perceive and face hazards differently. Firstly, the typical uneven distribution of the 'tolerance band' found in most societies of developing countries determines that the same flood may have a different impact on individuals, households or communities depending on the social and economic sector to which they belong (Affeltranger, 2001; Wisner et al., 2004).

Secondly, the precarious physical, social and economic conditions of many communities settled in urban areas prone to flooding may transform even the smallest or every-day event (such as heavy downpours typical of tropical climate) in an environmental hazard (see Figure 2.4 B).

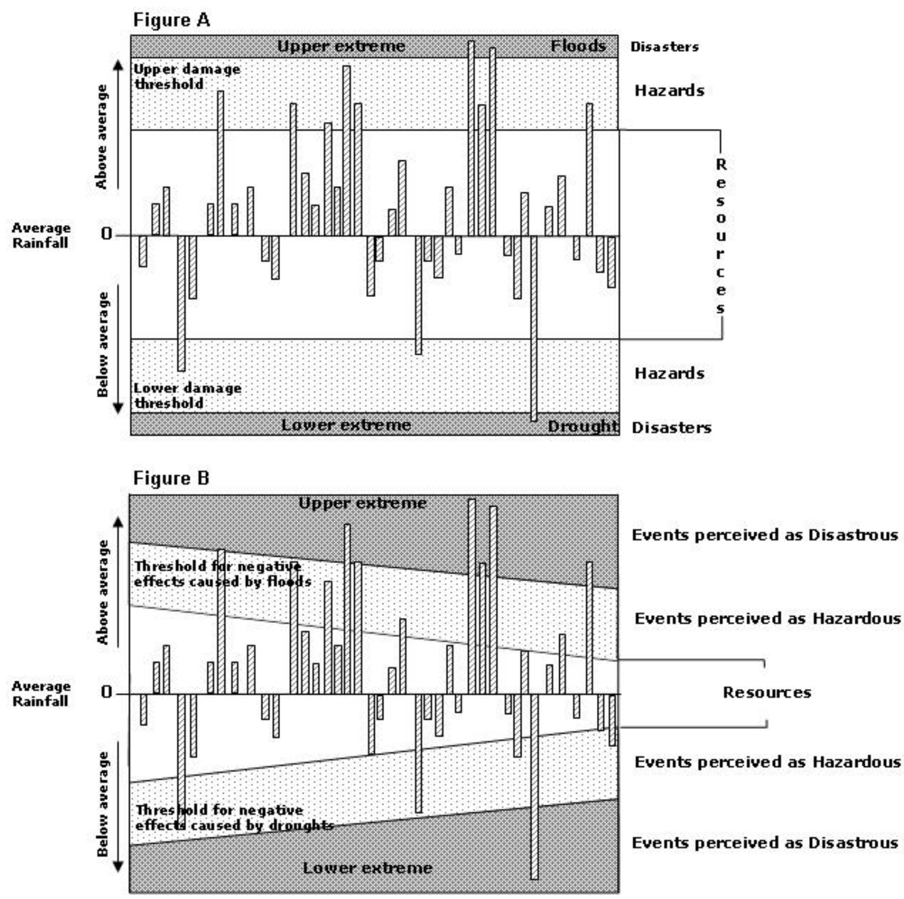


Figure 2.4: Hazard and disasters as a function of human resources and hydrometeorological events: a) disasters as caused by extreme events (Hewitt and Burton, 1971 in Smith, 2004). b) Disasters as an outcome of all scale flood events and increasingly narrow 'tolerance' band (reinterpreted from Hewitt and Burton, 1971 for this research)

Compared to destructive extreme events the effect of small and isolated but recurrent floods has been neglected and is by far more difficult to recognize. Yet, less severe but recurrent small flooding events become a frequent experience in the life of poor and marginal groups and constitute a permanent threat to their social and economic welfare (Lavell, 1994).

In most areas these small and medium size events are far more common and recurrent than dramatic or extreme events, but the hazardousness they entail is hardly perceived whether by the media, authorities or experts (Wisner et al., 2004).

As shown in graph B in Figure 2.4 those frequent minor events embody a cumulative pressure that has the capacity to progressively erode people and governments' tolerance band and their resources to cope. In many tropical countries for instance communities have not yet recovered from previous seasonal floods when they have to face already a new hydrometeorological cycle of events.

At municipal or regional levels these cyclic and seasonal floods are perceived as 'normal' or 'within the average behaviour of the system'. The prolonged effects or long-term stresses associated with low-scale, patchy or isolated floods is therefore hardly reported and tracked; however their negative influence disguisedly wears away local resources and opportunities and perpetuates the levels of poverty and human insecurity (Pelling, 2003; UN-ISDR, 2004; Marulanda and Cardona, 2006).

Unlike the visibility and widespread distribution of direct damages associated with large or extreme flood events (i.e. people evacuated, buildings damaged, roads destructed) the damages of small or seasonal flooding are more difficult to perceive. Often their negative effects are related with people's exposure to every-day risks, poor sanitation, unsafe housing and pollution (Pelling, 2003). People affectec by high fever and cholera as result of polluted waters as well as disease spread through animals (i.e. leptospirosis caused by rats) are currently reported as some of the most flood-related negative and insidious effects (see Figure 2.5).

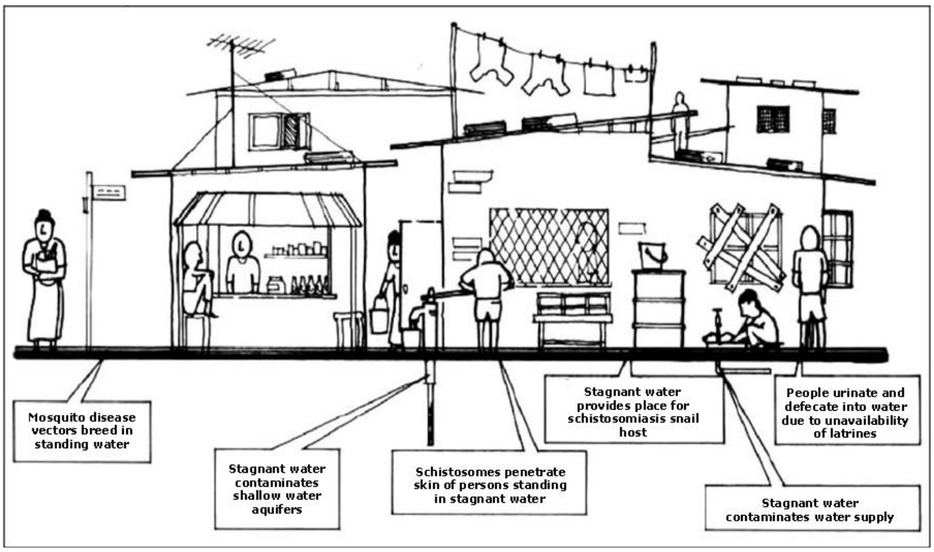


Figure 2.5: Perennial floods, stagnant waters and poor drainage as chronic or every day hazard for urban poor communities (source: Caincross and Ouano, 1991).

Moreover, in less developed countries the levels of disruption and deaths caused by floods are becoming more associated with indirect or secondary threats such as perennial health impacts, incidence of water-related diseases (such as typhoid and malaria), pollution and distress rather than the number of people directly displaced or drowned (Wisner et al., 2004; Smith, 2004; Parkinson and Mark, 2005).

Every-day or small events also represent a threat for people's social and individual relationships and values (Sjoberg, 1998) by disrupting or straining the social network on which many individuals or groups rely. The incidence of water-borne diseases, small but repetitive losses, less working days and loss of self-sufficiency can put most of the members of a poor community under continuous economic and psychological stress.

The social strength required to cope as a community and the possibilities to provide, or search, for support between themselves (when bigger floods arise) are slowly squandered by these small 'unperceived' events. They also affect part of the survival mechanisms required to reduce the risk of disasters.

The failure to perceive the threat that floods of different magnitude pose to the urban poor as well as the assumption that communities are protected by a tolerance band vulnerable just to extreme events only has led to the exclusion of medium and small floods, and their consequences, from expert-based risk assessments and official records. Moreover it ignores the fact that for many communities in developing countries seasonal or small floods make disasters part of their everyday living, as portrayed in Table 2.1.

The summary presented in Table 2.1 indicates how conditions such as economic poverty, social and political marginalization, lack of options as well as lack of resources keep poor communities live under permanent conditions of 'disaster' and that disaster related to environmental extremes is just one component that strikes from time to time next to more frequently recurring every-day risks and small-scale floods (Maskrey, 1989; Blaikie et al., 1994; Anderson, 1995; Wilchex-Chaux, 1998; Lavell, 2004).

2.2.3 Flood risk and the predominant approaches for its assessment

Currently it is being increasingly recognized how the perspective one has influences the way in which floods are categorised as hazards. Particularly the identification of flood hazard is often performed as one-way scientific tool in which the knowledge, assumptions, and perspectives of the assessor (i.e. scientist, technician, insurer) are the major input for the assessment.

Yet, with the increasing understanding of floods as chronic hazards the inclusion of the local communities' perspectives in the identification, assessment and management of risk, is now regarded as crucial.

Table 2.1: Connection between floods, every day and disaster risk in urban areas (modified from Bull-Kamanga et al., 2003; and Parkinson, J. 2003 for this research)

Scale of event	Everyday risk	Small scale Disasters	Large scale Disasters
Type	Localized flooding mostly caused by inadequate drainage of storm water runoff. (See Figure 2.3 flood types 1 and 2).	Small scale often seasonal events, less localized han everyday risk floods. Drainage flooding may affect larger areas	Large scale inundation.
Frequency	High frequency to perennial. Can happen almost every time it rains if drainage infrastructure is lacking or very poor.	Frequent (often seasonal) mainly in low-lying areas	Low frequency
Magnitude	Very small	Small to medium	High
Fatalities as result of the direct impact	None. Deaths linked to secondary or indirect impact are poorly or not addressed.	1-9 persons killed 10 or more injured	10 or more killed 100 or more seriously injured
Total impact	Main impacts are related to deterioration in environmental health conditions, particularly those related with water-related diseases. For most urban areas of DC's these remain the main cause of premature death and chronic diseases	Temporary disruption of transportation systems and inconveniences to city life. Contribute to propagation of water-related diseases and cause structural damage as result of immersion in floodwaters. Significant yet underestimated contribution to premature death, serious illness or injury and poverty ratchet effect.	Widespread damage and disruption of urban life. Can be catastrophic for particular places. Take place mostly in low and middle-income nations. Need for external assistance
Perception	Less visible, they are hardly noticed by media, outsiders, municipal or regional institutions. Mostly perceived as a 'problem' just by local affected communities.	Because of their seasonality or high recurrence these events are often perceived as 'normal' or 'low risk' by experts and authorities and therefore hardly recorded as disasters. They may become seasonal or annual disasters for vulnerable sectors of the society.	Owing to its high magnitude and overall impact these are the events that often reach the headlines and are addressed as 'disasters' by the media, experts and authorities.
From every day to disaster risk integrated framework	Small impact for the city (as a whole) but can entail chronic impact for localized sectors and communities	Continuum of risk	Very large, catastrophic impact for the whole city and surrounding areas

Currently the methods available to characterize flood hazard depend basically on the specific purposes of the classification or project. The most conventional approach to flood risk assessment is based on the probability or likelihood that an extreme event will occur. After identifying the extension and other physical factors of the flood, the social, economic and environmental implications of the occurrence of the event are assessed. A second approach is based on the selection of a 'design' event, often an extreme (i.e. 100 year return period) based essentially on the notion of 'acceptable' risk (see Figure 2.6).

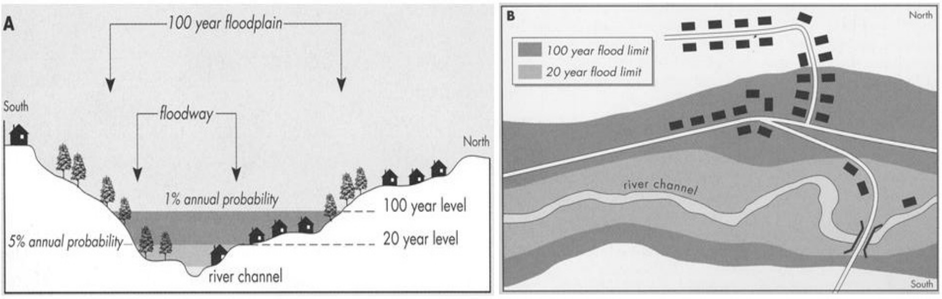


Figure 2.6: Risk assessment and zoning in a floodplain using the 100 year return period as design event (source: FEMA data in Smith, 2004)

These approaches use the historical worst-case scenario that may occur or actually has happened in the basin. Often the results are presented in the form of zoning for land use planning and floodplain development.

A third approach is based on the theoretical maximization of the meteorological factors that potentially can happen in an area and lead to the worst possible storm producing the worst possible flood. These are termed the Probable Maximum Storm and Probable Maximum Flood, respectively. The fourth approach is to use a probability-based analysis where systematic records and historical information on past flooding are used to develop a relation of probability of occurrence versus magnitude. The peak flood discharge and corresponding water level are established for various frequencies of occurrence or return periods of events such as once in 25 years (1:25), 50 years (1:50), and 100 years (1:100); after this damage is estimated for each probability (UN-ISDR, 2004).

Methods for vulnerability assessment, particularly loss estimation, are available in the form of loss or stage-damage curves which can be developed from actual flood events and are used to simulate damage for (potential) future events. They can be based on assumptions from existing databases (building structure, market and consumer ownership statistics, data on social classes) where type, age and social class of the occupants classify residential buildings into major categories. valuation surveys are also used where inventory is surveyed in the different dwellings at risk in particular flood-prone areas. (Penning-Rowsell and Chatterton, 1977; Sande Van der, 2001). The expected losses are the result of a generalised relationship between flood characteristics such as water depth, velocity or duration and physical damage (Smith and Ward, 1998). These methods are mostly based on field interviews and questionnaires on damage to properties and levels of injury to people. The results depend on the response of the interviewees and difficulties exist in extrapolating the curves from one place to another as a result of differences in warning time, building type and content (Sande Van der, 2001).

One of the most relevant and freely available software to calculate loss scenarios derived from the occurrence of flooding (among other hazards) is the HAZUS software, an interactive software released by the Federal Emergency Management Agency (FEMA, 2002) and the National Institute for

Building Sciences (NIBS). The recent HAZUS-MH is a multi-hazard loss estimation system, made for ArcGis software and full datasets on the level of census tract, and can be obtained for the entire United States. Because of the complexity and large quantity of the input data, it has proven to be rather difficult to apply the HAZUS methodology in other parts of the world, where less accurate data is available. The methods have to be adapted for use at different levels of detail (e.g., nationwide, provincial or municipal scale), and for different applications (e.g., buildings, facilities and casualties). Whereas large cities often are able to attract the resources and capacity to set-up such a risk management information system, medium-size and small cities and municipalities most often lack these possibilities.

The above mentioned approaches based on the occurrence of extremes or 'worst-case scenarios', are mostly intended for large-scale extreme events and for the management of floods by structural measures. These approaches, however, usually overlook or dismiss the chronic and long term threat that less severe but repetitive small events (i.e. with a 2, 5 or 20 year return period) pose to communities located in flood-prone and unprotected areas. At the same time they assume that all sectors of society are well adapted or have a tolerance band wide enough to absorb the effects of low recurrence floods.

Any approach to identification and assessment of the hazard that floods pose to urban communities therefore needs to differentiate among the different types of events and include less severe but more recurrent events which may not cause major human losses in a single event, but have a hidden and cumulative dampening impact on community's wellbeing (Lavell, 2004; UNDP, 2004) as already presented in Table 2.1.

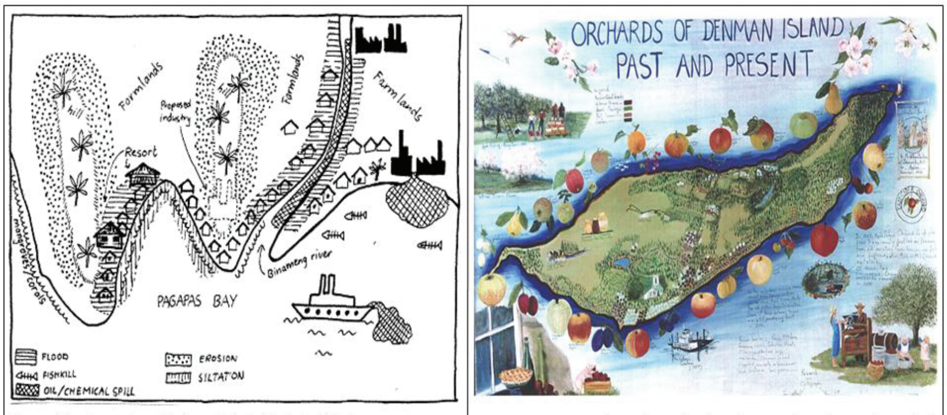
In fact, the existence of different levels of disaster risk and disruption has been better addressed by community-based methods or approaches that at least include some degree of community involvement. Community flood risk assessment is a diagnostic process leading to a common understanding of a community's disaster risks. The size of the flood-related problems as well as the resources and opportunities to cope wwith these are identified and analyzed.

Community flood risk assessment has four components: a) Flood hazard assessment; b) Vulnerability to flood assessment; c) Capacity assessment and d) People's perception of the flood risks. The flood-related information is assembled through tools such as Capacity and Vulnerability Assessment (CVA), Hazards, Vulnerability and Capacity Assessment (HVCA), and Damage, Needs and Capacity Assessment (DNCA). The typical information that can be gathered by these means is related to:

- Analysis of flood management activities and practices at the community level.
- Analysis of community's perception of flood risk.
- Determination of the needs and expectations of the communities in relation to flood mitigation and loss minimisation.
- Assessment of their levels of flood preparedness.

- Methods to enhance their capacity and options for more effective responses to reduce flood vulnerability
- Community-based flood management plans.

Figure 2.7 presents two characteristic outputs of these approaches.



Source: http://www.adpc.net/pdr-sea/cbdo-dr/chapter3-4.html
Source: Common Ground mapping project http://www3.telus.net/cground/maps.html

Figure 2.7: Flood hazard map in Pagapas bay (Philippines) and mapping of community's resources in Denman Island as outputs of community-based assessments.

To date, one of the main drawbacks of the application of purely community-based approaches or those with a strong link to social sciences (also known as the 'constructivist approach' to disaster risk assessment) is that they usually present a strong bias towards vulnerability analysis and the processes leading to it. The actual 'trigger' processes in nature, the hazards and hazard events themselves, its analysis and assessment often receive too little attention or are taken as facts, as if they were given and immutable realities (Wisner, 2003).

On the other hand the results of community-based approaches have been more widely used for preparedness and mitigation phases before and after disaster strikes, and are still weak in the implementation, planning and execution of developmental approaches to manage risk and prevent disasters (Heijmans and Victoria, 2001; IFRC, 2002a; Christian Aid, 2003; Cannon et al., 2003).

Attempts to link natural and social sciences into more collaborative assessments is being reinforced by the participatory use of GIS. The public and participatory use of GIS (PPGIS) is increasingly applied in projects aimed at empowering groups whose interests are often ignored in traditional (GIS-based) applications and assessments (Obermeyer, 1998).

Some of the PPGIS applications focus on social narratives and the recording of local knowledge to enhance the participation of indigenous groups' in official decisions that affect them (Arvello-Jimenez and Conn, 1995; Forbes, 1995). PPGIS applications seek to correct the inequities in GIS technology transfer among the most vulnerable members in society (Metzendorf, 1998).

Collaborative assessments supported by GIS help incorporate local knowledge, historical ‘folk memories’ of disasters, participatory needs assessments, problem analyses and local priorities, and facilitate understanding of local responses and coping strategies. Participatory mapping and use of GIS seem also useful tools for communicating this type of knowledge to environmental scientists; the clarity and conciseness of 'citizen maps' allows decision makers to take into account inputs from the citizens which often tend to be ignored (Forrester et al., 2003; Abarquez and Murshed, 2004).

Increasingly the use of Participatory mapping and participatory GIS (P-GIS) capabilities is becoming a promising tool for supporting and strengthening spatial planning and disaster risk management. This process may assist communities to look at their environment and explore alternative scenarios based on understanding of their own goals, constraints and preferences (Gonzales, 2000; Weiner and Harris, 2003; McCall, 2003; Rambaldi et al., 2005). Participatory GIS involves communities in the production of spatial data and spatial decision-making. Local people could interpret the outputs from a GIS or contribute to it, for example by integrating participatory mapping to modify or update information in a GIS.

Appropriate risk communication supported by GIS tools and procedures has been considered of great help particularly for increasing the essential trust and confidence between actors and for mediation and reaching consensus (Covello et al., 2001; Maxwell, 1999; Maskrey, 1998). GIS-based participatory approaches are being enhanced by simple terminology using words which people can understand and relate to (Sors, 2001). From this perspective, PGIS may help in the democratisation of risk-related information and the development of tailor-made applications for vulnerable communities.

Nevertheless, the proactive use of PPGIS from merely spatial analysis and visualization to problem solving has been so far more widely applied in the field of natural resource management, land uses and land reform (Weiner et al., 1995; Harris and Weiner, 1996; 1998) than in disaster and risk management; very few examples exist of its use in this field.

2.2.4 The use of local knowledge and GIS for flood risk assessments in study cases

As McCall (2008) states it is surprising that there are not many more examples of the participatory use of GIS and of the participatory mapping of hazards and risk. Most approaches to flood risk assessment independently apply one or another of the aforesaid methods, but few cases do exist that integrate the local knowledge collected into spatial representations and analysis of flood risk components. In addition most of the few examples available in the literature have been developed especially in rural settings, while applications in non-rural environments have been poorly researched and documented.

From the application of participatory and GIS-assisted methods for collaborative flood risk assessments found in the literature a set of seven cases were evaluated (see Table 2.2).

Table 2.2: Study cases analysed on the use of local knowledge and GIS for flood risk assessment

Case study	Name	Type/ Country	Scale/ Setting	Reference/ year
1	Disaster prevention and mitigation for the lower Lempa River basin	Project EL Salvador	Basin level Urban and Rural	Lavell , 2001
2	Flood hazard and vulnerability analysis for the city of Turrialba	MSc Research Costa Rica	Local urban	Badilla Coto, 2002
3	Community-based flood risk assessment using GIS for the town of San Sebastián	MSc Research Guatemala	Local Semirural	Peters Guarin et al., 2003
4	Sustainable Land Use Planning for Integrated Land and Water Management for Disaster Preparedness and Vulnerability reduction in the Limpopo Basin	Project Mozambique	Basin level Urban and Rural	UN-HABITAT/ UNEP, 2007
5	Integrating participatory GIS and political ecology to study flood vulnerability in the Limpopo Province	PhD Research South Africa	Local Rural	Nethengwe, 2007
6	Local and popular folklore and culture on hazard and vulnerability meets geographical information system for the risk reduction preparedness of the people of the Barrio San Antonio of Naiguatá, Vargas Estate.	Project Venezuela	Local Urban	Muñoz Rodríguez, 2007
7	Assessing the vulnerability to natural hazards on the provincial/ community level: the contribution of giscience and remote sensing.	Ongoing PhD Research Mozambique	Local Rural	Kienberger, 2007

The study cases as well as the risk assessments differ in their scale, objectives, setting and activities, yet they help to exemplify current approaches to collaborative work between experts and at risk communities. All of them took advantage of the combined use of local experiences elicited though the use of participatory approaches; some of them were supported by GIS and earth observation products.

All the studies found that the communities concerned have a clear awareness of the threat in terms of the flood-proneness of the area occupied, even in those cases where people have being living for no more than a decade in those areas.

This knowledge includes peoples’ interpretations and explanations regarding flood threat, awareness of its genesis, recurrence, forecasting as well as potential responses and behaviour of at risk people. In addition, data on the characteristics of the events was always retrieved, mostly referring to maximum water depth, duration, social and economic losses experienced by families and individuals. It also concerned data on the physical damage undergone by public and private buildings and the damage to critical infrastructure such as hospitals, schools, churches, police stations.

In general, data related to extreme threatening events experienced by the communities such as those produced by strong hurricanes, and extreme flooding with a 25 to 50 year return period, were most easily recorded. The involvement of local people was found important as it helped to understand the local context and people's behaviour. Factors like ethnicity and cultural background were foregrounded, because of the strong influence that life style and socioeconomic level exerts on vulnerability and risk assessment. The consultation processes carried out became an important instrument to develop the projects because it allowed balancing the technical approach with that of the local people taking into account historical processes, community perceptions, personal experiences and unequal power relations. Apart from the diagnostic value, the inclusion of the vulnerable communities also aimed at creating capacities for coping with floods and droughts by, for instance, setting up a SMS warning system, flood level markers, identifying evacuation routes and safe havens in the project areas.

In general all the studies made use of GIS and remote sensing to map the possible effects of floods on local communities and physical infrastructure. In areas were imagery such as Landsat and other digital information was already available they were used to produce thematic information that supported the different stages of the diagnostic process and the participatory design of risk scenarios and and management plans.

In other areas where very poor or no information was at hand, GPS and mobile GIS-based tools were used for the collection of information on flood related issues with participation of communities, local authorities and NGOs and other relevant actors. Databases containing detailed information on social, economical, physical topics were created by means of geo-referenced interviews, and the detailed mapping of important infrastructure, such as public buildings, drinking water access, roads and bridges, areas and households that were affected by past floods, land use patterns and the like. In these cases the communities had the opportunity to share their knowledge and support the production of inputs for flood hazard and vulnerability maps (see Figure 2.8).

In general the information generated by these means was functional and used to produce flood hazard maps (polygons or surfaces) which clearly delineate flood-hazard from flood-safe areas, identify most vulnerable households and land uses, and to take decisions regarding the location of settlements, infrastructure or the re-location of project sites (to a flood-safe area). Nevertheless, in most of the cases it was found that the management of spatial information for flood risk identification and assessment was rather general. The projects made very poor use of the spatial aspects and relationships of the local knowledge found. The modelling and spatial analysis regarding flood hazard, socioeconomic and political aspects is very plain and related only to the use of basic GIS features such as points, vectors and polygons. The capacity for data integration and spatial analysis as well as multi-criteria procedures for vulnerability and risk scenarios for decision-making was not found implemented in any of the projects.

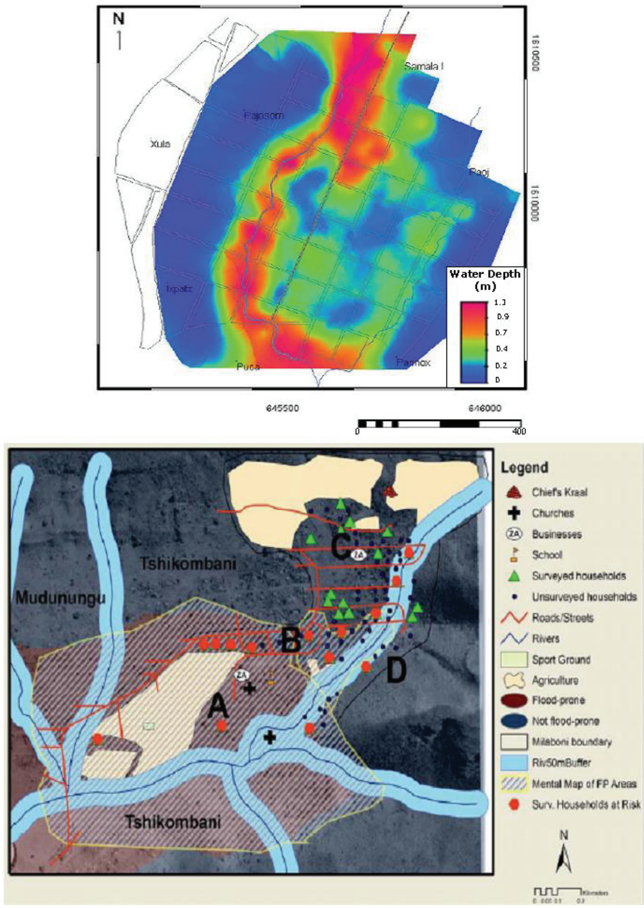


Figure 2.8: Interpolated flood hazard map generated out of local experiences with flood events Guatemala (top) and PGIS-based analysis of socio-political factors of vulnerability to floods in Milaboni Village (South Africa) (bottom)

Similarly, the use of powerful features of GIS such as the ability to merge local spatial data with other sources of information for obtaining new combinations and information that help to better visualise, interpret, predict and communicate flood risk as an spatial phenomenon was deficient.

The study cases illustrated that spatial information and databases can be developed that allow integrating local community perceptions and experiences with traditional GIS data. It was also found that this integration helps to portray the hazards experienced by the communities once floods takes place, to identify the most vulnerable people and activities and to find differential social and economic aspects of flood risk. However it also showed that, regarding the use of more advanced features available in GIS for spatial analysis, there is still a long way ahead. Finally Table 2.3 presents a compilation of the strongest and weakest points, regarding the combined use of local knowledge and GIS for flood risk assessment, found in the above analysis of study cases.

Table 2.3: Summary of the strong and weak points found in the study cases linking local knowledge and use of GIS

Case Study	Strengths	Weaknesses
Case 1. Lempa River , El Salvador	The community-based activities were seen as tools for participation and analysis and not as mechanisms for teaching or transmitting information from the technicians towards the participants. Public participation could be considered as high, people fully contributed to the risk assessment; their solutions and recommendations were integrated into the management plans.	The use of sketches in stead of actual maps or imagery of the zones did not take fully advantage of the spatial knowledge probably available among the communities The participatory activities did not include direct mapping or the use of local generated knowledge as direct spatial inputs of layers for the risk analysis in GIS.
Case 4. Limpopo River Mozambique		The project made strong emphasis on the vulnerability component. The analysis of the flood hazard was very technical and did not include local perceptions of threat rather made use of merely technical based parameters
Cases 2 and 3. Costa Rica Guatemala	Both researches were performed in data poor environments and managed to develop spatial and GIS based tools for flood hazard, physical aspects of vulnerability, damage and risk assessment based on local knowledge and experiences with past events	The assessments were rather technical and did not include deep analysis and modelling of social aspects or the inclusion in the assessment of the knowledge available among the community regarding these issues.
Case 5. South Africa	Systematic assessment of socio-political aspects leading to flood vulnerability PGIS was used to portray, at some point, aspects which are considered influencing the differential vulnerability of the households	The flood hazard identification and assessment was rather general. Very poor use of the spatial aspects of the local knowledge found. The modelling and spatial analysis for flood hazard, social, economic and political aspects was very plain related to the use of basic features such as points, vectors and polygons.
Case 6. Venezuela	Thorough spatial identification of some of the natural hazards and sources of public insecurity perceived by the communities	Very plain use of GIS spatial analysis capacities, limited to the geographical location of perceived threats
Case 7. Mozambique (ongoing research)	Important attempt to link up-to-date procedures for spatial modelling with participatory activities	Regarding the hazard component of flood risk is not clear how is being analysed and if there is going to be spatially modelled and used to determine vulnerability to flood. Furthermore is not mentioned how, regarding this aspect, the local knowledge is going to be tapped, collected and integrated into the assessment.

2.3 Conceptual framework of the research

The UN-ISDR strategy for risk management recognizes that there is hardly a single approach to effectively reduce and manage the risk from natural events. Instead it recognizes the benefit of using an array of measures and methods which final aim is to arrive at solutions that are practical, appropriate and sustainable for the community at risk.

To be able to develop those tailor-made solutions a thorough risk identification and assessment is needed. Identifying risk does not just mean to evaluate the potential for certain damaging events to occur and to determine the damages that they may cause to a given community. It also implies determining how vulnerability conditions have been created and developed over time within a community. To achieve such comprehensive assessments actors in the risk management arena need to adjust the way in which they look at natural events as hazards, and how they perceive at risk communities. For this research the first step was to recognize that 'experts' need to expand their understanding about risk issues.

Most of the researchers in natural sciences have been taught that risk in its objective dimension can be measured and represented in terms of expected damages or losses. For carrying out this task they based their judgement in the 'best available methods and information'. Frequently these science-based knowledge and numerical conclusions overlooked other valid types of knowledge (e.g. historical, personal observation, surveys of community preferences, etc.) and did not involve the people that actually bear the threat. Risk assessments and risk management strategies focused on the *worst-case scenario* or exceptional losses while paying less attention to the cumulative impact of low-magnitude events and small-scale damages that can cause even more harm to exposed communities because of its shorter recurrence period.

Assessing and modelling risk requires that together with the more evident physical aspects other facets that concerns people's vulnerability such as the fragility of the household and collective economy, the absence of basic social utilities, lack of access to property and credit, air and water pollution, high rates of illiteracy and the absence of opportunities be also taking into account. At urban scale vulnerability seen as an internal risk factor must be related not only to exposure of the material context or the physical susceptibility of the exposed elements, but also to the social frailty and lack of resilience of the flood-prone communities. This requires looking into the community's capacity to respond to or 'manage' the impact.

In this research the gap acknowledged by several studies (see Bruton, 1980; Smith, 1976; Green et al., 1981; Sjoberg, 1999; Taczanowski, 2002) between lay and expert knowledge and perception of potential events and their associated risk was taken into consideration and it was assumed that communities have their own 'subjective' dimension to perceive and deal with the effects of hazardous events. Furthermore it was necessary to acknowledge that flood risk is perceived differently by those that see flooding as a phenomenon to measure and model and those who have to deal with their effects in their everyday life and who in consequence have developed their own way to represent, measure or dimension the threat (modified after Cardona, 2004).

This subjective description of risk then becomes part of the risk identification process propagated in this research in order to avoid these differences between what is perceived by people as threatening and the professional assessments. The study follows the notion of Montague (2004) who argues that several of the shortcomings of conventional evaluations can be tackled by engaging communities since the very beginning, that otherwise are found on the receiving end in the risk identification dialogue. The capability to develop a more complete list of warnings, examine the risks that people themselves are willing or able to take; compare alternatives, using all available knowledge, and recognize not only the risks they faced but also the benefits they obtain by living in flood-prone areas are considered all advantages of including local communities in the assessment process.

Nevertheless, this research also acknowledges that the incorporation of such judgements in disaster risk identification is just at its embryonic stage. Even though arguments in favour of integration of other local sources of knowledge into risk identification and the participation of communities in their own risk identification and management processes appear from all sides, few methods and tools exist for doing so effectively. The study, therefore, is focused on providing elements to achieve risk identification at the local level based on the knowledge existing within the communities in the study area by the use of participatory and GIS tools. The role of the researcher and the use of tools such as GIS within these processes are seen as supportive. The learning-based approach proposed here is an alternative way to understand a complex disaster situation through inquiry and interaction. The learning process does not necessarily have to be done at the same time with all social actors together. In this research it was decided to work with the communities at risk and the municipality in an interacting process. It was assumed that it is feasible to elicit and integrate into GIS-based models some of the knowledge that the studied communities have developed by living in a flood prone place, experiencing hazardous events and dealing with the risk they represent themselves. By structuring and representing this spatial and non-spatial tacit knowledge through maps, reports, graphs and tables (in other words turning the knowledge into information), the aim is that it can be incorporated and used by communities and municipalities in their own processes of flood risk identification and management.

It is recognised that tools such as GIS and other geo-information technology have the potential to limit but also to enhance participation of communities; this depends on the role that is given to these tools. Regarding the use of GIS for community-based risk assessment approaches need to be followed that stress the application of the techniques rather than the techniques themselves. For this study the focus is exactly the process of enhancing the inclusion of local knowledge into risk identification and information production. GIS therefore is seen as a tool among others which should facilitate the integration of diverse knowledge with equal significance seeking a common objective. It was assumed that technically and organizationally it is possible to integrate much of the information that is produced by participatory methods into a GIS, despite the fact that regarding natural hazards and disaster management this has been seldom or poorly attempted.

Despite the challenges that the lack of methods for capturing, modelling and portraying the variables of (flood) risk from the community's point of view creates, the integration of the local knowledge was seen as an asset. The aim is that in this way the perceptions, concerns and expectations of the communities can be uncovered and complex situations can be more easily explained. Besides it facilitates understanding and communicating of the flood problematic between communities and other local and external actors.

On the other hand it was assumed that maps, qualitative analysis, anecdotes and narratives can be converted into information that is compatible with government-generated data and that the final products can become valid enough to be incorporated within official databases. Once spatially expressed and stored the locally based information can be regularly and easily updated and can contribute to the processes of information-production, capacity building within the communities and institutional organizations dealing with risk management in data poor, but knowledge rich, environments.

Chapter 3: Implementing the methodology for eliciting and modelling flood related local knowledge

The objective of this chapter is to present the methods that were applied in order to carry out the research discussed herein. The approach is explained in two stages: The first one deals with the application, mostly during fieldwork, of a blend of methods borrowed from participatory or community-based approaches in combination with mobile or standard GIS. This combination of methods was implemented in order to firstly capture knowledge and perceptions that exist among the locals and secondly the spatial relationships between this knowledge and their socioeconomic context. The second stage (Section 3.7) presents the procedures followed for handling these local experiences and perceptions in digital format so that they may be used as inputs for hydrodynamic and spatial modelling of flood hazard, vulnerability and risk in a GIS-environment. This chapter is fairly elaborated and detailed as the methodological design and development are considered part of the substance of this thesis.

3.1 Introduction

Any effort to evaluate the threat represented by floods as well as the vulnerability and risk of the local communities requires (as a first step) learning from people's own knowledge and perceptions. On the one hand, they are the ones that have to deal with inundations on a regularly basis and therefore have their own ways of perceiving the threats from flooding. While enduring the impact of flooding they have become aware of their own susceptibility and have developed (in response) their own coping strategies in order to adapt and survive.

This research emphasises the need that local risk-related knowledge and perceptions be converted into crucial components for risk and disaster management efforts carried out by technical staff, local authorities or NGOs. Understanding the circumstances of communities settled in flood-prone areas should be as equally important, if not more, than acquiring spatial and quantitative data for flood modelling or calculating the spatial patterns of flood hazard, vulnerability and risk.

Disaster risk assessment is customarily seen as a purely scientific and technical activity, especially by those from the natural and geo-sciences. Often, these professionals prefer not to involve local communities, or at best consult them in order to obtain information to parameterise, calibrate and validate their models. At some point this is understandable as, from their point of view, most of the public and other actors know little about the technicalities of disaster risk. However, as it has been stressed throughout this work, with regard to flood risk a large amount of 'localised' knowledge does exists among the communities settled in flood-prone areas, which is very relevant for risk assessment. If this knowledge has helped people to deal with the threats represented by flooding, it should therefore be the basis with which risk assessment and management should be developed (Wisner et al., 2004).

3.2 Implementing the learning-based approach

The task of identifying and assessing risk, in its broadest sense, is more than educating lay people and local officials or providing them with data. Disaster risk assessment as a collaborative task should include receiving information from citizens and authorities and being educated by them through their experiences about hazards, vulnerabilities and risk. While interacting with communities and local authorities it is necessary that researchers let their 'scientific' understanding and perception on risk be influenced by the perceptions of the local communities. In such a research framework local people are also designated as 'experts', whereas outsiders are designated as 'facilitators' for the flow of information and understanding between actors (see Figure 3.1).

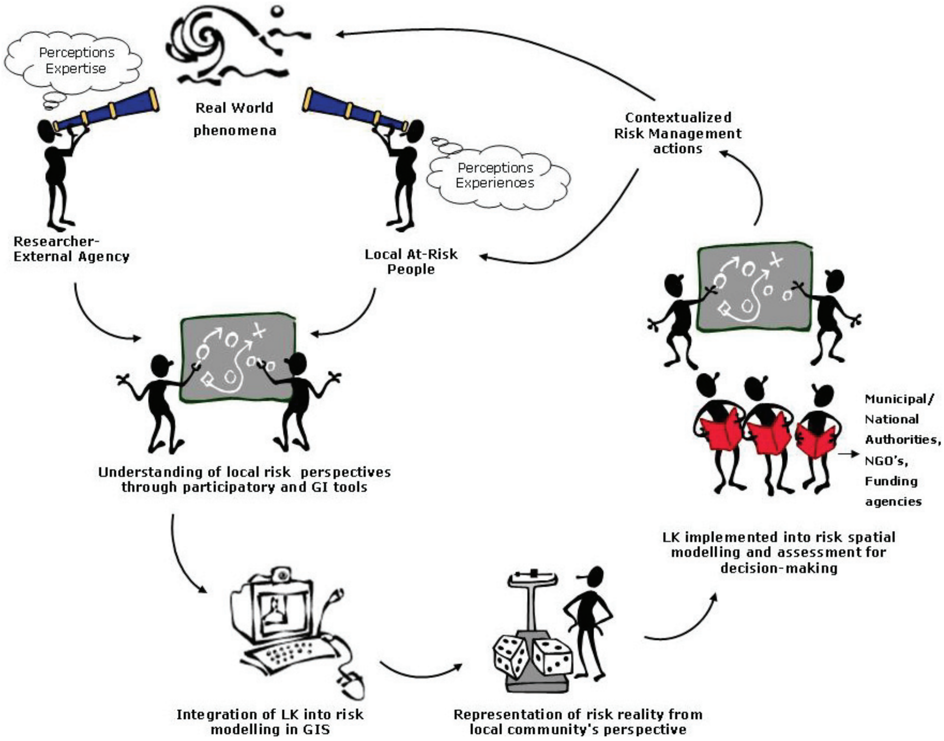


Figure 3.1: Schematic overview of the learning-based process for implementing local perspectives into GIS-based risk assessments in support of management and decision-making.

The learning-based method proposed for this research focuses on the combination of local knowledge linked to flood and typhoon disaster risk with the use of relevant spatial and hydrological data. This blend of methods aims to provide local authorities and the communities with tools that can enhance their disaster and risk management schemes even in the face of much uncertainty and limited data and information. Several tools have been developed to convert the perceptions and experiences of the studied communities into relevant and accessible inputs for external actors, so that they can be used for GIS-assisted flood risk assessments.

By sharing insights from their own experience and knowledge the local actors involved in the participatory activities allowed the researcher (or other external actors) to acquire a deep understanding of the various aspects related to their 'risk' reality. In this case, the methods and tools (including the GIS) brought into the analysis by the researcher are means to firstly elicit the tacit knowledge, oral descriptions and narratives already present among the people in the communities.

Secondly they help to transform this knowledge into spatial and non-spatial inputs for risk assessment. These participatory and technical tools support the representation of people's knowledge and facilitate the communication among local actors. They also enhance the role of the communities in the risk management decision-making arena and create opportunities for further actions to manage the flood risk together with local authorities and NGOs (see Figure 3.2).

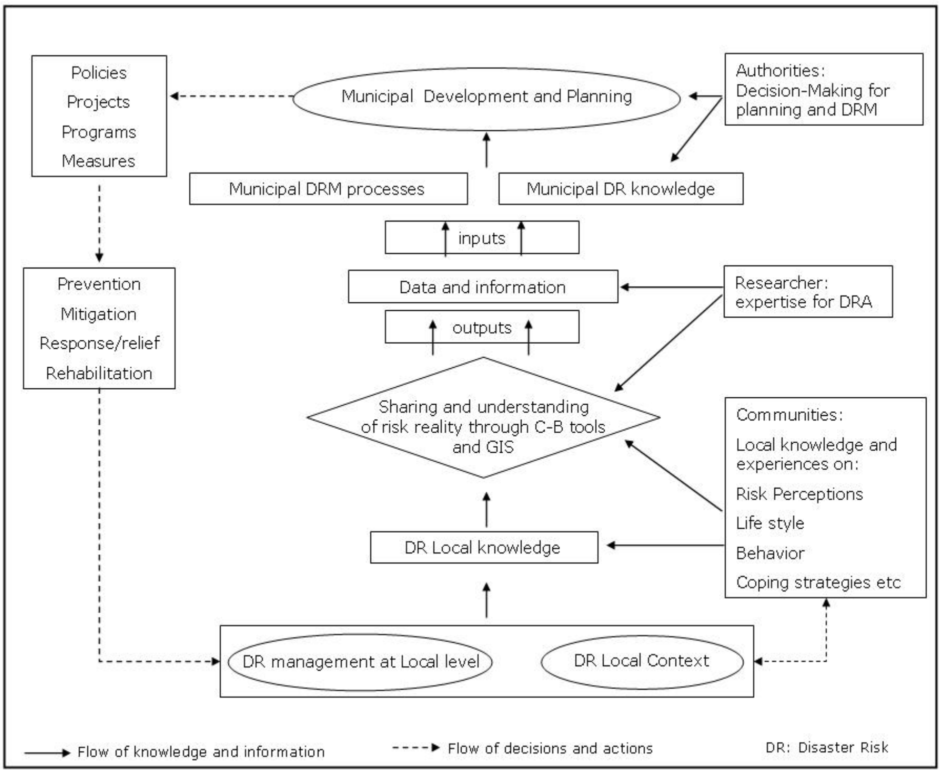


Figure 3.2: Framework for the implementation of local knowledge into disaster risk management processes at local level

The implementation of methodologies that permit the flow of knowledge from communities (through researcher) until local and municipal authorities was considered important for this research, as firstly the chances that the research responds to the problems and needs of those who are ultimately to benefit from it are increased. Secondly the output (i.e. the risk assessment in this case) provides a rich picture of the local socioeconomic context in which the communities perform their everyday life and therefore, closely reflects the situation at hand. Thirdly the exchange of various forms of knowledge among the actors, including tacit and situational knowledge, is encouraged, facilitated or enhanced. Finally, by offering knowledge-driven, rather than data-driven processes for problem identification and analysis, local authorities and communities are presented with ways to tackle the data-shortcomings - usually found in small and remote urban areas of developing countries.

3.3 Translating the conceptual model into elements for risk analysis

The adaptation of the aforementioned framework for flood risk analysis aims to pursue an integrated analysis of what type of events threaten the people, what make them more vulnerable to floods and through what mechanisms they are able to cope with the occurrence of these events. It also looks for enhancing the risk analysis by including linkages between socioeconomic factors, every day risk and vulnerability to natural hazards found in the studied communities.

The translation of the risk assessment model into the various elements used in this research to spatial analysis of flood risk is presented in Table 3.1.

The selection of this framework also determines the scales of interaction and analysis for the research. Identifying community knowledge and perceptions requires an analysis at micro-social and micro-territorial scale. Surveying at individual, household and ward (also referred in this research as 'Barangay') level helped to assess differences and particularities in the knowledge which some times were determined by the differentiated characteristics of both the individual and group (i.e. age, gender, economic status, time period settled in the area) and the context. Moreover, micro-scale research made localised and context-related issues visible in which most of the times are overlooked in analyses at regional scale. The patterns that allow identifying who could be vulnerable or 'at risk' as well as where, why, when and how were more visible and easier to address, at smaller scales. It also contributes to the selection of relevant hazard, vulnerability and risk indicators for monitoring, decision- making and risk reduction plans at local level. These concepts will be further discussed in the following sections of this chapter, and the application to the study area in the next chapters.

Table 3.1: Conceptual and logical components for flood risk spatial modelling

Components of the conceptual model for flood risk assessment		**Logical model: Elements and indicators used to spatially represent the conceptual model**	
Geo-Hazard	Flood	Water depth Duration Velocity	-Group/individual experiences about past events -Hydrological modelling
Vulnerability	*Exposure*	Location	-Surface elevation of the terrain -Location in relation to nearby elevated areas -Location in relation to elements susceptible to strong winds (antennas, large/robust trees, advertisement boards)
		Quality of the Built environment	-Building Types -Development level
		Quality of the Natural environment	-Waste management -Presence and origin of stagnated waters
	Capacity levels	Socioeconomic status	-Household composition -Occupations (type of activity, location) -Number of working people -Dependency ratio -Access to basic services (health, education, water, sanitation) -Access to resources during 'normal' times (land, goods and savings) -Access to resources during 'crisis' times (warnings, evacuation, relief)
	Coping	mechanisms for risk management according to daily life aspects	-Coping mechanism before, during and after flooding related to: housing, livelihood, food, health, sanitation, safety of belongings, mobilisation and overall safety.
Risk		Past, present and future scenarios for flood events with different return period	- Flood scenarios for different events - Vulnerability of the elements under analysis - Implementation of socioeconomic development scenarios

3.4 General overview of the methodology of this study

The approach for data collection is a combination of geo-spatial technologies, remote sensing techniques, hydrological modelling, analysis of institutional setting and actors (regarding flood management) and participatory approaches for data gathering and analysis (about hazard assessment, elements at risk, vulnerability and risk reduction). The methodology to achieve the research objectives is illustrated in Figure 3.3 and consists of the following components:

- **Exploratory Scoping:** This exploratory visit constituted the first approach to the study area. Activities such as workshops and meetings with local actors, exploratory local visits and collection of secondary data contributed to initially depict the situation at hand. In addition this initial step provided an overview of the flood situation and context, key persons and organisations, nature and importance of the relationships inside the community, policies and legislation among others.

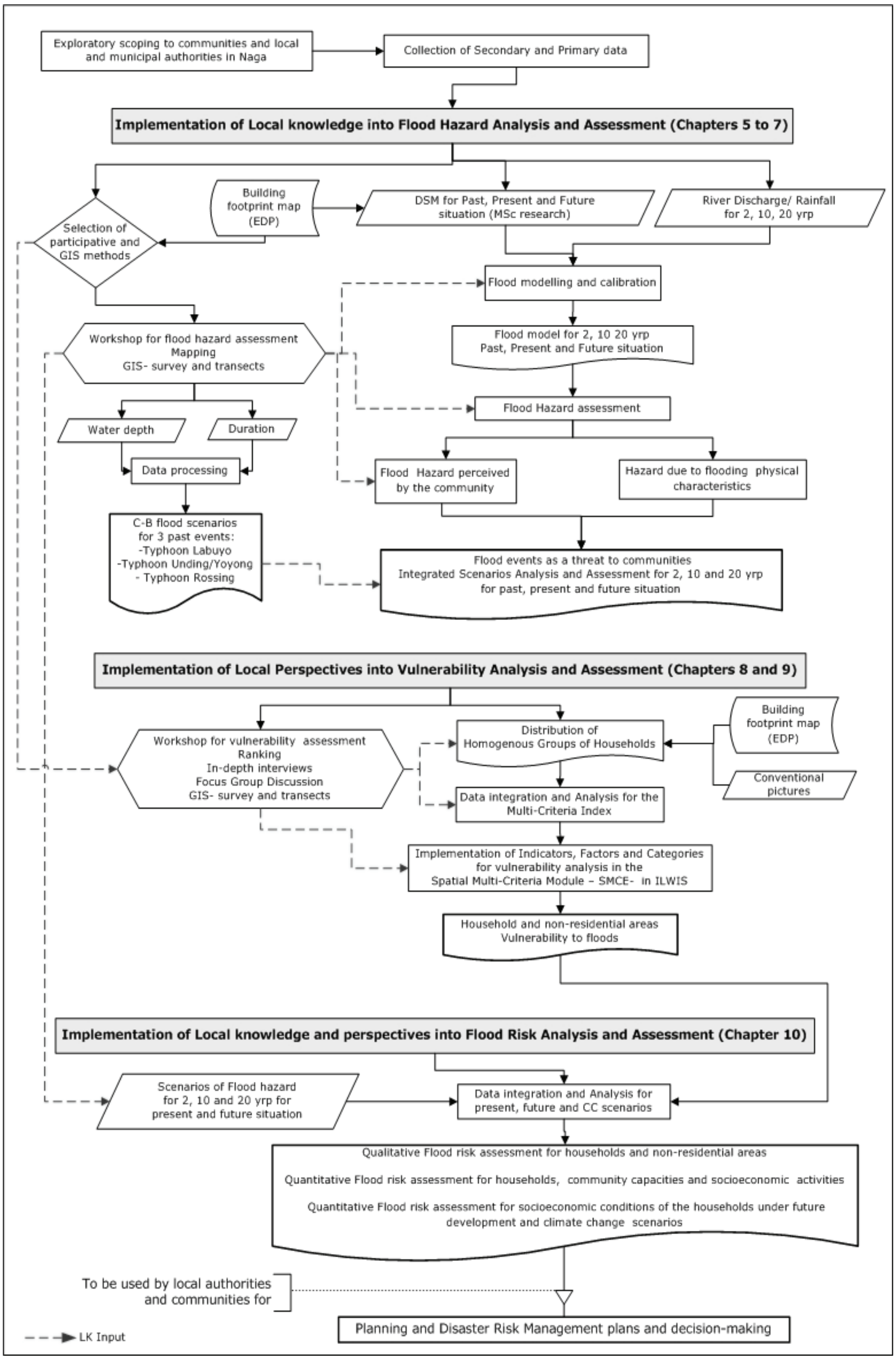


Figure 3.3: Conceptual and methodological framework for implementing local knowledge into flood risk assessment.

- **Application of tools for eliciting the local knowledge and perceptions:** During the fieldwork stages a number of participatory techniques and tools were used for bringing out, understanding and learning the point of view of the local communities regarding flood risk issues. Some of these methods were fused with the use of GIS, e.g. individual in-depth interviews; joint GIS-assisted transect walks, field mapping and a GIS-assisted household survey.

- **Analysis of local community risk-related knowledge and perceptions:** The local knowledge and perceptions found were analysed in order to implement the notions of flood hazard, vulnerability, mechanisms for coping and risk (found as tacit elements in the community's perceptions of threat) in risk assessment.

- **Flood modelling approach:** The community perception of the flood threat in terms of water depth and flood duration was used as input into hydrodynamic modelling, using the SOBEK hydrodynamic software. Parameters for the flood modelling consist of a digital surface model for the study area, surface roughness data, and boundary conditions. Three flood scenarios with return periods of 2, 10 and 20 years were modelled for past, present and future development situations, in which the effects of elevated areas on the overall flood hazard were analysed.

- **Vulnerability analysis and assessment:** Various aspects that determine the spatial vulnerability patterns found in the two barangays were analysed based on the results of participatory exercises. Factors that were taken into account are related to occupation, livelihood means, housing (type), land ownership, education, health status, environmental quality (sanitation, waste management and presence of stagnated waters), access to drinking water, access to services and development-related infrastructure (drainage, public transport, roads), and availability of assistance during crisis times (warnings, relief, evacuation centres). These factors were integrated using Spatial Multi Criteria Evaluation, in which the priorities of the factors were derived from the local communities.

- **Risk assessment:** The vulnerability information was then combined with the hazard scenarios using both qualitative and quantitative risk assessment, for the various flood scenarios. The qualitative risk assessment used a matrix approach in order to combine the community derived vulnerability index values with the hazard classes. Quantitative risk assessment was undertaken in order to derive a number of indicators, which can be directly linked to disaster risk reduction programmes. Financial losses as result of successive flooding, number of people that would fall below the food and poverty threshold, the number of people requiring direct food support and shelter, and the number of people without access to drinking water or sanitary facilities were some of them. The risk was also calculated for future scenarios, involving both the development of the area leading to different distributions of flood waters, as well as concurrent flooding resulting from possible climate change.

3.5 Connecting with the Local Government Unit and people in the Barangays

A first stage, meant to serve as exploratory scooping and general fact finding, was performed as the first activity in order to approach the study area. In this period several activities contributed to initially depict the governmental, institutional, managerial and socioeconomic conditions in Naga. Contacts were established with municipal and Barangay officers, the joint programme for the research was determined and secondary data was collected.

3.5.1 Building rapport

The first activities were comprised of both official and informal visits, and the distribution of a simplified project brochure and introductory meetings with municipal officers (Local Government Unit- LGU) in charge of: the Disaster Management Office, Planning and development, City Environment and Natural Resources Office (CENRO), City Health Office (CHO), City Social Welfare and Development Office (CSWDO), Urban Poor Office (UPAO), City Engineer's Office (CEO) and Electronic Data Processing Unit (EDP). These meetings and interviews were meant to build rapport with the municipal authorities, chief officers and employees of the different departments.

Based on these initial activities a selection was made of the wards that would be studied in detail: Triangulo and Mabolo (see Section 4.6). After selecting the two areas considered as most suitable for this research, the next step was officially approaching the local officers in each of the Barangays and presenting them the project as shown in Figure 3.4.

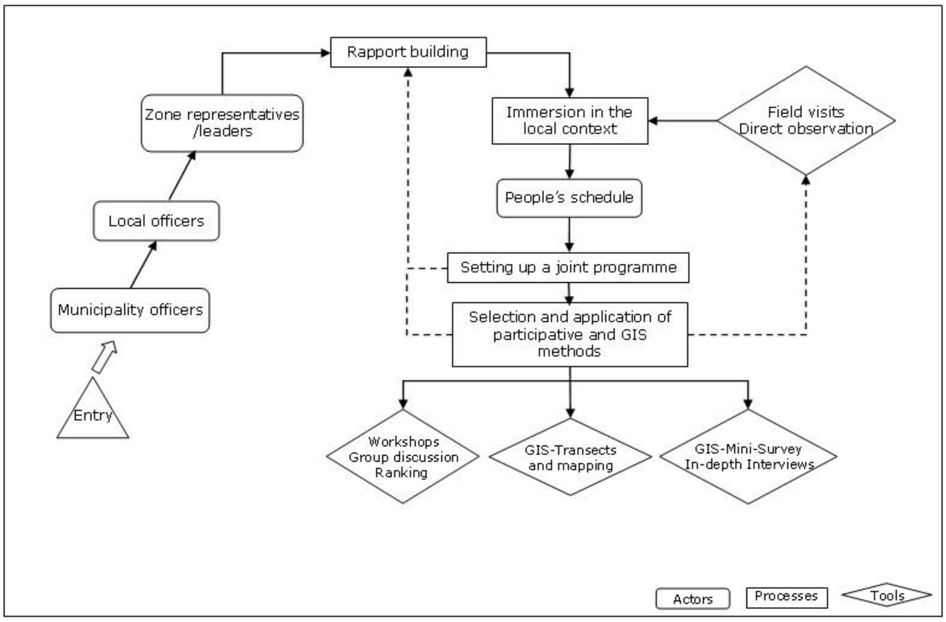


Figure 3.4: Steps and techniques applied during fieldwork for approaching and setting a joint programme with local officers and people in the communities

During this step it was important to clearly talk about the objectives of the study, without creating different expectations. Because of the topic of the project and the foreign origin of both the researcher and the Institute (ITC) some local officers and leaders originally mistook them as belonging to an overseas NGO.

This type of organisations is commonly associated with funds for social issues, infrastructure or other type of disaster relief projects for the ward. After clarifying these aspects and making sure that no false expectations were raised, several meetings were carried out; the aim was to obtain a first approach to the community and the occurrence of floods and their management, from a local point of view.

This initial approach to officers and local people was followed by less formal activities aimed to create empathy with them and the community. Building rapport as one of the initial steps is strongly advised by community-based approaches pertaining to disaster risk management; in this research this stage was performed by means of informal visits to key actors within the community, transect walks with local officers and informal chats with lay people.

The main objective of this activity is to build a relationship and create trust with the locals. In this stage flood-related facts were collected by asking open questions and allowing Barangay inhabitants, from all zones, to freely express their opinions not just on the subject matter but on any other issue of significance for them. This first immersion was also important for the researcher as it provided a richer picture and understanding of the community in terms of their cultural, social, political and economic context.

3.5.2 Collecting the secondary data

During the initial stage a considerable amount of time was also spent on the collection and compilation of secondary data. The information that was initially collected was represented among others by:

- Comprehensive Land Use Plan (CLUP).
- Statistical Profile (2000).
- Naga City Disaster Mitigation Plan (carried out by ADPC, 2001).
- Protocol and guidelines used by the city government on its disaster management programme.
- Naga City Counter Disaster Plan.
- Emergency Rescue Naga Guide.

One of the major obstacles in this research was to obtain adequate high resolution imagery. These products were meant to generate or update the building footprint map of the study area, which would serve as the key spatial layer, to which most of the other types of data would be linked. Unfortunately, it was not possible to obtain high resolution satellite data, owing to the frequent cloud cover of the area. Also no adequate aerial photographs could be obtained so that an orhophoto could be generated. Eventually it was possible to acquire a 2m resolution KVR (Russian) image taken in 1991, which was used for digitising the building footprint map, which was later updated through fieldwork.

Some of the spatial data obtained as inputs during the process of flood risk assessment, part of which were provided by the EDP office, included:

- Topographic data (elevation contour line, land use, soil types, land cover, hydrographical maps).
- Administrative data (political and jurisdictional boundaries)
- Infrastructure data (buildings, road network, utilities, bridges, properties, facilities, hydraulic or engineering structures).
- Hydrometeorological data (historic flood maps, flood discharge, tidal data etc.).
- Socioeconomic data (census, socioeconomic levels distribution, public services coverage etc.).
- Natural features (mainly rivers and creeks).

3.5.3 Defining a joint programme

After obtaining the commitment of the Barangay officers, zone leaders and several key persons as well as grassroots people from the community, a joint schedule was developed and agreed upon for each Barangay (see the example for Mabolo ward in Box 3.1).

The programme was described in simple (rather than technical) terms; it included a variety of methods and activities to be performed together with the Barangay officers and/or leaders (depending on their availability). It also integrated group activities to be performed with the community, or individually by the researcher such as the GIS-survey and in-depth interviews.

While designing the programme it was important to take into consideration that most activities, especially the outdoor ones, required the participants to devote a considerable amount of time from their normal activities. The programme therefore had to be flexible and adjusted according to their availability. As aforementioned some activities were carried out indoors such as workshops, focus groups discussion; and some outdoors (transects, mapping). Outdoor activities such as transects were carried out in a group while some of the others where performed solely by the researcher with support of an assistant (translator).

The interviews and mini-surveys where carried out without the presence of Barangay or LGU officers. In the wards many people have close connections with them and hence the researcher did not want to take the risk that their presence might bias the opinion of the interviewee or inhibit him/her to freely speak. Finally the use of individual interviews and activities were aimed also to confront and validate the knowledge gathered and produced during the group activities, in particular those with the Barangay officers.

Box 3.1 work plan proposal for flood risk assessment designed togheter with ward officers, zone and community leaders in Barangay Mabolo
STEP 1. •Objective: - Identify the threat that floods and typhoons represent for Barangay Mabolo community. •Methods: - Workshop for Hazard identification and discussion (with emphasis on typhoon, flooding and environmental threats). •Expected output: Description of the floods and typhoons that have affected the community. During this activity we will try to identify in which period inundations happen, the areas they affect, type of warnings received by the community, from whom, and the experiences of the participants with past episodes. •Duration: 1 day
STEP 2. •Objective: - Spatially locate primary and secondary threats associated with floods and typhoons •Methods: - Transecting and Mapping together with ward officers or zone leaders (according to their availability) •Expected output: - Digital maps of primary and secondary threats associated with floods and strong winds (i.e. areas with deepest and long-standing floodwaters, location of antennas, advertisement boards, open sewage system, organic threats (waste dumping areas, piggeries etc.) •Duration: 1 day per zone approximately
STEP 3. •Objective: - Describing the history and evolution of the community. - Methods: - workshop with emphasis on the grounds for positive and negative changes in social, economic, physical and environmental aspects within the Barangay •Expected output: -historical profile of the communities and Barangay development •Duration: 1 Saturday afternoon (owing to the availability of community participants)
STEP 4. •Objective: - Spatial location of people that was severely affected by Typhoon Unding-Yoyong •Methods: Survey and interviews to households. This activity will be performed in two stages: in the first one the people affected by the last typhoon will be located and spatially geo-referenced with the assistance of ward officers and zone leaders. The second stage comprises the interviews which will be made only by the researcher and her assistant. •Expected output: -Digital maps that show the location of families that were severely and moderately affected; houses that were destroyed and other damages caused by the last typhoon. - Digital maps of households interviewed - Digital records of water depth and duration reported by the households •Duration: stage 1: 1 /2 day per zone; stage 2: 1 to 2 weeks
STEP 5. •Objective: In the context of Barangay Mabolo, identify: a) how weather and floods affect the daily life of the people in the Barangay b) identify which people are more affected by floods and typhoons, c) what makes them more susceptible to be affected and d) what helps or hampers their faster recovery when a flood or typhoon hits the area. •Methods: Workshop September 3 •Expected output: Analysis of factors that contribute to make people more or less affected when a flood or typhoon strikes. Identify the means people in the Barangay have to counteract the effects of floods and typhoons and which are the more felt needs when an event of this type takes place. •Duration: 2 Saturday afternoons (owing to the availability of the participants)

3.6 Tools for eliciting community risk related knowledge and perceptions

The cornerstone of this research is what is being named as 'local (flood) risk related knowledge', referring to the empirical tacit knowledge that communities have developed by living in a flood-prone environment for some time, experiencing threatening events and performing strategies to cope and deal with the risk they represent to their everyday life.

The process of identifying, collecting and corroborating community's knowledge and perceptions on flooding was made through the intensive use of several participatory or community-based tools often combined with mobile and standard GIS. The selection of methods was also done in compliance with the scale of analysis and level of interaction required.

At individual and household level the knowledge aimed to be captured was related with:

a) Flood events experienced in terms of type, magnitude, duration, date.
b) Outcome of every flood scenario by considering physical, economic and social aspects of the family.
c) Practices developed to 'manage' the flood/typhoon risk during 'normal' and 'crisis times'.
d) Use of resources available at Barangay and municipal level to 'manage' the flood/typhoon risk.
e) 'Manageability' of these events by making use of household' own resources.
f) Influence of weather conditions, hydrological cycles and flood related issues in their life style.

Collective knowledge, understood as the knowledge that the group of people living in a given Barangay have developed, was related to:

g) Historical records of events striking the ward (see step 3 in Box 3.1)
h) Characterisation of the events triggering flooding in the Barangay in terms of type, origin (natural or man-made), magnitude, recurrence etc.
i) Spatial and temporal distribution of every flood scenario and the hazard posed by those events.
j) Impact, at ward level, from the occurrence of flood events by considering physical, economic and social aspects of the community as such.
k) Profile of the families more affected and those for which recovery takes more time.
l) Practices developed to to 'manage' the flood/typhoon risk during 'normal' and crisis 'times' as a community.
m) Use of resources available at Barangay and municipal level to 'manage' the flood/typhoon risk.
n) Manageability of these events by making use of the wards' own resources.

3.6.1 Linking participation and GIS

The selection and application of the tools, whether purely community-based or combined with the use of GIS, was based on their possibilities for helping the researcher to create opportunities for interacting and discussing with Municipal and Barangay authorities, local people and among the members of the community themselves. More than 'extracting' data and information from the participants, the application of these tools allowed the actors to listen to each other, learn, share, corroborate and argue about the responses or comment to issues that were under scrutiny. On the other hand, in the absence of conventional data and information for risk assessment at this very local level the tools also allowed the collation and generation of primary spatial and non-spatial data on risk issues.

According to their suitability for achieving the above mentioned aims the implemented methods could be divided into:

a) Tools to generate discussion and debate around social, economic and management issues while at the same time generating qualitative information from key persons and community members (e.g. interviews, focus group discussions).
b) Tools to generate exchange of knowledge and experiences and directly and indirectly collect information that could contain spatial components as workshops which included mapping, reconstruction of events, physical descriptions, ranking etc.
c) Tools for eliciting knowledge and experiences which have a strong spatial component and that assist in the generation of quantitative and qualitative information; the data so collected was directly used as inputs for the spatial analysis by means of a mobile GIS (e.g. direct observation, transects, and geo-referenced surveys and interviews).

In the following section a number of these tools are explained further.

3.6.2 Individual in-depth interviews

All through the fieldwork period in-depth interviews and informal conversations were conducted with key persons at municipal and Barangay level. According to its character the interviews can be divided in two sets: formal and informal ones. The first set consisted of twenty formal interviews with key persons (municipal and local officers, representatives of national institutions at municipal level, local Catholic priests, midwives, Barangay security officers and the Barangay waste management commissioner) conducted with a previous appointment and a fixed array of topics (i.e. main differences in their activities during 'normal' and 'crisis' times, their personal and institutional role in emergency management, personal use of (geo)-information for the performance of their task). These semi-structured interviews were guided by a set of questions; however, they were conducted in a semi-open format to allow the interviewee to talk freely about the issues. The second set of interviews was more informal and open and was carried out at community level. These included interviewing nearly every one of the residents whose houses were reported as 'destroyed' or 'heavily damaged' by the typhoons from November 2004 (Unding & Yoyong); but also residents located in different topographic levels and belonging to different socioeconomic groups within the Barangay (see Figure 3.5). This set is comprised of around twenty interviews for each Barangay.

Figure 3.5: Open Interview with a household whose house was destroyed by a typhoon (left) and Focus Group Discussion on flood vulnerability with Barangay officers at Mabolo.

During fieldwork the interviewing activity provided an insight on the cohesion, consistency and heterogeneity of the knowledge found among groups and individuals at different administrative and community levels.

3.6.3 Focus group discussions- FGD

Focus Group discussions were conducted mainly with local authorities at municipal and Barangay level (see Figure 3.5). This activity allowed the researcher to contrast the knowledge, experiences and perceptions of two groups of actors which have to deal with risk-related issues from a different perspective. Local (Barangay) authorities develop their knowledge because of the direct confrontation with the hazardous event itself in their own homes and area under jurisdiction; the local government unit (LGU) officers and other authorities at municipal level instead live in flood-free or more developed areas, which are not so severely threatened when a flood or typhoon strikes. In the aftermath therefore their task consists of mainly providing assistance and taking decisions for managing the situation in the worst affected areas.

At municipal level two gatherings were held with the presence of the mayor and representatives from the units that play a role in disaster management and digital information management. The occurrence of the typhoons from 2004 was used as basis for discussing the municipal strategies and criteria for flood/typhoon risk disaster management, the role played by national organisations, and the activities and roles of the different offices of the Local Government Unit (LGU). Also the role of information in disaster risk management with emphasis on geo-spatial issues was discussed as well as the information management strategies during 'normal' and 'crisis' times.

The same topics were discussed at ward level. The group discussions with local (Baragay) officers also included specific issues such as perception of safety from the natural and built environment, characterisation and spatial distribution of socioeconomic groups of households found in the Barangay, procedures for the damage assessment carried out by them after events and so forth (see Figure 3.5).

3.6.4 Field Workshops

Three participatory workshops were held in each Barangay during the two fieldwork stages (see Box 3.1). They were conducted as introductory activities to other community members (different from Barangays officers) and as a way to have an overview of the flood risk related knowledge and perceptions existing among different members of the community. Every workshop had between ten to fifteen individuals (apart from the local Barangay officers), with a fair mixture of men and women, many of whom have been living in the Barangay for more than twenty years (see Figure 3.6).

Figure 3.6: Simulation of flood water raise (left) and mapping activities (right) performed by the participants and the researcher during the workshops carried out in both wards.

Each workshop lasted approximately four hours, and was programmed in such a way that people were involved in activities most of the time. This also helped to avoid endless discussions and the prevalence of dominating personalities and personality 'noise' that often accompanies round table discussions (IFRC, 1996).

The tools used during the workshops helped to focus on three topics: hazard identification and analysis, factors contributing to vulnerability and coping mechanisms and 'manageability' strategies at household and ward level. These workshops were considered important as they allowed for interaction with local communities; besides obtaining a wide range of opinions and information particularly when little data is available (as was the case in the two Barangays). The workshops were aimed to elicit and collect the tacit flood and risk related knowledge that individuals may have and that otherwise is not easy to retrieve. The participants are often not aware of their own acquaintance of these facts, and therefore in these cases the researcher acted as the catalyser who elicits and systematise such knowledge according to issues under scrutiny for instance differentiating between aspects that are related to the flood threat, or concerned with vulnerabilities, coping mechanism, behaviour, warning systems and the like. After finishing one of the first workshops in Barangay Mabolo one of the participants expressed with amazement:

'I was not aware how much we knew about the flooding problem in our Barangay'

Workshops gave people the opportunity to interact as part of a community and therefore expose, compare and agree with the knowledge and perceptions of other community members. The format for one of the workshops on flood and typhoon hazard identification is provided in Box 3.2.

Box 3.2 Flood and typhoon hazard identification workshop, Triangulo	
Activity 1. (15 minutes)	**Ice breaker**. Informal welcome to the participants. Includes person to person presentation of the PhD and MSc students with souvenir from Holland
Activity 2. (20 minutes)	**Introductions**. Participants (community members, Barangay officers and researchers) introduce themselves. The project is briefly presented, aims and activities are explained.
Activity 3. (30 minutes)	**Living in the Barangay**. Few people (3) among the participants briefly tell their experiences about how is like living in the Barangay both in 'normal' times and when the wet and typhoon season approaches
Activity 4. (40 minutes)	**Consensus panel and hazard ranking**. Grouped by zones participants discuss and identify which are the flood events that take place in the zones in which they live. A general profile for the occurrence of these events is developed for all zones and the whole Barangay. These events are ranked accorded to the hazard those events represent for the community.
Activity 5. (45 minutes)	**Map drawing**. A large map of the Barangay was drawn on paper. Features such as rivers, landmarks, infrastructure were located as well as low-lying areas, entrance route for floodwaters, areas prone to be flooded, areas prone to stagnating waters etc.
Activity 6. (15 minutes)	**Social Break**. Refreshments were offered to the participants. The 'foreigners' talk about their experiences with 'Philippine' cuisine delicacies.
Activity 7. (45 minutes)	**Simulation performance**. Flooding at several stages (ankle, knee, waist, chest, above chest depth) is simulated in order to elicit people's perception and behaviour. During this exercise information about damages and negative (and positive) effects of the flood scenarios identified was discussed.
Activity 8. (30 minutes)	**Review and closing of the session**. Conclusions about the flood risk situation in the Barangay were drawn. Feedback about the exercise and activities carried out was also formulated.

3.6.5 Joint GIS-assisted transect walks

A series of walking sessions together with local people were carried out through all zones of the Barangays and along all main access and pathways. They were aimed to identify, and discuss different environmental issues and factors contributing to the vulnerability to floods and typhoons present in every Barangay. These joint transects were carried out mainly in the company of local Barangay authorities. Barangay officers, by mandate, are designated to '*maintain the public order, protect and secure life and property, and maintain a desirable and balanced environment*' (Philippines Local Government Code, 1991). At Barangay level they are responsible for, among others, disaster management and implementation of environmental municipal programmes (e.g. waste management).

During these walkover studies the Barangay officers demonstrated deep knowledge of the situation in their zones and the Barangay in general. Narratives about how the different zones have been developed through time, patterns of settlement, changes in landuse and landscape and their implications were discussed during these walks (see Figure 3.7). It was also an opportunity to talk to them about the evolution of flood risk over time and the damage and havoc caused by super typhoons hitting the area.

The Barangay officers were very much able to assess most of the economic, social and physical root causes for disasters in their own zones and the Barangay. However linkages with secondary sources of threat (i.e. danger represented by advertisement boards during strong winds), unhealthy practices (piggeries) or indirect effects of flooding were less straightforward to identify for them. In these cases the researcher acted as a source of information and could take advantage of the opportunity to raise awareness about such issues. During these transect walks local people approached the group frequently to talk and express their concerns, for example about clogged drainages, hanging wires, waste management and the like.

While carrying out these walks a hand-held PC with GIS software (ArcPad®) was used in order to gather spatial information. This tool became supportive as it allowed the researcher to display feature layers (i.e. road network, old creeks, buildings) and facilitated the 'on site' discussion and analysis of environmental issues. After the transect walk the data collected (by means of the mobile GIS) was converted into GIS maps. These maps were used later on, during workshops and FGD activities, for further discussion of the problems addressed while transecting. At the same time the GIS-based transects were used to complement and corroborate indirect mapping carried out by means of indoors activities.

3.6.6 Joint GIS-assisted field mapping

The joint direct mapping procedure was aimed at updating and complementing the various digital thematic features obtained from the municipality (building footprint, road network and Barangay zones boundary). This information was integrated with the data acquired while transecting with the local officers and other Barangay representatives (see Figure 3.7). The main objective of this joint mapping activity was to collect environmental and hazard related-information (with a spatial component) together with the participants. This activity was also performed in order to get an understanding about how people perceive their area and some of the problems arising from floods and typhoons, from a spatial perspective. Being able to discuss why some effects of natural events and man-made interventions take place in specific areas within the Barangay, gave the participants (including the researcher) the chance to deepen the understanding of root causes and consequences of the flooding problematic.

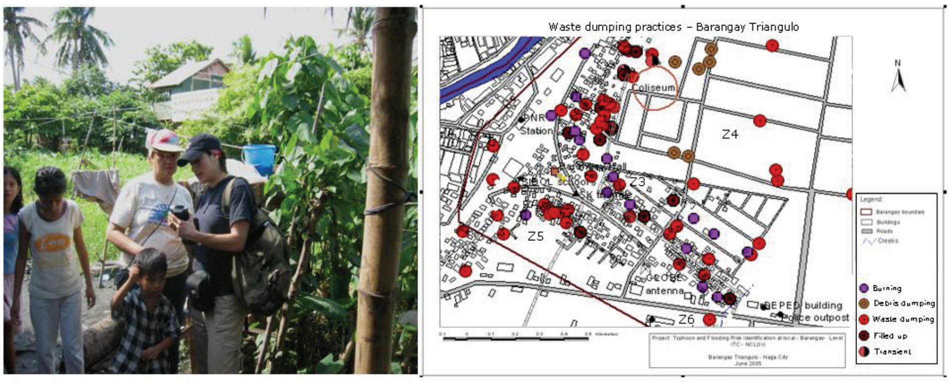


Figure 3.7: GIS-based transects carried out with ward officers (left) and output of GIS-direct mapping for waste dumping practices in Triangulo (right).

First a 'landmark' map of the Barangays was made, containing the most important reference points of the area. This map was explicitly requested by the local officers and displays landscape features used by the community as reference points. Most of these features are not present in the existing official cartography managed at municipal level. While working at a very detailed scale, they became important as they assisted both the community as well as the researcher to spatially contextualise further discussions.

Direct maps were also generated in areas where, according to the local officers and community members, flood duration and depth has increased as result of new developments and terrain elevation and modification. Waste dumping practices, presence of natural and stagnated waters, and available facilities (water sources, public sanitary services) were also mapped by this procedure as shown in the right graph in Figure 3.7.

3.6.7 GIS-assisted household survey

A detailed survey was carried out in both wards using a pre-designed questionnaire on a home to home basis (see Appendix 3.A). The analysis of conditions at household level was based on the Household Livelihood Security Assessment (HLSA) method proposed by CARE (2002). In this approach the livelihood security is defined by the access to income and resources to meet basic needs including adequate access to food, potable water, health facilities, educational opportunities, housing, and time for community participation and social integration. The survey was carried out in two stages and made use of a combination of random and stratified sampling. During the first stage, a probability-based random sampling was carried out in order to obtain a non-biased insight into the diversity of conditions present in the zone, and acquire quantitative information that supports further statistical analysis and comparison. The results of the sampling also helped to reveal spatial relationships between risk factors (hazard, vulnerability, coping mechanism and overall risk) for their analysis.

The questionnaire used in this stage was divided in two main sections (see Appendix 3.A). The first section was aimed to characterise the households' socioeconomic aspects as well as the physical and structural elements in their residences and the environmental quality of the surroundings. The second section consisted of a list of questions aimed to elicit the experiences, perceptions and coping strategies developed by the family unit to deal with the occurrence of floods and typhoons.

The random sampling was carried out based on the list of residents per zone provided by the Barangay office. From this list a random sample of 140 households in Triangulo and 121 in Mabolo equivalent to the 10% of the households registered in the Barangay was taken. This sample size provided a margin of error 0.3 which is considered acceptable for social and educational research (Bartlett et al., 2001). The sample was distributed according to the number of families registered per zone (see Table 3.2).

Table 3.2: Distribution of sample size for the random GIS-assisted survey

	Barangay Triangulo		**Barangay Mabolo**	
	Nr Households	Sample size	Nr Households	Sample size
Zone 1	185	19	140	14
Zone 2	120	13	196	19
Zone 3	296	30	315	31
Zone 4	265	27	210	21
Zone 5	137	21	204	20
Zone 6	321	34	161	16
Zone 7	155	15	-	-
Total	**1479**	**149**	**1226**	**121**

Afterwards the family was visited and, if agreed, one or several of the members could contribute to the interview. In cases where the head or other adult member of the household was not present, not able or willing to allocate time for the interview another name was randomly selected from the list. The total sample was composed of 270 households, according to the data on Table 3.2. Approximately one quarter of the survey (60 interviews) was carried out during the first fieldwork stage of this research (August - September, 2004) with the assistance of two MSc students from the ITC. Their research *Economic, social and structural aspects of Flood Vulnerability* (Monrroy Prado, 2005) and *Analysis of Community's Coping Mechanisms in Relation to Floods* (Palmino-Reganit, 2005) also carried out in the framework of the SLARIM project provided valuable inputs for this study.

The survey was finished in the second fieldwork stage (May-November 2005) and was complemented with a purposive (stratified) sampling. In stratified sampling the population under research is divided into classes or strata and then a simple random sample is selected for each. As mentioned above, this technique is often performed as a complement to more probabilistic-based surveys. This method has also proven useful in urban areas where the poor are sometimes mixed with better-off households within neighbourhoods (CARE, 2002). In this case the survey was performed based on the characterisation of the socioeconomic groups observed in every Barangay. This more oriented survey included for instance people belonging to specific occupations and groups such as beneficiaries of urban poor housing programmes (e.g. the *Gawad Kalinga*) in Triangulo and small farmers and fishermen in Barangay Mabolo.

During the survey, the existing building footprint map was used as background layer in the mobile GIS for the geo-referencing of the residences. Later on the information collected was downloaded and handled using ILWIS software. The data coming from the survey as well as the inputs from workshops and FGD were used to support the up-scaling of the vulnerability analysis from household to 'homogenous units' of families at ward level as described in Chapter 9 of this study.

3.6.8 Training course and MSc research

During the research period a training course was also organised in Naga in order to support the research. From 23 August to 3 September 2004 a course was organised in Naga, entitled '*Urban Flood Mitigation'* (UFM). The course was jointly organised by the International Institute for Geo-information Science and Earth Observations (ITC) The Netherlands, the Asian Institute of Technology (AIT), the Asian Disaster Preparedness Centre (ADPC) Thailand and the Municipality of Naga. The objective of the course was to give the participants, which included several officers of the Local Government Unit, overviews of the geo-information tools that can be used to mitigate the impact of floods. It combined the application of state of the art hydrological and hydraulic simulation software (HEC-HMS, HEC-RAS and SOBEK) with Geographic Information Systems (ILWIS). Special emphasis was put on mapping vulnerability of buildings, transportation lifelines and people using new Remote Sensing data (high resolution imagery) and mobile GIS (ArcGIS) combined with a Global Positioning System (GPS). A three-day workshop was given on *GIS-based Decision Support for Urban Flood Management* in which the appropriateness of advanced technologies like GIS and flood modelling for decision-making was discussed with local experts and officers.

In the weeks after the course, a fieldwork was carried out with four MSc students to collect data for detailed flood hazard and impact assessment and to identify coping mechanisms when floods occur. In 2005 two other MSc students carried out their research in close collaboration with the municipality of Naga as part of the ITC's SLARIM (Strengthening Local Authorities in Risk Management) research project. From these researches the most significant, for this study, was the one on *Digital Surface Model (DSM) Construction and Flood Hazard Simulation for Development Plans in Naga City, Philippines* by Abdul Rahman (2006). In this study emphasis was given to the mapping of recently elevated areas and the measurement of surface topography with theodolites. The updating of elevated areas was carried out in collaboration with officers of the City Engineers Office (CEO). Thus, by using their equipment and staff, the idea was to improve their capacity to acquire this type of information and keep updated the topography of the city in the GIS available at the Local Government Unit by themselves. Having an updated terrain model was deemed important in this study as all these new developments change the topography by elevating the ground, increasing the impervious areas and shifting the flood problem to neighbouring low lying areas.

A summary of the tools used to elicit the local knowledge related to floods as well as the outputs generated are presented in Table 3.3.

Table 3.3: Summary of participatory and GIS tools applied and main outputs

Activity	Target group	Objective	Output
Workshop	Open invitation to local officers, zone leaders, key informants and other community members	Identify the threat that floods and typhoons represent for the people in the community	-Historical profile of the floods and typhoons that have affected the community. -Perceptions of the threats posed by flooding and their characterisation. -Timing and periodicity of different flood types. -Community mapping of affected areas. -Warnings mechanisms available to the community.
		Identify aspects contributing to the vulnerability of the families	-Factors that contribute to make people susceptible to be badly affected when a flood or typhoon hits Naga.
		Indentify the coping mechanism performed by the households during different flood types and stages	-Strategies performed by households before, during and after floods according to daily life aspects such as: Housing, income, food intake, access to facilities, health and sanitation, safety of properties, mobilisation and overall safety.
Focus Group Discussion	Barangay officers and zone leaders	Reconstructing the occurrence of a flood or typhoon event	-Analysis on how the mechanisms and elements available at municipal and ward level are used once a typhoon or flood strikes the wards. -Identification of concrete measures to prevent or reduce the negative effects of floods and typhoons based on the resources or programmes at hand (Barangay, municipality).
GIS-assisted Transects	Barangay officers and zone leaders	-Mapping of development-induced changes in flood behaviour. -Mapping of secondary threats associated with floods and typhoons	-Identification of hazard and vulnerability issues across the Barangays. -Reconstruction of the main urban expansion processes in the ward. -Digital map of areas with environmental problems (stagnated waters, inadequate waste management practices).
		Identification of potential negative effects of floods on community services and critical facilities	-spatial localtion of roads, bridges, drainage system, facilities in reference to flood levels and duration
GIS-assisted survey	Households	Identify hazard, vulnerability and coping issues at family level	-Inventory of life style aspects per family. -Disruption and losses experienced as result of past floods. -Evolution of flood risk in their surroundings through time. -Management of environmental and sanitary aspects at family level.
		Identification of specific flood events that have hit the Barangay and affected them	-Water depth and duration of three particular floods that most of the people were able to recall.

3.7 Linking Local knowledge and spatial modelling

As mentioned throughout this chapter, one of the main objectives of this research is related with the possibility to convert people's perceptions and experiences into inputs for risk assessment; therefore this too includes the spatial modelling stage. Introducing communities' points of view of their risk 'reality' to the GIS-based spatial analysis required the joint learning approach implemented in this research made emphasis on the following aspects: a) creating opportunities for introducing at-risk peoples' perspective into risk modelling design b) converting the knowledge and perceptions of at-risk people in valid inputs for the modelling process and c) giving equal, or even more, emphasis on the aspects of spatial modelling that will contribute to portraying and enhancing the understanding of the people's problems rather than on the technology or data acquisition itself.

The process of creating a spatial representation of the several aspects of local knowledge related to flooding and typhoon risk found was achieved through Longley's et al. (2005) four levels of simplification (abstraction) presented in Figure 3.8, as follows:

1. The first level or *reality* corresponds to flood and typhoon occurrence and their interaction with communities as the real world phenomena under scrutiny (see Figure 3.1). The aspects to be considered for representing this particular phenomenon are mainly defined from the perception and experiences that communities have; however it also includes the aspects that, from the researcher point of view, should become part of the analysis (i.e. secondary threats). When these aspects were not present or had a different expression in peoples' perspective (i.e. waste management, building safety) they were brought in and included as part of the discussions and analysis by making use of the participatory methods described previously.
2. The second level is the *conceptual model* in which the components of Flood Risk: Hazard, Vulnerability and Coping capacities (adapted from Pelling, 2003) are structured and represented. This level takes the knowledge, experiences and perceptions that communities settled in the study area have as starting point (see Section 2.3). This conceptual model (second level) or computer-independent representation was refined after the first fieldwork stage; as the participatory work done together with the communities and local authorities allowed the researcher to have a more contextualised insight into the risk-related conditions of the area.
3. The third level or *logical model* constitutes the spatially-oriented implementation of the conceptual model in terms of geo-information (see Table 3.1). The implementation of this logical model was done in three steps: first the elements, relationships or processes required to represent the elements of the conceptual model were elicited through the learning-based approach; secondly most of the data about the phenomena under analysis (flood risk in this case), was collected and analysed 'on-site' together with the participants.

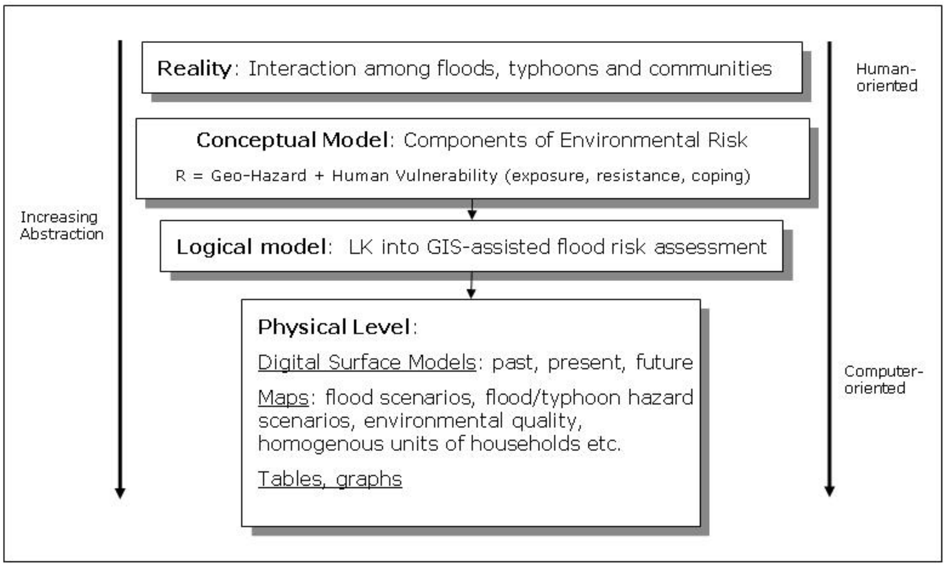


Figure 3.8: Levels of spatial representation of flood risk from communities' point of view (adapted for this research from Longley's et al., 2005).

Finally the third step related to data processing and spatial modelling was undertaken directly by the researcher in the stages of the research subsequent to the fieldwork. In this respect, it must be highlighted that even if most of the inputs were derived through interaction with the community the way in which the analysis and integration of the locally-derived information is presented in the following chapters are the sole responsibility of the author of this research. However, it should also be mentioned how the use of the analytical possibilities provided by GIS such as data handling, spatial analysis and visualisation (among others) were always oriented and committed towards representing the risk reality from the community's point of view. On the other hand it is important to highlight that while the risk-related dataset supports the spatial implementation of the logical model their creation, collection and analysis was not necessarily restricted to the application of the models (i.e. for hazard and vulnerability spatial modelling)

4. The fourth physical level of representation constitutes the databases and digital files used to represent flood and typhoon risk from the communities' point of view. The database as well as this book became part of the products to be delivered by the SLARIM project to the communities and Municipality of Naga. Analogue copies of most of the maps created directly 'on-site' were also provided to the Barangay office, the local authorities and to those participants which requested them. As will be further explained in the empirical chapters (Chapter 5 to 10) the development of physical and spatial models for each of the components of flood risk (hazard, vulnerability and risk) was undertaken by following the GIS-based procedures considered the more adequate for integrating the local knowledge gathered and representing the risk reality as close to the communities point of view, as possible. The summary of the data used in this level is presented in Appendix 3.B

3.7.1 Flood hazard assessment

Regarding the first component of risk the research aimed at integrating flood extent mapping based on participatory approaches with conventional flood modelling and GIS-based analysis. The first approach to spatial analysis of flood hazard comprised the reconstruction of past events out of the experiences of the community and making use of the data gathered through the GIS-supported survey and interviews. The second method is more related with the use of hydrodynamic modelling using up to date software.

The perceptions of threat derived by means of participatory focus group discussion and analysis were converted in categories of hazard that later on were applied to the spatial outputs of flood distribution, depth and duration. These procedures were meant to demonstrate that GIS-based analysis can assist communities to express and communicate their concerns and perspectives about issues that may directly affect them. On the other hand, it was intended to demonstrate that the use of community derived parameters and perceptions on hazard may help to broaden the general understanding, particularly at municipal administrative levels, on the impact of urban development-related processes which may amplify the hazards that communities are facing already.

As it is further explained in Chapter 4 one of the common strategies for urban development in Naga consists of raising the level of the terrain by dumping earth and land filling. This has been considered one of the most efficient and cost-effective practices for the wealthy and official sectors to avoid or to mitigate the risk of flooding for their private or public investments. The modification of the topography alleviates the flood problem in comparatively small areas but shifts the risk towards other zones and social groups with less resources and capacities to manage the increased threats.

Based on these facts it was decided to evaluate the evolution of flood hazard and risk through time, using various scenarios of topography modification in the study area. However, in order to be able to model and analyse the dynamics in flooding three hazard maps were calculated for the *past* (early 90s), *present* (2005) and *future* (2012) scenarios. For each scenario three flood events were modelled with different return periods (2, 10 and 20-year). This resulted in nine hazard maps which were classified using the community-based criteria of 'manageability' (expressing in which degree the households are able to cope with a given combination of water depth and flood duration). The resulting maps were compared in order to identify areas where changes in flood hazard (i.e. increase or decrease in categories) have taken place.

A flowchart of the flood hazard assessment procedure is provided in Figure 3.9

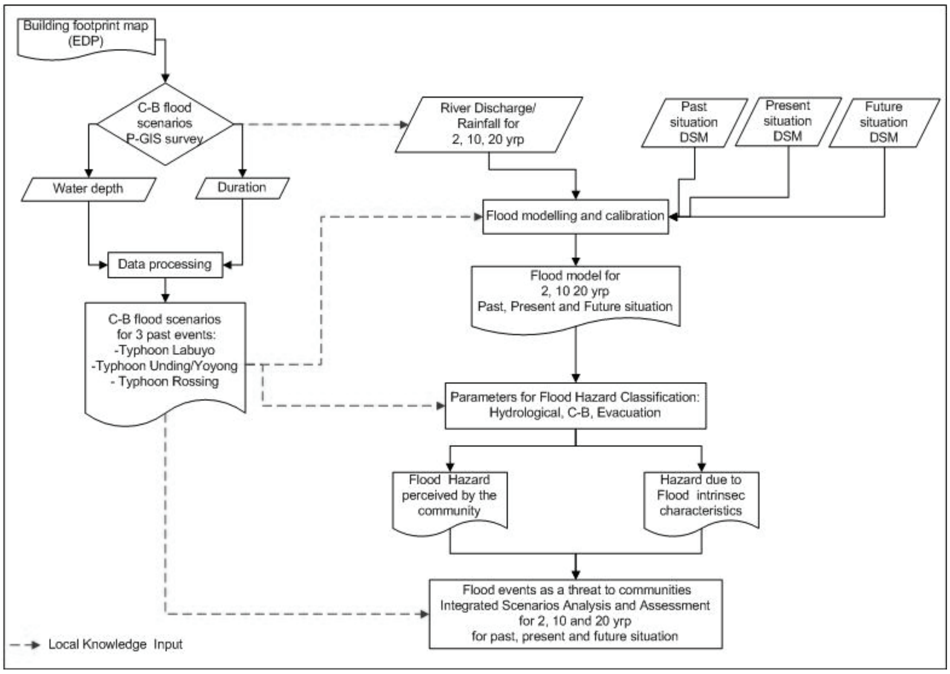


Figure 3.9: Procedure for flood hazard assessment combining local knowledge (LK), community-based (C-B) approaches and hydrodynamic flood modelling.

3.7.2 Flood extent mapping based on local experiences

The combination of participatory tools and mobile GIS, described earlier on in this chapter, formed the basis of the information for the reconstruction of historic flood scenarios. As initially there were limited data available on flooding at Barangay level a process of identification and reconstruction of past events was considered a suitable tool. The combination of these flood scenarios with the parameters used by the communities for hazard identification greatly added to the understanding of the flood threat experienced by them. The initial identification exercises allowed identifying the spatial distribution and behaviour of flooding episodes for every zone within the two wards.

During fieldwork the existence of mental records on the occurrence of the most significant or recently occurred events were found widespread not just among the local officers, leaders or participants in the workshops but also with lay people. In the GIS-assisted survey (described earlier) the flood extent of a number of flood events was recorded, and the areas were outlined that are particularly susceptible to flooding (even by 'normal' rainfall episodes).

The reconstruction of past events is a combined exercise which comprises the elaboration of a map that depicts the spatial distribution of a given event (based on the data collected during the GIS-based survey) but also includes the accounts and direct experiences on the episode from the affected communities. The systematic collection of data allowed the reconstruction of three main events that have occurred in the past, for which consistent and sufficient information was collected from the people's accounts. These are summarised as follows:

a) **Minor flooding event:** This flood scenario is caused by heavy rains and slight riverine overflow produced by 'normal' tropical storms on an annual/biennial cycle. During fieldwork this scenario was directly crosschecked as the researcher was present when the tropical depression Labuyo hit the Bicol region, including Naga, during high tide period from September 19 to 23, 2005.
b) **Moderate flooding event:** This scenario was caused by the combined action of Typhoons Unding and Yoyong that ravaged Naga city from November 19 to December 2, 2004.
c) **Major flooding event:** This scenario occurred during Super-typhoon Rosing (30October - 04 November, 1995) and was always recalled during workshops and interviews as the one causing the highest and long-lasting flooding in Naga.

Reports of the households on the maximum water depth and duration for these specific episodes (both inside and outside the house) were collected by assigning a unique identifier to each interviewee and storing the geo-referenced point in a digital database. The facts provided by the households were validated by crosschecking with characteristics of the terrain, direct observations and correlations with data provided by neighbouring interviewees. After checking that the data sets so obtained had a *Normal* distribution, the coherence among themselves was tested by using Pearson correlation for the reports on water depth and duration of each event in the SPSS® statistical programme. A spatial correlation test was also carried out in GIS ILWIS®. Initially this test helped to determine if the datasets could be used for digitally reconstructing and visualising the flood scenarios equivalent to the specific events. It also helped to determine if the information was consistent enough so that they could be used to validate the equivalent outputs of the hydrodynamic modelling (described in the next section).

The main idea for reconstructing these events was to know (or at least have the most approximate idea) about the extent and spatial distribution of floodwaters for the whole wards during the event and not just point information in the plot of the geo-referenced interview. The collection of information was enough and distributed all across the Barangays therefore the *point interpolation* technique available in GIS ILWIS® was considered as appropriate to carried out this task. This method also known as *gridding* performs an interpolation on randomly distributed point values and return regularly distributed values. In ILWIS the output is a raster map in which each pixel has a value calculated out of the input point values. Several point interpolation methods are available (*Nearest point, moving average, moving surface, trend surface and kriging*). Where each of them have their own advantages and disadvantages related to the nature of the data itself, the spatial distribution and correlation of points. In this case, *Kriging*, a procedure based on the *theory of regionalised variables*, was selected as suitable. The geo-statistical interpolation or kriging interpolation method is similar to a probabilistic interpolation type. The weights are derived from the surrounding sample points and are not only based on the distance, but also on the strength of the overall correlation among the measured points (Maune, 2001). The basic interpolation assumption is that, values at a short distance are more likely to be similar than at a larger distance. The water depth and duration values for each pair is compared and expressed as the variance or covariance. Then, the spatial structure could be analysed through a semi-variance method. In ILWIS this method produces an additional output error map with the standard error of estimates (ITC, 2001). In this way it was possible to quantify the quality of the predictions and output maps shown in Chapter 6.

3.7.3 Hydrodynamic flood modelling

As aforementioned the reconstruction of flood scenarios using the experiences available in the communities was limited to three historic events. One of the limitations of this method is that it basically depends on the events for which people can precisely remember its whereabouts. Owing to the high recurrence of events usually just the most significant in terms of deepest floodwater, longer duration or negative consequences are well remembered plus those occurred in the short or medium term (i.e. less than two years). If, as explained in Chapter 6, the data on these events is not collected in the interim, the memories start to be mixed with new and past evens taking place every year. On the other hand the data coming from past experiences cannot be used to evaluate the effects of future flooding events that may occur particularly in areas where fast urban development can severely modify the morphology of the terrain and the behaviour of flooding. For this purpose hydrological modelling was applied too as part of the flood dynamic and hazard analysis performed in Chapter 7.

From the hydraulic programmes currently available the flood propagation programme SOBEK was used for a hydrodynamic approach to the modelling of floods in the study area. SOBEK is a fully dynamic hydraulic model produced by the WL|Delft Hydraulics; it has a combination of one and two dimensional (1D and 2D) flood models. The 2D flood model in SOBEK was designated to simulate the overland flow on the initially dry land and through complex topography (WL|Delft Hydraulics, 2006). Two-dimensional (2D) flood models require a continuous representation of terrain topography and incorporate a high versatility in providing information related not only with floodwater depth, velocity and spatial distribution but moreover with the variation of flood extent and duration over a user-defined time frame (Alkema et al., 2004). They became popular in flood modelling, especially in a complex topography of floodplain areas (Bishop and Catalano, 2001; Verwey, 2001)

In this research the modelling was undertaken using SOBEK-Rural, a product of the main SOBEK line of hydrodynamic water flow models. Running the model required basically two types of data sets as inputs which are separated into a set with a spatial component and a set of non-spatial data. Spatial data includes a Digital Terrain Model (DTM) or even better, a Digital Surface Model (DSM), which also incorporates objects such as buildings, road embankments and other man-made elements. In order to model the changes in flood behaviour resulting from changes in landscape, three DSM were generated, one representing the topographic situation of the study area in the early 90s, one for the (baseline) situation in 2005 and one for a future situation (defined as year 2012) including artificial elevated areas and some of the planned urban developments according to the Naga City Landuse Plan (CLUP).

The implementation of the model also required a one-dimensional channel network, and a land cover map. In an urban environment, such as part of study area, surface roughness has been defined by vegetation, buildings, embankments, roads, and other major obstacles, that would influence water velocity, speed and the flow direction (Alkema and Middelkoop, 2005), transformed into Manning surface roughness coefficients (Bishop and Catalano, 2001). Boundary conditions are also required, such as the river discharge in the various channel segments that enter the study area, and water levels related to tides in the Bicol bay area. An overview of the model input is given in Figure 3.10.

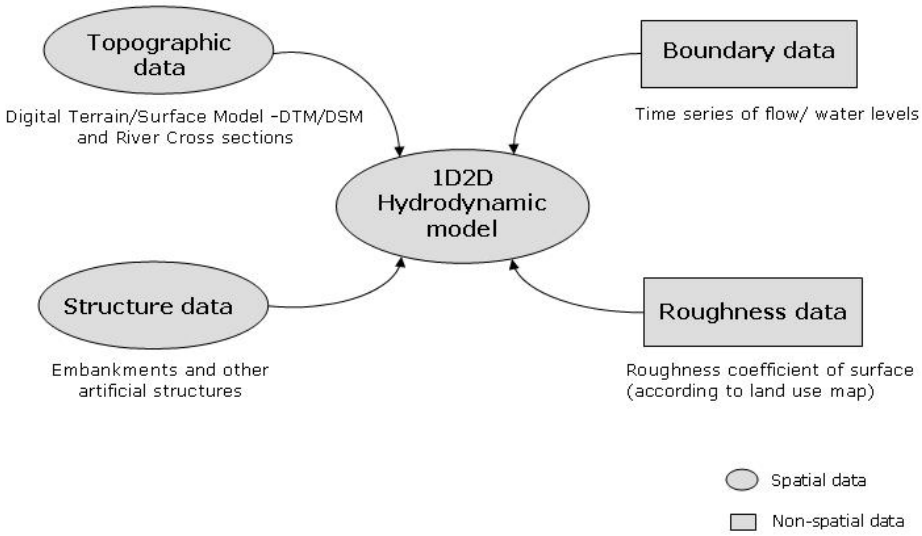


Figure 3.10: Parameter input for 1D2D hydrodynamic Modelling in SOBEK

Table 3.4 provides a summary of the type, details and source of the datasets used as inputs for the hydrodynamic modelling of flood scenarios.

The flood modelling for the study area was based on previous work by Tennakoon (2004), Gamage Wijeratna (2004), Otieno (2004), Bin Usamah (2005), Abdul Rahman (2006) and Stek (2005), who carried out their research as part of the ITC MSc programme. A complete description on the development and improvement of the data sets used as inputs in the modelling performed in this research can be found in these documents.

Flood modelling was carried out for three flood scenarios, related to floods with a 2, 10 and 20-year return period, which are comparable to those analysed using the community-based approach. Each of the three scenarios was analysed under three different situations of development, characterised by the three Digital Surface Models (DSM) for the *past, present* and *future* urban development.

Table 3.4: Data sets used as inputs for modelling flood episodes in SOBEK

Data	Features	Source
DSM for past , present, and future scenarios	Digital Surface Models depicting the topography in the early 90s (*past*), the year 2005 (*present*) and the expected development in 2012 (*future*) for both Barangays.	Tennakoon (2004) Rahman (2006) This research
Roughness map	Derived from Naga land use maps updated to year 2005	Tennakoon (2004) Rahman (2006)
Building Structures	Buildings, roads and railroads represented as solid block structures	Tennakoon (2004) Rahman (2006)
Boundary conditions for 2, 10 and 20 years return periods	Upstream and downstream water discharge information for the Naga and Bicol Rivers at specific return periods	BCEOM Consultants (1991) Bin Usamah (2005)
Rainfall data	Curves describing the relationship between the return period in years and the maximum rainfall in 24 hours for typhoons with 2, 10 and 20 year return period	BCEOM Consultants (1991) Stek (2005) This research

The resulting nine maps were classified using the parameters for flood severity derived by the commity in Section 5.4.3, and compared with the maps derived from the community-based flooding reconstruction approach. A more detailed description of the procedures followed in order to introduce local knowledge into multi-temporal spatial analysis and spatial correlation analysis is provided in Chapter 7.

3.7.4 Spatial Multi Criteria Evaluation for vulnerability assessment

A similar participatory approach as the ones for analysing the flood hazard was used in Chapter 8 to identify and analyse the elements that constitute the household 'resource band' against flooding, which include the aspects related to vulnerability and coping capacity. An analysis was carried out on the various social, economic, physical, developmental and environmental factors, and how these interact and determine the differentiated impact of flooding found among the researched communities.

Focus Group Discussions (FGD) with Barangay officers and community leaders were held in order to identify and analyse the main aspects of everyday life of households, how they may get disrupted during flooding and the extent to which they contribute to their vulnerability to flooding. During the workshops carried out in the two Barangays the participants were also asked to rank these factors. The GIS-based mini-survey was aimed to support the quantitative and spatial analysis of these aspects and explain why these factors were ranked with a different importance level in both wards.

The aspects analysed were related to socio-economic status, type and number of income sources, total family income, people living below food and poverty thresholds, household size, income dependency ratio, housing types, land tenure, health status, sources and access to drinking water, sanitary facilities, waste disposal practices, access to services and development-related infrastructure (drainage, public transport, roads and public facilities), and access to community services both during 'normal' and crisis times .

All these factors were analysed spatially and results were compared between the two Barangays. However, as it was assumed that households and economic and social activities are not vulnerable in the same way, the spatial analysis of the flood vulnerability was undertaken by differentiating the residential areas (occupied by groups of families) and the non-residential sectors, with more emphasis on the former. In order to up-scale the household analysis to ward level both Barangays were subdivided into `*homogeneous units of households*' which consisted of families with more or less similar socio-economics conditions. Where, each of these homogeneous units was characterised with a database containing data on the indicators presented in Table 3.5.

Table 3.5: Factors and indicators involved in the spatial assessment of flood vulnerability

Factor	Indicator
Socioeconomic status	Livelihood
	Income level
	Dependency Ratio
	Family Size
Housing	House type
	Land ownership
Facilities	Access to Drinking Water
	Sanitary facilities
Environmental quality of surroundings	Waste disposal
	Presence of stagnated and polluted surface water
Economic opportunities	Topographic elevation of business and services with economic importance for the community
	Topographic elevation of Road Network
Community Capacities	Topographic elevation of facilities with social importance for the community (town hall, health centres, churches etc.)

Factors, Indicators and *Categories* comprising the indicators listed on Table 3.5 were combined using the Spatial Multi Criteria Evaluation (SMCE) module that was available in the ILWIS software. The theoretical background for the multi-criteria evaluation is based on the analytical hierarchical process (AHP) developed by Saaty (1980). The first step of this spatial process consisted of defining the so-called `*criteria tree*' which comprised all Factors (F), Indicators (I), and the subdivision of these into Categories (C). The next step, known as *standardisation*, converts categories into values with increasing vulnerability between 0 and 1, based on the subjective evaluation obtained from the various participatory exercises. After standardising all the

Categories the next and final step was the *Weighing* (W) process which is meant to assign the relative importance for flood vulnerability of the whole set of criteria (see Figure 3.11).

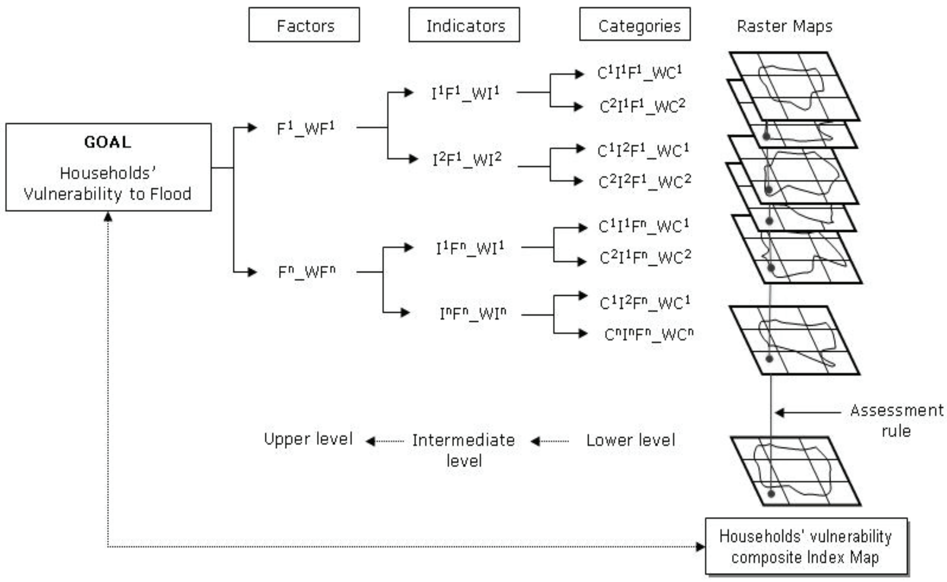


Figure 3.11: Schematic procedure for spatial multi-criteria evaluation based on analytical hierarchical process (adapted from Castellanos and Van Westen, 2008)

In the SMCE module the process of weighing criteria (within the same group or among groups) is facilitated by several tools such as 'Pairwise Comparison', 'Direct Weight' and 'Rank Ordering' derived from the Analytical Hierarchical Processing (AHP) (ITC, 2005).This analysis was performed from the minimum to the maximum levels of criteria in the model. Starting first with the definition of weights between the categories (or lower level) contained in a given indicator, then between the indicators (intermediate level) forming a factor; finally the weighing of the factors themselves (upper level) was undertaken, for which a special procedure using community-derived weights was used. The flood vulnerability of the non-residential areas was determined based on their topographic elevation (above the mean sea level) and therefore in the potential disruption as a consequence of floods. In this case the vulnerability index was set in a range from value 0 (no vulnerability) when no disruption of activities or potential damages can be expected to 1 (totally vulnerable) i.e. when activities are brought to a complete halt or total losses can be expected (e.g. crops).

The complete analysis of both the aspects that contribute to the vulnerability of the families in the study area as well as the construction of the Spatial Multi-Criteria modelling for the groups of households in the study area is presented in Chapters 8 and 9 respectively.

3.7.5 Qualitative and quantitative risk assessment

Risk assessment was the final step in the effort for linking local knowledge and spatial modelling. In this case qualitative and quantitative approaches were applied in order to provide examples of different approaches that can be performed at local level depending on the information at hand. The risk analysis carried out in Chapter 10 was aimed at providing a detailed look at the differential consequences that several inundations and risk scenarios may have on the wellbeing of the households in the study area. Potential losses to be inflicted by flooding were evaluated on the basis of the 2, 10 and 20-year flood events modelled previously in Chapter 7 (see Figure 3.3).

In the qualitative approach the flood hazard maps for these three flood events are combined with the vulnerability assessment obtained in Chapter 9. The aim was to determine the spatial distribution of flood risk for the households units and socioeconomic activities at the *present* (2005) or topographic and developmental baseline situation. The output of this approach helped to determine areas were (according to the community's perception) certain groups of households would not be able to 'manage' the disruption triggered by a flood. In this case the inclusion of local perceptions of risk also facilitated the comparison among zones inside a given ward or even between Barangays; it helped to determine, for instance, in which of them risk management measures may benefit a bigger number of households and increase teir opportunities for managing the risk of disaster.

The quantitative part made use of elements and outputs from Chapters 5 to 9 in order to develop four risk scenarios for *present* (2005) and *future* (2012) developmental situation and climate change scenarios (see Figure 3.3). Losses and negative implications derived from the occurrence of the 2, 10 and 20-year floods were calculated by making use of the livelihood, housing and facilities *Indicators* used in the former vulnerability assessment. For this step, information collected by means of the participatory approaches carried out during fieldwork, particularly the interviews and survey became essential. From them the percentage of losses that a given flood stage may cause was derived as well as the time (in days) that the activity, asset or service comes to a halt, remains damaged or out of service. In this way flood risk could be then expressed in monetary terms such as the amount of income that will be lost, the cost of replacement of damaged elements and the like.

The risk analysis and assessments and its outputs in the form of tables, indicators and maps are provided in Chapter 10.

3.8 Limitations and constraints

This research is about integrating flood risk related local knowledge into GIS assessments. Therefore, as described in the previous sections of this chapter, it required the application of numerous descriptive, qualitative, quantitative, statistical, spatial and other techniques and methods in order to achieve its objectives. Owing to the complexity both of the topic as well as the approach selected it was expected that some limitations, nuisances and constraints will manifest themselves during the development of the research. The first problem was finding the adequate study area; given the high level of interaction with the local people required, at the beginning it was expected that the research could be carried out in a Spanish speaking country. The inadequacy of the area proposed by the Comision Nacional de Emergencias (CNE) in Costa Rica and the lack of safety conditions for such endeavour in Colombia (the researcher's country) left the research with no options other than looking for other areas even if language was going to be an additional hindrance to sort out. However, after being in Naga and interacting with the people in the Local Government Unit, the local officers in the Barangays and some of the local leaders it appeared that communication was not a real bottleneck. The Philippines has a strong influence from the United States which can be seen in the bilingual education, particularly at high school, and most of the media programmes, newspapers and advertisements. In the cases were direct communication was not possible, for instance with illiterate interviewees, the language barrier could be overcome by the use of the translator from the area. Yet it has to be acknowledged that by using an intermediary in the communication some, unavoidable, bias and particular interpretations of the narratives and opinions may have been introduced. The researcher also had the feeling that by using an interpreter perhaps some of the finer details present in the accounts were missed. Another issue while carrying out fieldwork was the condition of being a foreigner for the researcher. Some people were more willing to openly talk about certain issues precisely because they saw the researcher as an external actor with no bias or political attachment. On those occasions issues such as corruption, favouritism, unfairness during relief distribution, poor enforcement of ordinances and the like where openly discussed. In contrast other households were reluctant or ashamed to openly discuss these topics or their personal or family situation; in the Philippine culture people are used to show their best (particularly to foreigners) and therefore tend to avoid other people becoming aware of the difficult circumstances they are undergoing. It was the researcher's opinion that Nagueños are particularly concerned about the image that outsiders will have of them, their city and their country. This could be the reason, for instance, why some of the most negative coping mechanism reported particularly in social studies such as engagement in prostitution, illegal drugs dealing and illegal gambling (locally known as *jueteng*) were never reported in the interviews despite some evidence that they do exist in the study area.

Sharing and learning from the people in the communities did not constitute a major difficulty for the researcher. The attitude of the participants in all the community-based activities, of the interviewees and all those that in one or another way contributed with their knowledge to this research was always open and collaborative; only some tension aroused when transecting with Barangay officers. At some point this was both unavoidable and understandable as during these activities sensitive issues (some of them related with their official tasks and performance) were discussed. On these occasions a reminder that the researcher was there to analyse and understand these issues and not for judging them or asking for accountability was enough to appease the situation.

Finally, it should be mentioned how the lack of similar studies particularly those that integrate local knowledge into mainstream GIS spatial modelling was another challenge for this research. Having to implement some of the methods and applications from scratch implied lots of learning by 'doing' as well as investment of efforts and time that otherwise perhaps could have been avoided.

Nevertheless, despite these limitations and constraints the author considers that all these efforts were worthwhile to understand and spatially portray the 'at risk' community's knowledge and perceptions.

Chapter 4: Triangulo and Mabolo Barangays in Naga City – The Philippines

The objective of this chapter is to present the general characteristics of the study area: the wards, locally know as Barangays, Triangulo and Mabolo in Naga City. Owing to its location, the presence of flood problematic along its history, but moreover the interest of the local authorities for improving the flood disaster risk management, Naga City in the Philippine archipelago was deemed as the adequate place for accomplishing the objectives of the study.

4.1 Introduction

Owing to its geographic location and socioeconomic conditions the Philippines is considered to be 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 constitute a major constraint to the much needed development (World Bank, 2005).

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 size city located in the floodplains of Bicol River, in the so-called 'typhoon belt', and experiences two to five typhoons annually accompanied by extremely intense rainfall. The annual recurrence of these events has created a high level of awareness of the flood threats among the communities and the local government. However the implementation of effective measures to counteract the negative effects derived from this type of events is still lacking. Furthermore vulnerability reduction and risk management are still not included as central components of poverty reduction and development plans within the municipality.

4.2 General characteristics

4.2.1 Location

Among the oldest cities in the Philippines, Naga City traces its roots back to the late 16^{th} century. It is located approximately 380 kilometres southwest of Manila and about 100 kilometres north of Legaspi City on the main island of Luzon. Geographically it is located in the fringes of Mount Isarog (a dormant volcano); between 130 36' 40" – 130 38' 40" North Latitude and between 1230 12' 30" East Longitude; administratively Naga City belongs to the Bicol Region or what is known as Region 5, in the province of Camarines Sur (see Figure 4.1).

Owing to its strategic location in the confluence of the Bicol and Naga Rivers, The city has always been an ideal place for trade, as well as a regional transportation centre for farming and fishing activities. Naga also serves as a major commercial, governmental, educational and cultural centre and therefore has been locally known as the 'Heart of Bicol'.

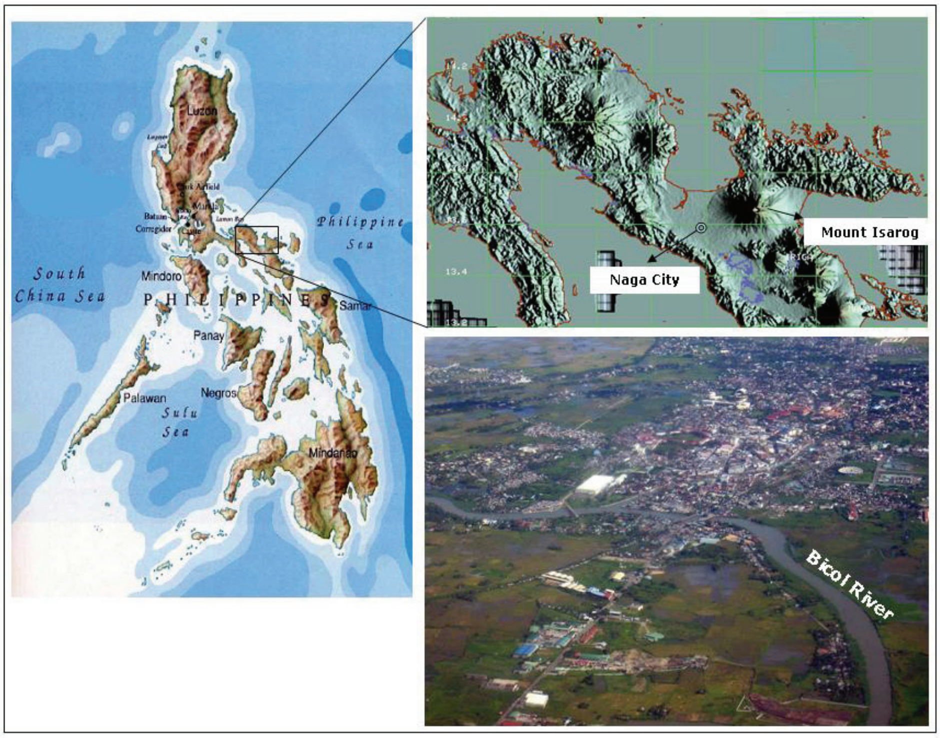


Figure 4.1 Location of Naga City in the Philippine and Bicol region context. The oblique picture in the lower left corner corresponds to the urban area of Naga City

Although it has a relatively small land area (8,448 hectares) with 137,800 inhabitants (by the year 2000); it is currently the most densely-populated city in the Bicol region (CPDO, 2000).

Today Naga is a busy commercial place, administratively divided into 27 wards which are also known as *Barangays*. Residents of the city are called *Nagueños* and have Bikol as the most common and predominant language used among the households. However, certain ethnic groups when among themselves speak their respective dialects and/or languages, such as Tagalog, Ilokano, Waray and Chinese.

4.2.2 History

According to Gerona (2003) riverine settlements already existed in the vicinity of the Naga River at least around 900 A.D. The name *Naga* is apparently derived from the Malay word to designate the *acacia* tree as its wood seemed to have an important cultural symbolism for the ancient inhabitants (Pardo de Tavera, 1887).

At the early times of the Spanish conquest in the sixteenth century the ancient village of Naga had around three thousand houses concentrated along the middle of the riverine district constituted by the Naga and Bicol River which was the main passageway to the gold mining areas and fertile villages of the Bicol plain (Gerona, 2003). The Spaniards took advantage of the location using both rivers to separate themselves from the native settlements as strategic defence against possible attacks. During the colonial times the portion of the city occupied mostly by the Spaniards and located towards the western margin of the rivers, was know as Caceres and became the capital of the entire Spanish community in the region and the heart of the socioeconomic, bureaucratic and ecclesiastical activities and institutions. According to the chronicles between 1600 and 1800 the life in the region was generally marked by widespread poverty and social instability attributed mostly to socio-political factors such as massive depopulation, outbreak of hostilities and oppressive colonial structures (Gerona, 2003).

In the nineteen century a gradual vitalisation of the economy was linked to the expanded production of the *Abaca* fibre to the United States and England. The relatively stable economic situation created by trade allowed the construction of public works in the city such as one of the first canals to drain and protect the city, particularly the market and commercial area, which since then was located in the highly flood-prone area that it still occupies nowadays (Esquivel, 1832). During this time the cathedral, the seminary and the bishop's residence which stood near the bank of the river, were transferred inland in order to avoid flooding.

In 1898 the Spanish government was brought to an end in the province and one year later Americans took over and remained in power for almost half a century introducing exceptional changes in urban and economic issues, mainstreaming Naga towards a more dynamic global socio-economic commerce (Arejola, 1963). During this period the city experienced a boom in construction by means of *subdivisions.* The city adopted this model for urban expansion where the owner of the land overtook the development of the site. This model of expansion was implemented in sectors that used to be swampy areas associated to the Bicol River floodplain. Roads were also repaired and elevated as according to the reports they were permanently subjected to the destructive effects of floods as in some streets flooding could last for several days (Freer, 1909).

In 1941 the World Ward II broke out and the country was invaded by the Japanese. During that period Naga became the refuge of the Japanese power in the region. This occupation virtually destroyed the major means of production and led to the collapse of the local industry because of the forced isolation imposed (Ancheta, 1977). Owing to the airstrikes and heavy bombings at the end of the conflict (1945) Naga was literally levelled to its ashes with just a few buildings escaping destruction (Hidalgo, 1976).

In 1946 the independence of the Philippines was declared and two years later Naga was erected as one of the first provincial cities in the Bicol Region. Immediately the city started the post-war reconstruction period during which the emerging city underwent remarkable transformations leading to its current status as one of the first class cities in the country.

4.2.3 Socio-economic features

Although an established centre of commerce in the Bicol Region, Naga's socioeconomic performance before the mid-1980s was poor. Since 1988 transparent and good governance practices have helped the city to regain its premier status and to become one of the country's brightest economic and a role model in development in the Philippines (Mangahas et *al*., 2006). According to the National Economic and Development Authority (NEDA) Naga is seen as the 'conduit of development of the Metro Naga Area and the Legaspi-Iriga-Naga-Daet growth corridors (NEDA, 2002). In this plan Naga City is identified as a primary urban-subregion centre characterised by commercial, marketing and administrative functions serving the entire Metro Naga area and containing most of the higher level communication, economic, recreational, administrative and marketing functions (MNDC, 2002).

The dynamic economy of the city is evidenced by its 6.5% average annual growth rate, the presence of two business districts and several new growth zones, and an average family income that is 126% and 42% higher than the national and regional averages respectively (Robredo, 1999). These facts become important as, based on recent statistics, Bicol is one of the five poorest administrative regions in the Philippines. Although Naga represents only 0.48% and 2.9% of the region's land area and population respectively approximately 21% of all investments in Bicol are concentrated in the city. An estimated 51% of all enterprises in the whole province of Camarines Sur are concentrated in the city (Robredo, 2003).

According to classification of the National Statistics Office, Naga City population is 100 percent urban. In 2001 the city has a ratio of 100 females to every 95 males. The age distribution of the population can be considered as very young with more than 59.2 percent under 24 years old (Age Distribution Census -1995). In 1990, the literacy rate of the population was registered at 98 percent. Of the population of seven years and older, 40.74 percent had attended elementary education; however only 29.92 percent of the youth has finished high school education. The high proportion of those that had completed at least high school education may be partly attributed to free secondary education in public schools. Academic degree holders or those who graduated from college constitute 13.6 percent (Naga City, 2000).

By year 2000 the city's labour force (population of 15 years and older) comprises 60% of the entire population. Of the total labour force, about 57% are considered economically active and the unemployment rate is around 5.4% (Naga City, 2000).

The leading causes of mortality and morbidity are mostly diarrhoea and respiratory-related illnesses (pneumonia, influenza, asthma). These are largely water-borne diseases, which are indicative of water quality, sanitation conditions and constant flooding in the city. Health services and facilities are more than adequate to serve the city's population with 7 beds per 1,000 inhabitants; 1 physician per 684 and 1 dentist per 1,294 citizens (Naga City, 2000).

Despite its classification as 'urban' in economic terms Naga City remains primarily an agricultural economy. From its total land area of 8,448 hectares nearly 73 % are used for agricultural purposes. Major crops are rice, coconut, sugarcane and corn. Rice, being the staple food for Bikolanos, occupies the highest percentage of cultivated area (see Table 4.1).

Table 4.1 Naga City land use (CPDO, 2000)

Land Use	Area (ha)	Percent (%)
Residential	1100	13
Commercial-transportation	165	2
Light industrial	30	0.5
Agro-Industrial	140	1.8
Agricultural	6185	73
Institutional	150	1.8
Parks/open space	2.5	0.01
Forest parks and reserves	611	7.2
Dumpsite	3.5	0.04
Cemeteries	17	0.2
Water bodies	44	0.5
Total	8448	100%

Regarding business the major types of activities in Naga City are wholesale and retail trade, banking and finance, insurance, real estate and other services. The immediate neighbouring towns of Naga City including Canaman, Magarao, Milaor, Calabanga, Camaligan, Minalabac, Gainza and Pili benefit much from various trading activities with the city. These towns are also members of the Metro Naga Development Council (MNDC), a pioneering concept in integrated area development that seeks to enhance resource allocation and integrated development among its Local Government Units. The major activities with these towns are trade of vegetables, dried fish, fresh catch fish, handicraft, rice and fruits.

Naga city strives to provide an environment that nurtures the progress and dynamism of its local enterprises and industries. It also has obtained one of the highest overall competitiveness ratings in the Philippines among the small cities based on business activities, infrastructure, human resources, linkages and accessibility, quality of life, local governance, and dynamism of local economy (Naga City, 2000). However, as Naga is a landlocked city the lack of adequately equipped seaport or a bigger airport limits, to certain point, its opportunities to catalyze trade and commerce (Mangahas et al., 2006). While it possesses a rich endowment of fertile soil and mineral resources, agricultural productivity has historically been low, requiring an increasing dependence on neighbouring towns to meet its local food and rice requirements. In addition areas are being converted to other uses based on the proposed land use plan of the city. The Department of Agrarian Reform (DAR) office reports that since 1982 up to 1998 a total of 276 hectares of agricultural lands have been approved for conversion for non-agricultural use (Naga City, 2000).

The industrial sector of Naga, however, is still at an embryonic stage and the few secondary industrial or manufacturing activities do not offer significant basis for inter-regional trade (Naga City, 2000). To date the manufacturing industries are mostly limited; comprising around 378 small enterprises for food processing, metal works, furniture, car shops, warehousing and storage establishments. The urban road system is well developed and highly articulated resulting in a circulation system that gives easy access to all residents. The public intra-city transportation is well served by motorcycle cabs locally called '*trimobiles*', jeepneys, buses, for average daily traffic (see Figure 4.2). Modes of transport available include small boats to reach neighbouring riverine towns, train through the Philippine National Railroad (PNR) south line railway and a small airport in neighbouring Pili.

Finally the tourism sector, except for the Peñafrancia fiesta, is still to be developed. The Festival of Our Lady of Peñafrancia is celebrated on the third week of September. During this festivity the image of Madonna is brought from its shrine to the Naga Cathedral where *novenas* are held. The statue of Our Lady of Peñafrancia is carried on the shoulders of male devotees. On the last day, the image is returned to her shrine following the Naga River route. This festivity draws a number of domestic and foreign visitors and tourists every year who visit the region annually, on the strength of this event (see Figure 4.2).

Figure 4.2 Aspects of Naga city's life: Commerce and transport in a central road (left) and procession during Nuestra Señora de Peñafrancia festivity (right) (Photos taken by Muhibuddin Bin Usamah)

4.2.4 Administrative division

Naga city as all the municipalities and cities in the Philippines is subdivided in so-called *Barangays* which is the indigenous word to designate wards or neighbourhoods in the Philippines. A *Barangay*, also known by its former Spanish adopted name, the '*barrio*', is the smallest administrative division in the Philippines and could be assimilated to a village, district or ward. As previously mentioned Naga City consist of 27 Barangays, of which seventeen (17) are located in the flood plains of the Naga and Bicol Rivers occupying a combined extension of 802 ha nearly 10% of the city area. The remaining 90% is conformed by 10 Barangays located in the upper terrains of the municipality (see Table 4.2).

The communities of the 17 Barangays, that are located in the floodplains often experience inundations during typhoon events. Affected by the Bicol River are Barangays Mabolo, Tabuco, Triangulo, Sabang, Igualdad and Abella. The Naga River crosses, and often inundates Barangays Dinaga, Lerma, Tinago, Dayangdang, San Francisco, Santa Cruz, Peñafrancia, Bagumbayang Norte and Sur, Calauag and Liboton. These 17 Barangays comprise the heart and centre of business and commerce of the city. The existing Central Business District (CBD-I) which is composed of the Barangays Abella, Dinaga, Igualdad, Sabang and San Francisco occupy nearly 11% (91 ha) of the flood-prone wards. The recently built Central Business District Two (CBD-II) includes Barangays Triangulo and Tabuco which are likewise located in the flood-prone areas (see Figure 4.4).

The remaining 10 Barangays outside of the flood plain are Balatas, Cararayan, Concepcion Grande and Pequeña, Del Rosario, San Felipe, San Isidro, Carolina, Pacol and Panicuason. Located in the upper part of the city they are mostly agricultural areas which are supposed to contribute to the food supply of the city. These Barangays are comparatively less densely populated than those on the low lying zone (see Table 4.2). The communities settled in these wards are relatively protected from flooding but more exposed to strong winds and flash floods.

Table 4.2 Population profile per Barangay for year 2000 (CPDO, 2000)

Barangay	**Area (ha)**	**Total population**	**Number of households**	**Density (Pop/Area)**
1. Abella	24.5	5,016	912	205
2. Bagumbayang Norte	26.2	2,331	443	89
3. Bagumbayang Sur	62.5	4,709	973	75
4. Calauag	54.9	7,208	1,297	131
5. Dayangdang	33.8	4,604	952	136
6. Dinaga	8.45	467	106	55
7.Igualdad	9.3	2,591	472	279
8. Lerma	5	2,329	463	459
9. Liboton	27.9	3,006	585	108
10. Mabolo	116.6	5,962	1,116	51
11. Peñafrancia	41.4	6,271	1,134	132
12. Sabang	45.6	5,991	1,107	131
13. San Francisco	11.8	1,139	242	96
14. Santa Cruz	72	5,750	1,143	80
15. Tabuco,	156	4,276	827	27
16. Tinago	40.5	3,927	778	97
17. Triangulo	154.6	6,882	1,326	45
18. Balatas*	202	6,808	1,262	34
19. Cararayan*	1,011	7,335	1,314	7
20. Carolina*	1,777	4,349	824	2
21. Concepcion Grande*	338	8,524	1,695	25
22. Concepcion Pequeña*	381	16,818	3,252	44
23. Del Rosario*	221	6,260	1,178	28
24. Pacol*	1,305	6,271	1,134	5
25. Panicuason*	1,470	1,847	332	1
26. San Felipe*	578	6,126	1,124	11
27. San Isidro*	273	1,813	331	7
Total	**8,448**	**137,810**	**26,317**	**16**

* Flood-free Barangays

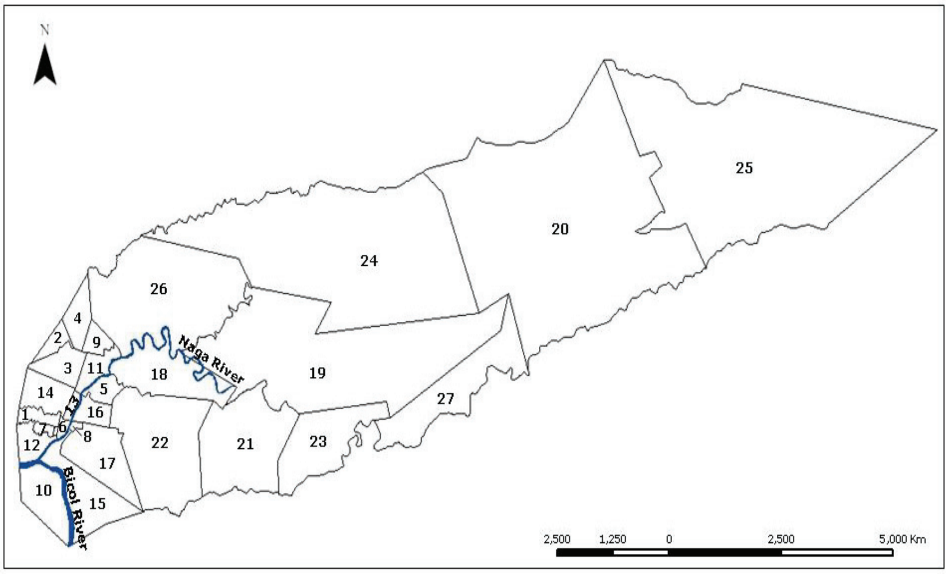


Figure 4.3 Distribution of the 27 Barangays comprising Naga city

Figure 4.4 Barangays and Comercial Busines Districts (I and II) in the flood-prone area of Naga City.

4.3 Flood and typhoon problems

As mentioned in Section 4.2.2 both the Naga and Bicol rivers, have caused flooding throughout the history of Naga City. Geomorphologically Naga City is part of the Bicol River delta in the San Miguel Bay. The city's topography clearly shows that its urban core is in a low lying area. Most of the urbanised area in the city has been erected in terrains less than five metres above sea level, making the lowest portion of the city highly prone to flooding.

Since early times therefore the communities settled in these territories have faced inundations triggered by typhoons each year. In the last decade however, factors related to the development of the city such as urban growth, population booming and reclamation of low-lying areas for commercial expansion are contributing to an increase of the flooding phenomenon.

In Naga most of the commercial growth is taking place towards areas that used to act as natural water reservoirs (open marshes and wetlands). In addition the municipality is encouraging the economic development of low lying areas by allowing private developers to raise massive structures by means of land-filling (*'dumping'* being the preferred term in Naga) that lack adequate drainage infrastructure. This model of expansion has amplified and spread the flooding problem towards new areas, modifiying the floodwater behaviour by increasing depths, duration and severity of flooding in areas where before flooding was marginal (ADPC, 2001).

The vulnerability of certain communities in the low lying areas is related to a combination of aspects such as widespread poverty, limited economic opportunities, and lack of affordable land in flood-free areas near to commercial sectors. Yet, aspects such as poor planning and institutional incompetence also play a role. Firstly as the city expands and attracts new investors the land uses become decided in terms of their market value and not in the understanding of their capability or the natural processes. In Naga the development and land use plan do not take into consideration the fact that the city is located in a floodplain. Therefore the land allocation for new commercial and residential projects as well as onsite relocation or some of the projects for housing the urban poor are primarily based on the economic value of the land and not on the protection of vulnerable people and investments (ADPC, 2001).

Secondly Naga is a rapidly growing city which demands that the infrastructure associated to its expansion grows at the same pace. However, no comprehensive plans for drainage system within the city and the expansion zones are currently available. Instead the Local Government Unit tries to meet this challenge by improvising and designing local solutions to local flood problems as they occur. According to Stek (2005) 'The actions of the Civil Engineering Office (CEO) are controlled by the floods and the floods remain beyond the control of the CEO'. In addition most of the natural waterways and drainage creeks in the city have been silted or built-over with structures blocking the natural flow of flood waters. The absence of any natural drainage ways subject the low-lying area to extended flooding even during moderate rainfall.

Thirdly in Naga, as in most of the cities in developing countries the policies, programmes and organization to deal with floods follow short-range disaster management strategies. Naga City has a strong reliance on response, post-disaster relief and short term preparedness (forecasting, evacuation) but lacks the implementation of more integrated and proactive short, medium, and long-term risk management strategies.

4.3.1 Flood types

Floods and other extreme weather related phenomena occur regularly in Naga. Because of the complexity of the Bicol and Naga River systems the city is used to experience flooding coming from several sources mainly during the typhoon season from June to December.

Because of its geographical setting the city is affected by Northeast Monsoon and Pacific trade winds. The Monsoon create a low-pressure area in the pacific known as the 'typhoon belt' resulting in around 20 tropical cyclones annually; approximately three typhoons strike per month, with its maximum during the months of November and December.

The Bicol river flood plain experiences between two to six typhoons each year some accompanied by extremely intense rainfall which usually produced the overflowing of the Bicol and Naga River causing regional flooding as illustrated in Figure 4.5 (OIDC, 1999). The system formed by these two rivers is intricate and both have highly variable water level easily influenced by the tides in the San Miguel Bay. This tidal action can cause fluctuations up to 1.2 m during normal times and up to three metres during long term recurrence events (BCEOM, 1991). The tidal action also generates backflow effects in the confluence area of both rivers (Stek, 2005). Recent studies have demonstrated that the elevation of the delta of the Bicol River in the San Miguel Bay (Bicol outlet) has been progressively raised by about two metres in the past 100 years as result of sedimentation; increasing the backflow effect of the streams in the low lying areas (Adolfo and Calara, 2003; Nippon_Koei, 2003).

As the main portion of the city is situated equally elevated or slightly below the rivers level heavy precipitation rapidly causes overflowing of the riverbanks causing damages to the communities. This situation is further aggravated by the heavy silting from volcanic processes and erosion of the basin slopes which currently undergo intense logging and denudation.

Finally more localised flooding problems are related to 'drainage overflows' which in the last decade are becoming extremely frequent. The existing drainage system is designed to drain the rain water naturally to the Naga and Bicol rivers. Therefore no pumps or other mechanism are in place to evacuate or retain the runoff and the drainage performance is always constrained by the level in the rivers. Thus if the water level in the rivers is rising as a result of high tide or high discharge, the low lying areas can experience flooding even if no heavy rain occurs in the city itself. Flooding associated to drainage overflows is mostly resulting from the inadequacy of the system rather than the high levels of the river (Stek, 2005). During heavy storms there are areas that undergo flooding regardless of the river level (see Figure 4.5).

Figure 4.5 Regionalised flooding in the floodplains of the Bicol River triggered by super typhoon Reming in 2006 (left- ALOS image UNOSAT) and localised drainage overflows as a result of heavy rains brought by tropical depression Labuyo in 2005 (right).

4.3.2 Magnitude and extent of flooding

Flooding in Naga City is always associated with the occurrence of heavy storms and typhoons taking place during the wet season. According to ADPC (2001) even flooding with a small return period can cause extensive and widespread disruption. In Figure 4.6 a set of flood hazard maps available for 5, 10 and 20 year return period produced by ADPC (2001) and based on historic events are presented.

In general the depth of flooding can reach up to two metres and, depending on the topography, it can last from less than three hours to several days. A 5-year flood with a 20% annual probability of occurrence can potentially affect nearly 99% of the residential zones in the low lying Barangays (341 ha.) as shown in Table 4.3. About 30,000 people (5,300 families) are settled in areas that might be flooded more than 0.5 meter and almost 17,000 people (3,000 families) are exposed to severe flooding (> 1m). The duration of floods with this return period ranges between five days to one week. The areas most severely flooded are located in Barangays Sabang, Igualdad, Abella, Sta. Cruz, Tinago, Dayangdang, Calauag, Mabolo and Triangulo where flooding can last for more than two weeks (see Figure 4.4).

Floods with a return period of 10 years will cover nearly 502 ha in the flood-prone Barangays, included their residential zone which adds up to 192 ha (see Table 4.3). About 42,000 persons are living in areas where flooding with more than 0.5 metres depth can occur. In this scenario between 26,000 to 32,000 people are exposed to severe flooding (> 1m). In some areas flooding can last between seven to ten days. The communities affected by deeper and long-lasting floodwaters are those in Sabang, Igualdad, Abella, Santa Cruz, Dayangdang, Calauag, Tinago, Mabolo, Triangulo and the Central Commercial Business Districts (CBD I and II).

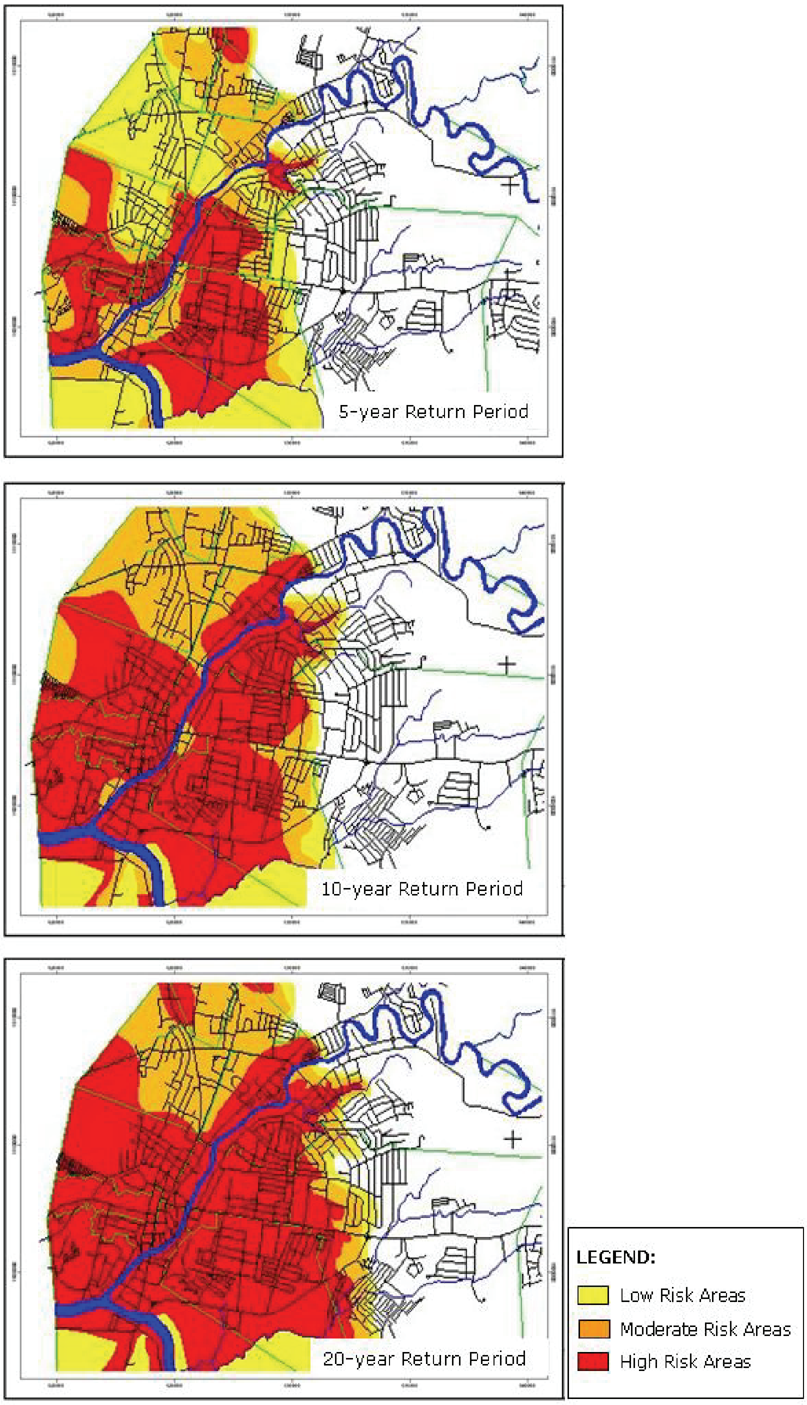


Figure 4.6 Existing flood maps for 5, 10 and 20 year return period in the low lying Barangays (used by the LGU of Naga City, source: EDP Unit)

Table 4.3 Areal extension of flooding with different return period in Naga (ADPC, 2001)

land use (ha)	Flood Scenario								
	5-year			10-year			20-year		
Flood depth (m)	**<0.5**	**0.5 -1**	**> 1**	**<0.5**	**0.5 -1**	**> 1**	**<0.5**	**0.5 -1**	**> 1**
Residential	118	102	122	7	145	191	1	86	259
Commercial	34	55	109	1	38	161	0	21	186
Industrial	4	7	29	0	4	36	0	0	40
Agriculture	18	36	104	15	22	150	7	30	180
Total	184	197	341	23	205	502	8	137	665
Area wards (perc)	23 %	25 %	50%	1%	23%	52%	0.1%	13%	65%

The scenario for a 20-year return period flood is similar to the 10-year flood in the sense that 100% of the low lying wards are inundated. In this case however the residential area affected comprises nearly 260 ha. The combined population affected by more than 0.5 m flooding corresponds to 43,000 persons or nearly 8,000 households. The Barangays affected are the same as in the previous flood scenario. However in this scenario floodwaters can last for almost two weeks and even more in some of the lowest-lying Barangays such as Triangulo and Mabolo.

Areas that can experience nearly one metre of flooding as result of discontinuous and inadequate drainage system during all type of storms are Liboton, Calauag, and Bagumbayan Sur and Norte. Flooding resulting from the combined effect of tidal influence affects areas closer to the Bicol River with lower riverbanks as those found in Barangays Mabolo, Tabuco, Triangulo, Sabang, Igualdad and Abella.

4.3.3 Impact of flooding in Naga

Naga City constitutes the access to the Bicol Region. Therefore, when typhoons hit the city and inundate its main national highways, the region becomes isolated. The fact that these vital lifelines become easily flooded is one of the major impacts of floods for the province. Not only the commerce and delivery of services gets interrupted, but the life of the inhabitants becomes seriously jeopardises as their mobility, provision of medicines, food and relief from outside is obstructed.

Regarding the impact in the city itself the area affected equivalent to the 10% of the total municipality may appear relative small when compared to the total lands of the city. Critically this area is inhabited by 85% of the city’s aggregate population and holds most of its main economic activities; which means that the impact of flooding becomes highly significant.

According to ADPC (2001) when flooding take place, particularly a 5-year return period magnitude and higher, the southern part of the built up area including the urban core of the city suffers severely. Commercial activities stand still, transportation from North to South is cut and transportation terminals do not operate. Recreational and shopping activities in and around the central business districts cease. Schools and offices are closed and the hospitals in the flood zone become isolated.

Regarding the losses undergone by the city as a result of typhoons and floods there is very limited data. Only in the last years some damage surveys and rapid assessments on the human and main economic losses have been undertaken by the Department of Social Welfare (DSWD) and the Office of the City Mayor. These data show that in 1998 the number of casualties reported were ten persons perishing either by drowning, hypothermia, cardiac arrest and foetal death as result of Typhoon Loleng (which brought winds at velocities exceeding 100 kph and rains that triggered a 10-year return period flood).

The reported number of damaged houses was of 8,634 from which nearly 1,700 (16%) were reported as totally damaged. From them 407 units were totally damaged by floodwaters. During the relief operation the government provided assistance for nearly 81,000 persons at a cost of PhP 655,000. The aggregated losses in properties and economic investments added up to PhP 29,450,000 for the entire city from which PhP 20 million corresponded to the flood-prone wards. A rough estimation based on the annual revenues allowed calculating an approximate PhP 31.5 million losses for the business in the flood-prone area as result of three days closure. The damage from severely damaged agricultural crops amounted to some PhP 39.6 million in 1998. Damage to vital public infrastructure (i.e. roads, bridges, schools, drainages and the like) was estimated at PhP 18 million with a 69% of this amount coming from flood-prone areas.

More recent data, collected after Typhoon Unding and Yoyong struck the city in 2004, showed that in total 1,974 houses were reported as totally damaged, 1,026 as heavily damaged, and some 8,218 partially damaged. People affected or displaced accounted for nearly 55,000 (almost 11,218 households) and 4 casualties (CDMO, 2004). A total of 757 ha used for agricultural crops and fisheries was totally destroyed and another 757 ha partially damaged with losses amounting PhP 22.5 million. Livestock losses summed up to PhP 93 million. Although extensive damage to infrastructure and institutional services was reported no economic evaluation was available for these losses.

In 2006 super typhoon Reming (category 5) struck Naga on November 30; just weeks after another typhoon (Milenyo) hit the Bicol region. According to the official reports the damage was widespread particularly to private dwellings, crops and livestock, public schools, farm-to-market roads, health and community centres, the city's waste management facilities, as well as to power, telecommunications and water utilities (see Figure 4.7).

The total damage was roughly estimated to have reached PhP 187.5 million (Naga Government, 2006). In this case estimation on the damages to vital public infrastructure facilities was available as follows: damage to School buildings was estimated at PhP 30.5 million; Barangay health and day-care centres at PhP 35 million; Barangay multi-purpose halls at PhP 27 million; various city government offices and facilities at PhP 10 million.

Figure 4.7 Infrastructure shattered by strong winds during typhoon Unding in 2004 (left) and ruined agricultural fields and homeless families as result of flooding during super typhoon Reming in 2006 (right).

Losses in the farm-to-market roads were roughly PhP 10 million, and for agricultural crops and livestock the estimated damage was an additional PhP 10 million (excluding damages from the previous typhoon Milenyio).

In general the data on damage found did not include the cost of secondary effects and the short and long-term impact of these events on the overall economy of the city and socioeconomic conditions of the citizens.

4.3.4 Perceptions of flood among Naga city's people

Owing to the high recurrence of floods and winds associated to the annual typhoon season people in Naga have generally adjusted and accepted them as a fact of life (see Figure 4.8). According to ADPC (2001) flooding is not really perceived as a serious problem and much more a risk to reckon with based on the proliferation of settlements and business along flood-prone areas.

In general it can be said that the management of the risk that these events represent attract little interest from policy and decision makers in either the public or the private sector (World Bank, 2005). In general the cultural attitude assumed to cope with the risk derived from flooding, strong winds and typhoons is based on the personal capacity of the individual to alleviate, prevent or bear the losses in accordance with their own financial means.

The low priority given to flood risk is evidenced for instance in the fact that the existing and planned development initiatives do not take flood hazard into consideration. Furthermore, the lack of comprehensive plans for drainage management and improvement and the location of several housing plans for the Urban Poor in flood-prone areas (because the land is government-owned or low-priced) are further evidences of this oversight. Another proof of the poor understanding about flood risk management is evidenced by the government-encouraged strategies for developing the low-lying areas.

Figure 4.8 Floods as a fact of life for communities in low-lying areas of Naga

The construction or retrofitting of buildings by raising the ground level (land-fill), elevated business establishments and wealthy subdivisions provides protection to these investments at the disadvantage of unfilled areas where flooding is further aggravated. The outcome of such initiatives, while benefiting a few households, often shift and aggravate the flood situation at the expenses of marginal groups. The poor population settled within and around developed areas just rely on coping mechanism such as building their houses on stilts or just simply 'managing' the situation when it occurs (ADPC, 2001).

The fact that flood hazard is not considered by the city's population as a central factor could be also deduced from everyday decisions as the location, for instance, of residence and commercial deeds. Damages or casualties caused by past events seemed to be taken as of little consequence compared to the socioeconomic benefits derived from the existing location. For the poorest families selecting their place of residence is not a matter of choice; they are forced to live in the riversides or areas almost perennially flooded as result of their lack of land entitlements or affordable land in flood-free areas. Actually some of the poorest households even consider they are better off during flood events because for several days they can rely on the relief assistance provided by the government or NGO's.

The rather fatalistic attitude of the general populace towards flooding risks tends to further increase the vulnerability of identified population sectors and groups. Such perception and attitudes breed some kind of indifference to the situation.

4.4 Existing disaster management structure

It has been mentioned that in Naga certainly individual, government and some multi-sector efforts being taken as counter measures to address flooding risks are mostly piecemeal, uncoordinated and reactive in nature. Yet it was acknowledged that certainly the city does not differ from the predominant approach to risk and disasters in the whole Philippines which originated in the World War II and was much geared towards preparation for war (World Bank, 2005). In addition the disaster management system in the Philippines is based on a decree from year 1978 which has not been updated since then. The national system in place does not address the need to take into account the evolving roles of the local governments, private sector and communities and does not promote and demand risk prevention and mitigation efforts from the Local Government Units.

In Naga, despite some governmental and private initiatives, the efforts are still too much oriented towards short term preparedness and humanitarian relief, partly linked to the aforesaid policies and governmental setting and partly linked to budgetary constraints. In order to manage hazardous situations derived from natural or man-made hazards the local government has in place a disaster mitigation organization composed of three bodies dealing with disaster preparedness, rescue operation and post disaster-relief assistance operations. In the last years several programmes have been initiated to reduce the vulnerability of Naga City to flooding and typhoons.

4.4.1 Current status of disaster management at municipal level

The role of the City as embodied in the Philippines Local Government Code of 1991, specifically in section 448
"The city, consisting of more urbanized and developed Barangays, serves as a general purpose government for the coordination and delivery of basic, regular, and direct services and effective governance of the inhabitants within its territorial jurisdiction".

This focuses on the empowerment of the Local Government Unit (LGU). This code grants the LGU a fiscal and administrative autonomy and planning authority and devolves the basic services like health, agriculture, public works, and social welfares, which includes disaster management, thus aims to improve the accessibility of services to its constituents. The services were put into implementation, empowering the LGU to pass pertinent policies to its effects.

The role of the Barangay is provided by Section. 384 of this code stating *"As the basic political unit, the Barangay serves as the primary planning and implementing unit of government policies, plans, programs, projects, and activities in the community, and as a forum wherein the collective views of the people may be expressed, crystallized and considered, and where disputes may be amicably settled".*

Increasing people's participation in decision-making or empowerment for decision making and policy-setting is one of the purposes of this law. Specifically, the City and the Barangay have the authority to formulate disaster management programs. This is strengthened by providing fiscal authority to the City and Barangay to disburse funds for disaster mitigation, response and rehabilitation programs. As stated in Section 1, Section 324(d) of Republic Act No. 7160, as amended, granting appropriation of funding for relief, rehabilitation, reconstruction and other works or services in connection with calamities. Such fund shall be used only in the area, or a portion thereof, of the local government unit or other areas affected by a disaster or calamity, as determined and declared by the Local *Sangguniang (*law making body of the Local Government Unit*)* concerned.

Regarding the management of disasters at municipal level, Naga has adopted several programmes and has in place special bodies involved specialised in response and rehabilitation once emergencies occur. Concerning the implementation of disaster mitigation there are three major special bodies being them: the Naga City Disaster Mitigation Council (NCDCC), the Emergency Rescue Naga (ERN) and the Naga City Disaster Mitigation Project Unit (NCDMPU) each one with specific tasks and appointed members from the local government unit offices as can be seen from Table 4.4.

Table 4.4 Naga City special bodies for disaster mitigation (ERN, 2004)

Unit	Members	Task
Disaster Coordinating Council - NDCC	• Philippine National Police Station (PNP) Commander as Vice Chairman & Action Officer • Organic City Officials • National Officials assigned to the City • NGOs	• Pre-disaster planning, community disaster preparedness, disaster control action for rescue, evacuation relief and rehabilitation
Emergency Rescue Naga -ERN	•Naga City Hospital •Naga City Fire Station •Naga City Police Station and its Auxiliary service •City Hall •Radio Groups •NGOs •City Engineers Office •City Social Welfare and Development Office	•Medical service (First Aid) •Rescue Services (Water, High Angle, Hi-Way, Collapsed structure, rescue, Fire, Domestic Violence, Mountain accidents) •Communications •Incident Command System (Mass Casualty Incident)
Naga City Disaster Mitigation Council - NCDMC	• Selected Organic City Officials • Sangguniang Member Representatives • NGOs • Selected National Agencies (OCD, DECS) • PNP • Fire Bureau	• Presence of Project Office • Implement Disaster Mitigation Program in Coordination with AUDMP and PBSP

The Municipal Disaster Coordinating Council is an organizational structure that can expand or contract depending on the disaster situation. Even though in theory its main tasks include coordination, operations management, public information, resource management and present projects for policy making, this body is perceived as a unit for disaster rescue operation and post disaster assistance operation only. No regular activities have been undertaken for disaster mitigation or risk management.

The Emergency Rescue Naga (ERN) has as main duties providing valuable and appropriate emergency response and pre-hospital care from first aid to victims' transportation in order to alleviate human suffering and save lives (ERN, 2004). The Emergency Rescue Naga is the city's emergency rescue service initiated by the government in 1991 to immediately respond to emergencies, disasters, and accidents. Its average response time is 3-5 minutes within the city proper and 30 minutes for the farthest mountain Barangays some 17 kilometres away. The ERN operates in consonance with its mandate as the emergency rescue unit and follows an action plan drawn up by the City Disaster Control Centre (Pineda and Buan, n.d.).

The general organisation that coordinates any disastrous or emergency operation is shown in Figure 4.9

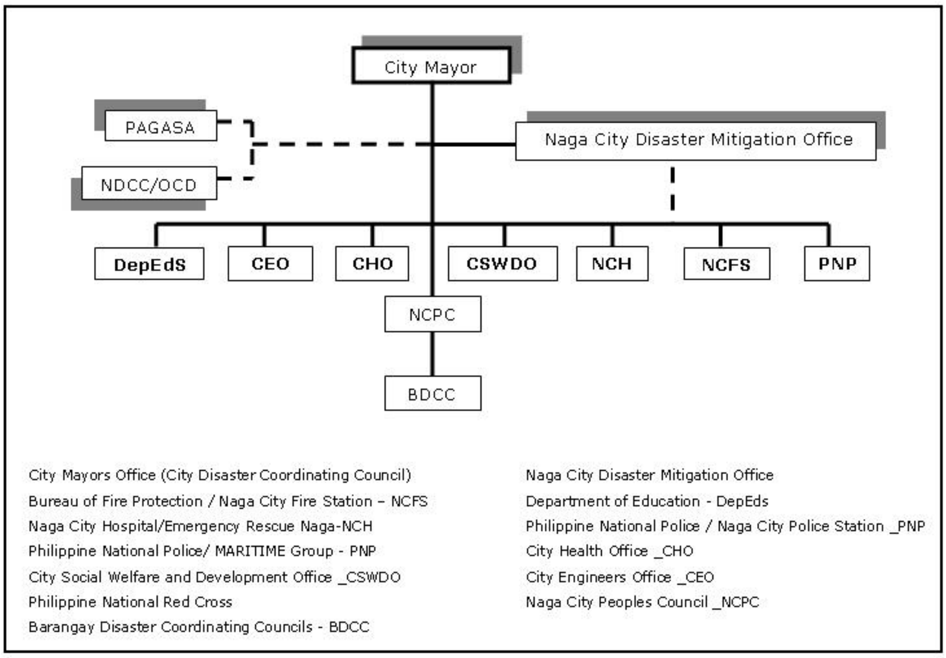


Figure 4.9 Framework for the coordination of emergencies in Naga city.

4.4.1.1 Warning, preparedness and emergency response

Before the implementation of warning and emergency response, effective assistance to residents of the 27 Barangays was seldom given, especially when typhoons and floods strike at night as transportation to distant Barangays was scarce. This contributed to the high mortality and morbidity in these areas during this type of events. Nowadays the municipal government unit is aware of the need to be prepared to evacuate people from flood-prone areas to higher levels and billet them in wind-safe buildings. The system in place is based on the PAGASA station in Camaligan which monitors and provides real time assessment for typhoons and flash floods.
The City Government then initiates a localized public storm warning system for planning and preparedness activities, using internet and local capabilities ensuring safety of the citizens as follows:

1. Typhoon Signal No. 1. Winds up to 90 Kph are expected within 72 hours
2. Typhoon Signal No. 2. Winds up to 90 Kph are expected within 48 hours
3. Typhoon Signal No. 3. Winds up to 90 Kph are expected within 24 hours
4. Typhoon Signal No. 4. Winds up to 90 Kph are expected within 12 hours

Depending on the evolution of the event several actions established in an action plan are executed such as a) activation of the Disaster Control Centre which should be certain that the City Secretary prepares the decking duties of the City Councillor for the Centre's operation, b) identification of typhoon evacuation areas that are safe and secure, c) Evacuation of residents of houses and buildings that are considered unsafe during typhoons, d) orientation of Barangay Captains, local Barangay officers (*Kagawads*) and volunteers as regards to their function and proper coordination with other involved agencies, e) preparation of ropes, tools, containers for food, water and fuel as well as emergency lights, candles, matches and other supplies and materials that may be needed for repair work, f) ensuring secure communication equipment and facilities and preparation of stand-by power.

During the execution of emergency response plans the highest priorities for evacuation are given to the sick and disabled, pregnant women, particularly those in the last trimester of pregnancy, mothers with offspring and unaccompanied children under her care, senior citizens (65 years old and above, semi-invalid), unaccompanied women under 18 years old. While these groups of people are secured in safe areas priorities are redirected to able-bodied males and Barangay security assistants (*Tanods*) which after helping with the rescue operations are assigned to secure areas.

Currently the city counts with eight (8) main evacuation areas in flood-free or less severe flooded areas as follows:
1. Naga City Hall
2. Peña de Francia School
3. Bicol Collage of Arts and Trades – Barangay Peñafrancia
4. Liberty Commercial Complex (LCC) in Sabang
5. All Barangay Halls
6. Plaza Quezon
7. Diversion Bus Terminal
8. Naga City Public Supermarket at Barangay Igualdad

As part of the emergency management the ERN has two telephone hotlines in operation with local providers: Ayantel's 168 and Digitel's169. These are complemented by two VHF controls (148.5 and 147.90). Volunteers are equipped with beepers. Calls to ERN come not only from Naga City but also from neighbouring municipalities owing to ERN's lead role (control centre) in the Metro Naga Emergency Rescue Network. Within Metro Naga, an extensive radio network was set up linking all offices of the mayor, the ambulances, and the police and fire stations. Handheld radios were also distributed to key personnel of each LGU. Of the 15 LGU's comprising Metro Naga, only four have fire protection bureaus and five ambulances (Pineda and Buan, no date).

Once a disastrous situation has been triggered the local government react immediately and distribute relief goods such as groceries, roofing and walling materials, medicines and the like to the affected victims even without waiting for assistance coming from the National Agencies. Rehabilitation effort is immediately underway, the materials for housing repairing are distributed almost immediately in order to avoid people become homeless and may return as soon a possible to their normal life (minimising the time in evacuation centres).

Regrettably, despite the warning setting that does exist in the city (at least on paper) during the occurrence of typhoons the warnings about the increased risk of typhoons and floods are given but apparently not heeded at the community level. According to the rapid assessment after typhoon Unding in 2004 many people said that warnings were too general or that measures to be taken were not clear. Warnings are useless unless they are acted upon. Hence according to the local authorities and specialized emergency bodies there is a need for raising communities' awareness on the importance of preparedness and mitigation (CDMO, 2004).

4.4.2.2 Disaster prevention and mitigation

As mentioned the predominant approach to disasters is mostly by relief and rehabilitation. However some measures, mostly structural, help them to minimise the impact of flooding. Some of these facilities are as follows:

- **Improvement of River Flow:** Several projects had been introduced by the LGU of Naga City to maintain the Naga River and Bicol River. These range from the cleaning up of canals and creeks to the improvement of the waste disposal system. Unfortunately, the existence of squatters or informal settlers along the river bank contribute block and pollute the river and impede the cleaning up tasks. The refusal of the squatters to be relocated or moved out of the area also hampers the cleaning/construction works on the river channel and the implementation of the mitigation measures (see Figure 4.10).

- **Construction of Dikes and Embankments:** Dikes and embankments have been constructed to control riverbank erosion and reduce the siltation of the river. The Naga-Calabanga embankment was constructed to fix the river channel and prevent it from siltation. The tidal gates were constructed to avoid the excessive water from the Bicol River flowing to the Naga River. This also serves as a bridge along the Naga River. However, if the tidal gate is closed or blocked by palisades it causes the increase of water level at the upstream which increases the severity of the inundation in the low-lying areas and the City centre.

- **Drainage Improvement Program** is a continuing activity undertaken by the City Engineering Office. It aims to facilitate the flow of water and reduces the duration of water in the area. However, these structures are built without a proper comprehensive plan and sometimes contribute to aggravate rather than solve the flooding problematic (see Figure 4.10).

- **Adoption of Naga City River Watershed Strategic Plan: t**he components of this program are the river park development, relocation of squatters, easement recovery and development, restoration and maintenance of vegetation cover. The easement recovery had started already however; problems have arisen as result of the occupation of the river borders by squatters.

Figure 4.10 Construction (left) and squatting inside the drainages (right) that are built to mitigate the impact of flooding in Naga

4.4.3 Proposed plans for Disaster Risk Management

As embodied by law, the City is responsible for the protection of the people, the City of Naga. Despite the overall lack of legal, political and economic support for implementing prevention and mitigation as strategies for risk and disaster management, a number of initiatives have been developed at local level in cities such as Naga. These projects are trying a more proactive approach to hazards, environmental degradation and risk reduction initiatives. In pursuing the objectives of UN-ISDR the disaster risk management plans are seeking to improve the quality of life for urban communities and not just waiting until disasters take place. The local authorities are progressively recognising that land use that failed to take account of these hazards is not sustainable and could cause considerable losses to the community and harm to the environment.

In seeking to ensure that their community could grow and prosper in a sustainable manner, Naga City officials sought to ensure a close linkage between hazard mitigation and land-use planning. Following a study from the Asian Urban Disaster Mitigation Programme which determined the priority areas of attention, they are crafting a strategy to manage hazards and to prevent environmental degradation in order to uplift the quality of urban life. The coordinated set of activities was formulated in what is known as the Naga City Disaster Mitigation Project (NCDMP) (UN-ISDR, 2002).

The Naga City Disaster Mitigation Project (NCDMP) is a program developed by the Asian Disaster Preparedness Centre (ADPC) under the Asian Urban Disaster Mitigation Program (AUDMP). The major concern of the project was to identify mitigating measures that will help the Nagueños, while promoting the importance of awareness and city planning for all potential hazards. As the first model city in the Philippines, Naga City's project focused on the need to mitigate disasters particularly those triggered by typhoons and flooding. The Naga City Disaster Mitigation Plan was prepared to make the city safer and more liveable. Primarily, it aims to establish awareness and mitigates the flooding and typhoon hazards, promotes policy reforms and standards for mitigation and responses. It focuses particularly on the poor community.

The project (if applied) is aimed to strengthen the capacity of the city to develop and implement disaster mitigation standards and practices by adopting four specific disaster management concepts, namely: a) The all hazards approach, b) The Comprehensive Approach that incorporates prevention, preparedness, mitigation, response and recovery, c) The all agencies approach and d) The prepared community aimed to building resilient communities particularly those in hazard-prone areas. The plan takes into consideration the fact that Naga City, owing to its geographic location, will still be subjected to typhoon and flooding; therefore it was essentially designed to reduce the physical, economic, and social vulnerabilities of the communities at risk and the entire Naga area in general. This was envisioned to be attained through strategies and interventions that would effectively control, minimize and prepare the city to handle typhoon and flooding hazards.

A comprehensive and integrated strategy was designed to simultaneously address the structural/physical, policy and institutional concerns for effective mitigation and management of the flooding problems in Naga within the context of resource limitations. Three major program interventions which are interrelated and supportive of each other were identified as follows:

- Physical/Civil Works Development Program
- Land Use Policy/Legal Reforms Program
- Institutional Development Program

The *Physical/Civil Works and Development Program* is intended primarily to provide mitigation strategies aimed at reducing the volume of floodwaters and duration of flooding through structural/physical measures. If applied the set of proposed measures will protect areas whose flooding is not influenced by the Bicol River up to a 5-year flood magnitude. The areas affected by the Bicol River flooding will likewise benefit from improved drainage that will reduce the duration of flooding to coincide with flood recession time along the Bicol River. The proposed sub-projects under this program include the Naga River Improvement Project, Naga City Drainage Rehabilitation Project and Strengthening Lifeline Facilities Project.

The *Land Use Policy/Legal Reforms Program* is aimed at introducing refinements and changes in the land use planning, policy and pertinent regulations in the existing and planned developments of the city. The primary consideration was to rationalise land use decisions and development directions within the context of flooding constraints. The plan provided a short-term and long-term perspective of the alternative options envisaged within practical and political considerations. Its components included the alternative Naga land use framework, provision of housing for the urban poor that takes into consideration flooding vulnerability, 'on-site relocation' programmes outside the flood hazard zones (FHZ); citywide awareness campaign on zoning and ultimately a flood mitigation alternative growth centre as a long term perspective.

The project ends with an *Institutional Development Program* intended to mobilize and harmonize government and community resources and capabilities towards a cohesive and participatory approach for disaster preparedness. It sought to encourage greater awareness and cooperation by the broad sector of society to provide direction and sustained effort for disaster management by measures such as organizational strengthening, community mobilization and preparedness program; information, education and communication (IEC) program and the establishment of a flood information system for Naga that would provide regular information on significant technical, social and economic parameters relative to risk avoidance, planning, response and monitoring. Furthermore, the information system is envisaged to assist local authorities and communities to formulate adequate information that helps to increase community awareness, protection and provides support for the implementation of mitigation measures (ADPC, 2001).

Although in paper the Naga City Disaster Mitigation Project (NCDMP) looks well conceptualised and designed to date its implementation has not been put into practice or it has been done on a piecemeal manner. Economic constraints but also political pressures and social implications play a role, particularly when dealing with the transformation of agricultural, low lying and natural swampy (flood retention) areas into land for urban expansion and development.

4.5 Floods and Information management in the local government unit

Creating an articulated Flood database system for Naga has been considered one of the significant non-structural measures for flood management proposed in the Naga City Disaster Mitigation Project (NCDMP). If implemented, the aim of such effort should be to count with updated information on critical technical, social and economic parameters relevant to effective disaster risk mitigation and planning, response and monitoring (NCDMP 2001).

4.5.1 The use of GIS and IT within the municipality

Naga was among the first LGU's to extensively computerize operations in the 1980s and adopt the use of the Internet. The city was able to set up its GIS unit in 1993 as a result of technical foreign assistance provided by the United States Agency for International Development (USAID). The city then became part of the Decentralised Shelter and Urban Development Project. The pilot test of the project was called 'Support for Land Use Mapping: Utilising Satellite Imagery and PC-Based GIS for Rapid Land Use Assessment'. The test involved the cities of Cebu, Lipa, Davao and Naga. The city joined the second phase of the project in 1994 during which training was provided on manual methods for data gathering, fieldwork and land use classification schemes (PADCO, 1994). Further technical assistance was provided in 1999 under the USAID GOLD project. By that time the objective was to select standard procedures through the use of GIS for local government units. In Naga city pilot tests for GIS applications were performed for fire risk assessment, building information, real property tax, monitoring socialised housing amortisation, mentoring business permits and nutrition of pre-school children (USAID et al., 2000). Currently most of these initiatives are not sustained as the offices concerned were not able to continue the use of GIS in their operations. Two applications however have remained relevant i.e. the tax mapping and business permits.

Regarding the use of GIS for flood risk management it was known that in the past the Disaster Coordination Office carried out a community survey; it comprised all flood-prone Barangays in which the depth and duration of four storms was collected. A database with this information was created for Typhoon Yoning (1998), Typhoon Monang (1993), Super Typhoon Rosing (1995) and Typhoon Sisang (1987). Inundation maps for these storms were prepared by using the average water level reported in each ward and used mostly for flood warning. Regrettably the data collected during these surveys went missing. Besides, the practice of collecting this type of information after each significant storm and using it for planning and flood risk emergency and risk management was not implemented anymore (Open interview to Disaster Coordination Officer; May 2005)

On the other hand Naga City is among the pioneers in e-governance in the country. Their website (www.naga.gov.ph) has been presented as an example of how local government units (LGUs) can promote good governance and transparency through the use of information technology. At the beginning apart from establishing net presence and presenting a profile of the city, it did not much else. However, in the last years E-Governance re-engineered the website, making it a city-wide concern focusing on using IT as a governance tool. The website has been also used to display layers of spatial information created by the local geographic information system available mainly for presentation purposes.

The maintenance and handling of the website as well as the GIS and spatial information is under the care of the Electronic Data Processing unit of the municipality. This body is also in charge of functions such as the development of the information system for various city government offices and functions, database and network management among others. However as mentioned most of the use given to the local geographic information system is mostly for the updating and printing of existing maps. This spatial information is also accessible to the general public in printed formats at various scales upon request. The maps available range from those showing road networks up to those for land use and leaflets of the flooding hazard maps presented in Figure 4.6.

4.5.2 Problems in utilization of geo-information at municipal level

Unfortunately the efforts required to maintain and strengthen the application and management of GIS as parts of the Local Government Unit routine were not sustained after the USAID project finished. According to PADCO (1994) some of the difficulties experienced by Naga after the training were attributed to the lack of a 'senior champion' capable of moving the applications forward.

By the time this research was carried out the lack of such technical human resource was still existing; from the several offices that were envisaged as able to improve their performances through the use of information technology just one, the City Treasurer's Office, was found as continuously using the existing GPS and GIS existing capacities; especially by keeping a database intended for business permit and tax collection. Other governmental units either had no databases or were just starting to systematise their files. Again others had not organised their records so that they could now be converted into digital spatial and non-spatial information (Cruz, 2004).

Many crucial thematic maps such as the previous land use plan or the current state of the drainage system were found still in deteriorate analogue formats (see Figure 4.11), while other data was not organised in a database structure. Furthermore it was found that the little spatial data that do exist in the municipality is not provided to the wards unless they requested it. As the awareness of the existence of such information among the Barangays captains and officers was very low most of the existing information hardly reached those instances where it could be of some importance for implementing local level programmes and plans.

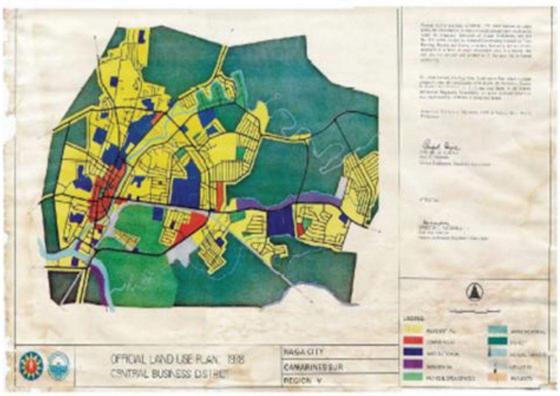


Figure 4.11 Important maps in deteriorated analogue formats (Land Use Plan) illustrate the gap in geo-information management found in the LGU of Naga.

While there existed some information on the occurrence and effects of typhoon/flooding in Naga (from various local government offices and national agencies), data gaps, duplications and problems in effectively utilising and communicating such information were also identified. Efforts to build databases and go digital were undertaken in a piecemeal manner and have resulted in islands of automation within and among units in the LGU. A clear example of the poor advantage taken of the spatial and modelling capacities for decision-making provided by the existing geo-information system at hand was evidenced during the production of the Comprehensive Land Use Plan (CLUP) approved in the year 2000 and the Naga City Disaster Mitigation

Project (NCDMP) in 2001. In both cases GIS was used more to map the terrain and locate some of the existing facilities than to perform spatial analysis.

Although the production of thematic maps such as population density, protected areas, slopes, facilities (schools, hospitals, day care centres, evacuation centres and the like) was useful for several purposes in the formulation of policies such as land use plans and disaster risk management, the potential of GIS as a tool was not fully maximised.

For instance no land suitability assessment was done to help identify suitable areas for conversion or to determine whether a proposed facility or areas for new development were appropriate in terms of flood hazard, accessibility etc. GIS could have been used for instance to map changes in land use over time, to identify areas which topographic level had been elevated and areas where flood behaviour had been reported as modified because of landscape modification.

This is the type of GIS handling and outputs which may help the city in modelling future development, urban expansion and risk disaster management. The crucial effort of collecting, organizing, compiling, checking and making this information available in straightforward formats is a responsibility of the local authority as part of their plans for the security and well-being of the taxpayers.

The local government expressed their openness to the idea of setting up an information system for disaster risk management and seek for ways of improving the GIS and its operation. Naga City local government has been widely recognised for innovations in local governance as evidenced by the many awards it received from local and international bodies. Therefore the enhancement of the already installed capacities for spatial information management should not be extremely challenging. However, the acquisition and use of GIS and EOS to monitor issues such as landuse change, urban growth or to model flood behaviour and hazard is costly.

Acquiring aerial photos or satellite images or conducting on-site inspection can be prohibitive for local government particularly when faced with more urgent problems to solve and scarce resources. The city mayor recognises that the existing data may not reflect the situation at hand and furthermore that the use made of it may not be the most adequate. Yet 'investing an important amount of resources in acquiring geo-information or enhancing the technical capacity of the personnel for the adequate handling and management of the GIS may not look rational when the same money could be invested into programmes for the urban poor' (Open interview to Naga City's Mayor; May, 2005) .

4.6 Profiles of the communities in Triangulo and Mabolo

4.6.1 Selection of the *Barangays* and communities for the research

Within the flood-prone zone of Naga City four Barangays known as Sabang, Tabuco, Triangulo, and Mabulo present the highest susceptibility to flood. As from the flood hazard point of view the four wards were suitable for developing the research, some of the demographic and risk-based aspects shown in Table 4.5 were also taken into consideration in order to decide which of them would become the case studies for this research.

Aspects such as changes in the land use and landscape as well as different urbanization levels were also taken into consideration. The aim was to find contrasting aspects regarding development, urban expansion and socioeconomic context as well as diverse flood related experiences and knowledge among the two communities.

Table 4.5 Demographic and risk related aspects of the most flood prone wards in Naga City

Barangay Features	Sabang	Tabuco	Triangulo	Mabolo
Area (ha)	45.6	156	154	116
Projected number of inhabitants by 2005 (from 1995 census)	6,502	6,240	7,469	6,470
Projected number households by 2005	1,140	1,175	1,500	1,230
Density (persons/ha)	142	40	49	56
Ave family size	5.7	5.3	5.0	5.3
Annual Population Growth rate (1995-2000)	-0.62	-0.58	+0.91	+0.72
Nr Urban poor households in danger zone (flood prone)	568	389	734	850
Nr housing categorised as high risk (light materials)	322 (25%)	43 (5%)	712 (59%)	887 (89%)

Source: Naga City statistical profile; (CPDO, 2000) and Naga City official website (http://www.naga.gov.ph/barangay/)

Triangulo seemed a highly urbanized area which, during the last decade, has experienced modifications in its land use and topography. These changes have deeply affected not just its susceptibility to flooding but moreover the perception and negative effects of flooding among the communities settled there. Mabolo, in contrast, is still a semi-rural Barangay currently experiencing a rapid growth in built-up area. According to the Comprehensive Land Use Plan (CLUP) Mabolo is one of the zones determined as expansion for industrial purposes with the consequent modifications in landscape and topography resulting from the recommended predominant model for expansion in the low-lying area of Naga based on land-filling.

4.6.2.1 Barangay Triangulo

4.6.2.2 General characteristics

Barangay Triangulo is located in the southwest portion of Naga, surrounded by Barangay Tinago in the North, in the South by Barangay Tabuco, in the West by Barangays Dinaga, Lerma and Tabuco and in the East by Barangay Concepcion Pequeña (see Figure 4.12).

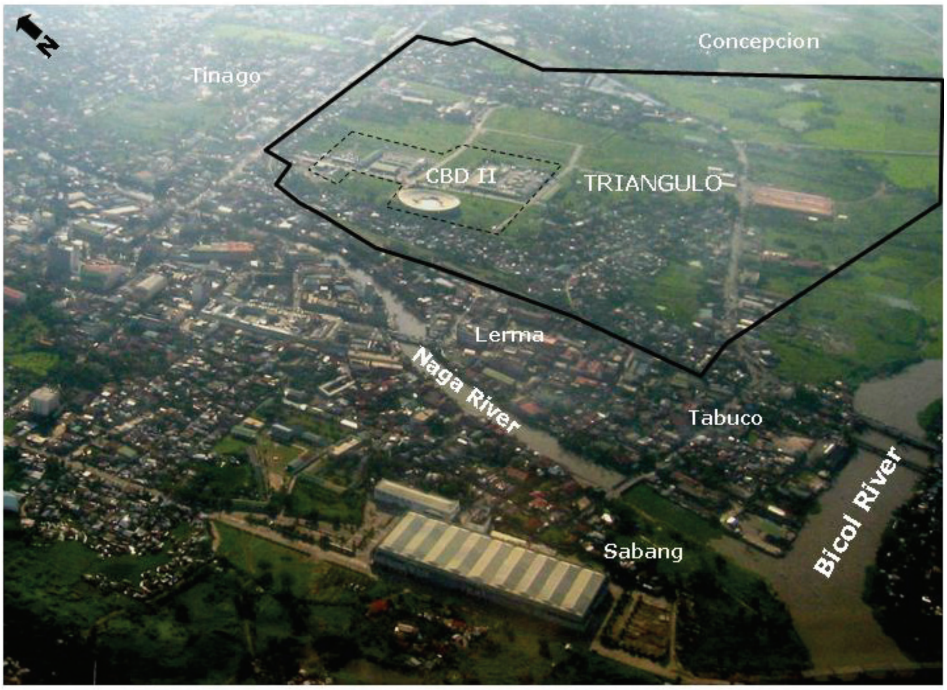


Figure 4.12 Location of Barangay Triangulo in the Naga city context

The total land area of Triangulo is 154 ha equivalent to 1.8% of the total land area of the city; from the topographical point of view Barangay Triangulo is a low-lying nearly flat terrain which used to be part of the Bicol and Naga rivers floodplains.

Administratively the Barangay is divided in seven zones: zones 1, 2 and 7 are located towards the north and northeast in naturally and man-made elevated areas which just experience heavy flooding during extreme events such as the 20-year return period flood. Zones 4 and 5 towards the southwest and zones 3 and 6 towards the south occupy the lowest lying areas and therefore face recurrent flooding (see Figure 4.13).

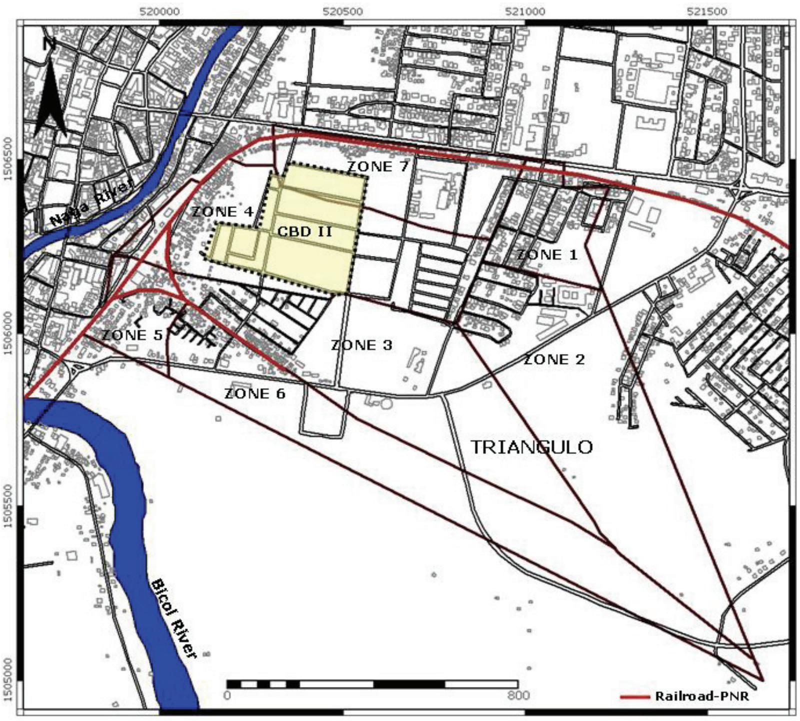


Figure 4.13 Administrative zones of Barangay Triangulo

4.6.2.3 Historical development

Many people remember how Triangulo used to be an open swampy area some 20 to 30 years ago, used mainly for *palay* (rice) cultivation. The area started to be populated after World War II when the employees and workers from the railroad (PNR) made it habitable by placing earth fillings and settled in the area, building homes and forming a community. Since the late 80's and owing to the boom in commercial activities and expansion of built-up areas the ward has experienced a series of landscape modifications. By making use of land-filling practices the terrain where the Naga City stadium, the bus terminal complex and the Central Business Two (CBD II) were built was raised at least three metres from the original ground level. According to ADPC (2001) while these areas were privately owned, they remained compatibly agricultural in use because of the high investment costs of alternative uses i.e. commercial or residential subdivisions (see Figure 4.12).

The high cost of filling and construction plus history of floods were not only disincentives for property owners to build, they made the area unattractive to real estate buyers. Hence, these spaces remained open and green and agricultural in use. As agricultural lands within an urban setting, they were not essential for urban access and so were not integrated into the urban circulation network. Another crucial factor was the government's failure to provide effective flood mitigation measures in those areas.

In fact, they were apparently kept as natural water catchment areas and city drainage systems were oriented to empty into them. For a long time incentives to develop these marsh areas were unheard of. Consequently, these green areas remained open interstices within the urban spread of Naga City both by market neglect and by 1978 urban land use policy.

Yet, the real estate boom in Naga in the late 80s forced owners of large properties to review the utility of their lands versus potential income if these were converted for urban expansion. Costs were still high, flooding was still there but the new incentive was the override of the 1978 Land Use Plan and its corresponding zoning. Where before the government did not pay attention to the open interstices, in the early 1990s, the city promoted real estate-led development and effectively induced realty development in the green areas and vacant spaces. The 1978 Land Use Plan was pronounced to be no longer in effect and zoning liberalization effectively proceeded. Land use on the green buffer zones was reclassified and used to establish the current and projected residential and commercial developments.

4.6.2.3 Land use and main socioeconomic activities

From the 154 ha comprising the Barangay 28% is allocated to residential uses, 53% is being occupied by commercial and business activities and 19% are set for urban expansion or used for marginal agriculture (see Figure 4.14).

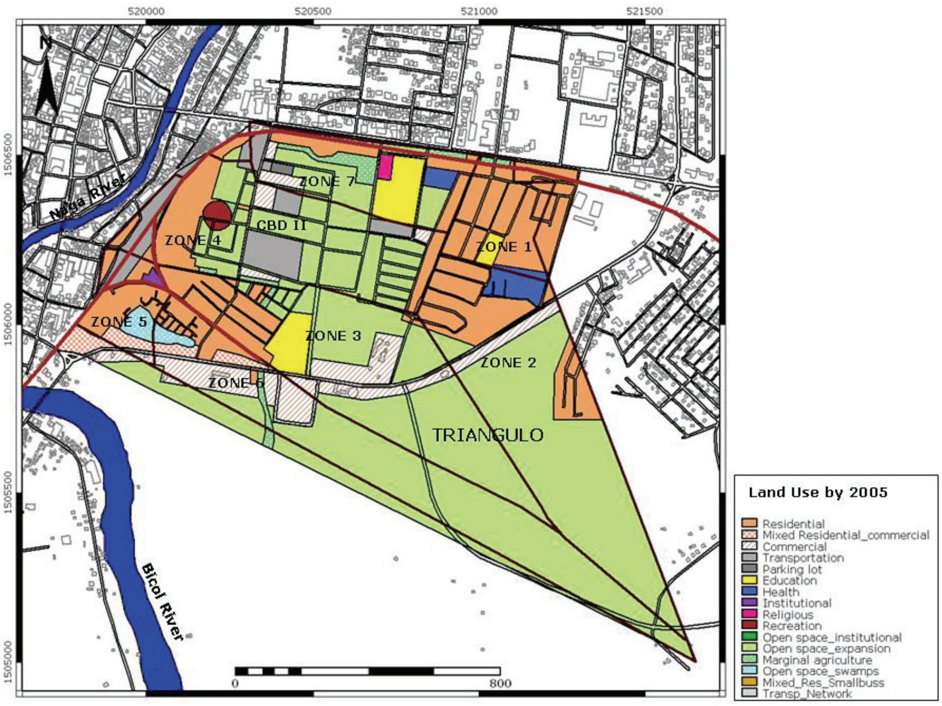


Figure 4.14 Detailed land use in Triangulo mapped during fieldwork (2005)

The main commercial hub of Barangay Triangulo is composed of 35 establishments which include auto repair shops, boarding houses, catering services, eateries and traditional sweet manufacture (*carenderia* of pili nuts), recreation and amusement centres, restaurants or fast foods, bus terminal, jeep terminal, auto supply, advertising shop, construction supply and small shops (*sari-sari*). These commercial establishments contributed a total annual tax due of PhP 155,900 to the City's budget. The City is gaining gross sales of PhP 4.4 million computed annually.

Most of its residents are labourers or work in informal eatery and sweet-making business; some are engaged in general merchandise services and small scale enterprises. Since this Barangay is located at the Central Business District, it is accessible to all kinds of vehicles, may it be public utility jeeps, tricycle or pedicabs.

4.6.2.4 Population and settlement characteristics

With a population of approximate 7,470 by year 2005 and an official average of five to six persons per household it comprises nearly 1,500 family units (Naga City, 2003). The gender development index shows that approximately 50.5 % (3,772) are male and 49.5 (3,698) are female. The distribution of the population by age corresponds to 34.5% or nearly 2,575 children below 14 years old; 61.5% or 4,590 between 14-65 year old and 4% (299) adults above 65 years old.

Regarding the place of origin nearly 50% of the inhabitants have been born in Triangulo, 10% come from other Barangays in Naga and the other 40% has immigrated to the city mostly from poor rural areas in the Bicol Region.

According to the Barangay profile from the total number of households (around 1,500), 12% live in two storey or multi storey residences; 25% have houses with split level and the remaining 63% in single storey houses. As regards the safety of the buildings according to the Naga City Disaster Mitigation Plan the 46% are in the high risk category as they are constructed in light materials, 27% are in medium risk with semi-concrete buildings roofed with corrugated irons sheets, 13% are in low risk with concrete frame with corrugated irons sheets and walls and the remaining 14% are no risk (Naga City, 2003). In this ward a high percentage of the settlers (about 60%) do not have deeds of the land where they are residing.

Regarding the provision of services 50% of households in the Barangay have telephone service (mobile, fixed) and 90% electricity. The drinking water supply is provided by NAWASA.

4.6.2.5 Main flood problems perceived

Triangulo is nearer to the Naga River and has a lower terrain where the water from adjacent Barangays drains. During flooding the highest water depth reported in Triangulo has reached more than eight feet particularly in zone 4 where the most marginalized households dwell. Families residing in other zones are used to experience between five to seven feet water depth during flooding. In these areas some natural depressions still remain, creating a complicated flooding pattern during flooding episodes or even after heavy rains. In zones 1 and 2 however the water depth hardly reaches 1 foot which is minimal compared to the low lying areas.

During fieldwork it was found that people in this ward have a high awareness of the flooding problematic in their area. For most of them flooding is a nuisance yet they consider flood as a natural event that cannot be avoided as it is attributable to the natural configuration of the area. However after the Central Business District Two Project (CBD-II) was built, and the area was allocated for high intensity commercial use, the communities in the immediately adjacent areas started to perceive undesirable effects. Complaints are related to severe flooding where before it was marginal. Some other people have complained of longer duration flooding and increased depths. Yet owing to their few socioeconomic opportunities most of the people do not have another choice than living in this area even if under the constant threat of flooding.

4.6.3 Barangay Mabolo

4.6.3.1 General characteristics

According to the folklore, the Barangay was named after the abundant tree called "*Mabolo*" that used to thrive in this area during colonial times. Geographically, this ward is located on the west side of the Bicol River and bounded in the North by Barangay Sabang, in the East by Barangay Tabuco, in the West by the Municipality of Camaligan and in the South by the Municipality of Milaor (see Figure 4.15).

Figure 4.15 Location of Barangay Mabolo in the Naga City context

The ward is semi-rural with a total land of 116 ha or 1.4 % of the Naga City total area. The configuration of the terrain is 85% plain between 0 to 2 m.a.s.l. and 15% rolling to undulating elevated between 2 to 4 m.a.s.l. This Barangay is divided in 6 administrative zones: Zones 1 and 2 towards the northern part and occupying the elevated portion of the ward; zones 3 and 5 are located towards the east and zones 4 and 6 towards the west and southwest. From them zones 2 to 6 are located in the low lying area and are therefore extremely prone to flooding (see Figure 4.16).

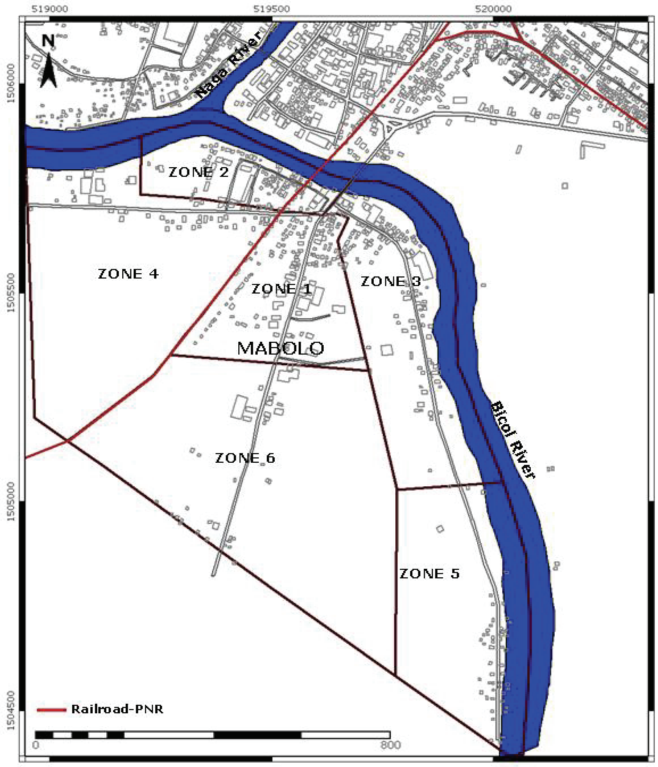


Figure 4.16 Administrative zone division of Barangay Mabolo

4.6.3.2 Historical development

At first Mabolo was only one solid '*sitio*' (small unit of Barangay) occupied by nearly 100 families, located mostly in zones 1 and 3. By that time most of the settlers used to work in agricultural activities for paddy fields (rice) and vegetables, while some others where fishermen or low scale retailers. People still remember how it used to be plenty of Mabolo trees especially in zone 5, 2 and part of zone 3. The Bicol River was clean, with just few water lilies passing by and plenty of fishes.

The processes of urbanization speeded up in the 80's after this land was reclassified from agricultural to mostly for industrial and residential purposes. The booming of urban expansion and construction of commercial projects in Barangays nearby for instance the LCC mall in Sabang also put a lot of pressure on the urbanisation of this ward. The increase in economic opportunities brought a consequent growth in population which migrated mostly from rural areas close by and settled some of them illegally, particularly in zones 2 to 6 (the flood-prone ones) as there were not more land available in the elevated areas in zones 1 and 2.

4.6.3.3 Land use and main socioeconomic activities

From the 116 ha comprising the Barangay 34% is allocated to residential uses, 16% is being occupied by industrial and business activities and 50% are set for urban expansion or used for marginal agriculture (see Figure 4.17).

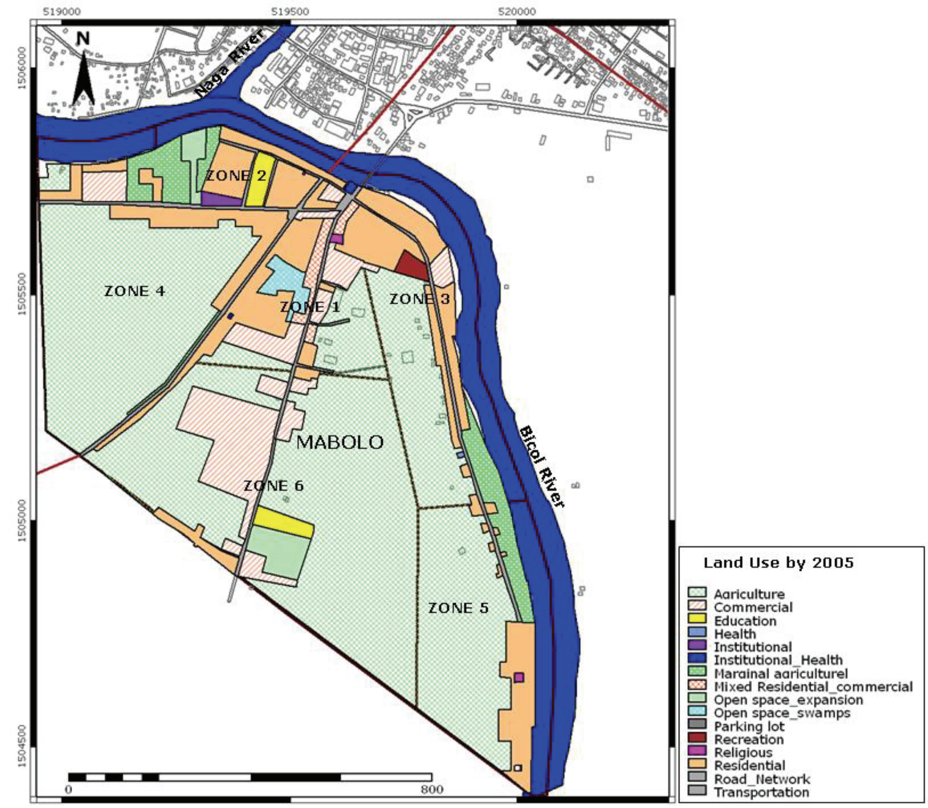


Figure 4.17 Detailed land use mapped for Mabolo during fieldwork (2005)

There are thirty commercial establishments present in this Barangay, including vegetables, corn and rice trade, eateries, general merchandise, lodging house, rice and corn mill, sari-sari stores and vulcanizing shops. These commercial establishments contributed a total annual tax due of PhP 171,200 to the City's budget. The City is gaining a gross sale of PhP 19 millions computed annually (Naga City, 2003).

The means of livelihood for the people in this community are mainly from vegetable farming, selling goods, drivers and labourers, distribution of goods, manufacturer, trade of vegetables or different raw materials, jeep and tricycle drivers and small and large entrepreneurs.

Barangay Mabolo is accessible to all kinds of vehicles. It has a public utility *jeepney* (passenger car for public use), bus and *tricycles*.

4.6.3.4 Population and settlement characteristics

With approximate 6,470 inhabitants and an official average of five to six persons per household it comprises roughly 1,230 family units.

The gender development index shows that approximately 50.2 % (3,247) are male and 49.8 (3,222) are female. The distribution of the population by age corresponds to 34.2% or nearly 2,213 children below 14 years old; 61.7% or 3,998 between 14-65 year old and 4% (259 adults above 65 years old). From the total population 65% were born in this ward, 8% are internal migrants from other Barangays in Naga City and 27% are external migrants from outside Naga mostly small rural areas nearby such as Milaor, Iriga, Pili.

Regarding the features of the settlement out of 1,230 total number of households 8% are living in two storey or multi storey houses, 2% are split level and the remaining 90% are single storey residences. Concerning the risk categories assessed by the Naga City Disaster Mitigation Plan 79% of the dwellings are in high risk which means built in light materials; 18% are in medium risk consisting of semi-concrete building with corrugated irons sheets for roofing; 2% are in low risk with concrete frame with corrugated irons sheets roof and walls and the remaining 1% made in reinforced concrete and were classified as not at risk.

The Barangay is provided of electricity service in 94%, 35% telephone service, the drinking water is provided by the Metro Naga Water District (MNWD) from deep wells.

4.6.3.5 Main flood problems perceived

In Mabolo the highest water depth the community reported as ever experienced reaches 7 to 8 feet. The most severely flooded sectors are in zone 2, 4, 5 and 6 as most of them are located along the Bicol River and owing to the features of the low lying terrain they drain the water from elevated and upstream areas. Zone 6 is land locked and thus inhabitants reported that after floods or heavy rainstorms the water stays for longer periods in this area as could be evidenced in Figure 4.15 where floodwater from a previous tropical storm was still there one month later by the time the picture was taken.

The communities in all the zones of this ward have a high awareness on the occurrence of flooding particularly as a result of high tides and typhoons. The seasonal occurrence of flooding and long-standing stagnant waters constitutes a nuisance for this community. The lack of drainage system is seen as the major problem which otherwise would help the people to 'manage' the situation created by the perennial waters that now act as sources for water-borne diseases.

Chapter 5: Understanding community perspectives of the threat

The aim of this chapter, as well as of the next two (Chapters 6 and 7), is to present a practical application of how the knowledge existing among 'at risk' communities, may enhance hazard identification and assessment and provide local authorities and communities with contextualised information for the further disaster risk management process. Chapter 5 constitutes the initial step for risk assessment. The experiences of the people living in a flood-prone environment and dealing with the continuous threat of flooding are elicited and structured in such a way that they provide a picture of the flood problem at hand and become primary inputs for further modelling and analysis.

5.1 Introduction

According to the conceptual framework adopted in this research floods and strong winds will become a hazard when, either combined or in isolation, any of their physical characteristics can adversely interact with a given community (the vulnerable element for this research); and cause direct or indirect damage and disruption to their everyday life. In order to implement the perspective of a community into flood hazard identification and assessment proper tools are required that support the elicitation of their experiences and interaction with floods. The analysis should also consider how the presence or absence of socioeconomic resources, warning systems, self-awareness and coping strategies determine the way that hydrological events become a hazard for certain groups within the communities and why.

The diverse analyses presented in this chapter were conducted in the form of participative assessments. The communities in the study area are familiar with the seasonal occurrence of flooding and therefore have developed their own approach for identifying the type and timing for the occurrence of various flood episodes and the way in which they interfere with their own 'normal' life. By means of interactive exercises and workshops the participants themselves identified, evaluated and ranked the events that usually pose a threat to them. They also described how flood episodes are forecasted, experienced and 'managed' in their localities. These interactive methods allowed the researcher to get a closer understanding of flood hazard and furthermore to structure it into basic concepts and parameters related to timing, intensity and manageability of flood events that could be further implemented into flood risk assessment.

As mentioned before, the performance of this type of exercises was facilitated by the fact that the communities selected as case studies have developed their own 'risk-related' knowledge. By being settled in an area where the geographical setting and geomorphic configuration determines the incidence of seasonal storms, strong winds and especially flooding this knowledge is developed by a cyclical confrontation of the people in these wards and the different hydrological events. This knowledge was found at all levels - from households to municipal officers. This general awareness is constantly reinforced and updated by daily weather forecast information disseminated by the media and the official institution in charge (The Philippines Atmospheric, Geophysical and Astronomical Administration - PAGASA).

5.2 Seasonal distribution of flood perceptions

People living in Barangays Triangulo and Mabolo, and Naga City in general, have a good understanding of the hydrometeorological cycles that their region experiences every year. In fact one may say that many aspects of their 'daily life' are ruled by these cycles. Their year, for instance, is clearly divided in the 'dry' or summer season (starting from late January to early May) and the 'wet' or rainy season which lasts around nine months from May, when the first rains arrive, until January when the monsoon, and associated typhoon season, ends. For them it is a fact that every wet season will bring associated phenomena which, either combined or in isolation, will trigger floods that may affect their locality. In consequence the annual rainy season is further differentiated according to the periods in which they may expect a given type and magnitude of flooding to happen.

Figure 5.1 illustrates the communities' perception on the relationship among customary hydrometeorological events and potential occurrence of flooding across a year. It can be seen how concerns related to the potential occurrence of flooding remain low during the first quarter of the year (dry season) and start increasing in late May, when weather-related events start to take place. In June this perception increases with the arrival of the first rain showers brought by the monsoon. It then reaches its maximum in the last quarter of the year as the typhoon season advances and the ground is already saturated and streams have swelled.

This schematisation of community risk perception is highly linked to the hydrological patterns found for the region, when at the end and beginning of a year there are high possibilities that some events occur simultaneously, as result of the coincidence of heavy precipitations and strong wind patterns. During the workshops the phenomena identified as likely to trigger flooding were as follows:

1. High tides
2. Heavy rains which may trigger riverine slow onset or flash floods
3. Typhoons or Super-Typhoons differentiated among those that bring mostly rain, strong winds or a combination of both (see Figure 5.1).

From Figure 5.1 it can be seen how from the perspective of the participants in the workshops there is high correlation between the division of a year, the potential occurrence of hydrological phenomena and the type of flooding that can be triggered. During the dry season none or minimal flooding is expected and therefore their perception remains low, yet it increases parallel to the arrival and development of the wet season reaching the maximum during the 'typhoon season'.

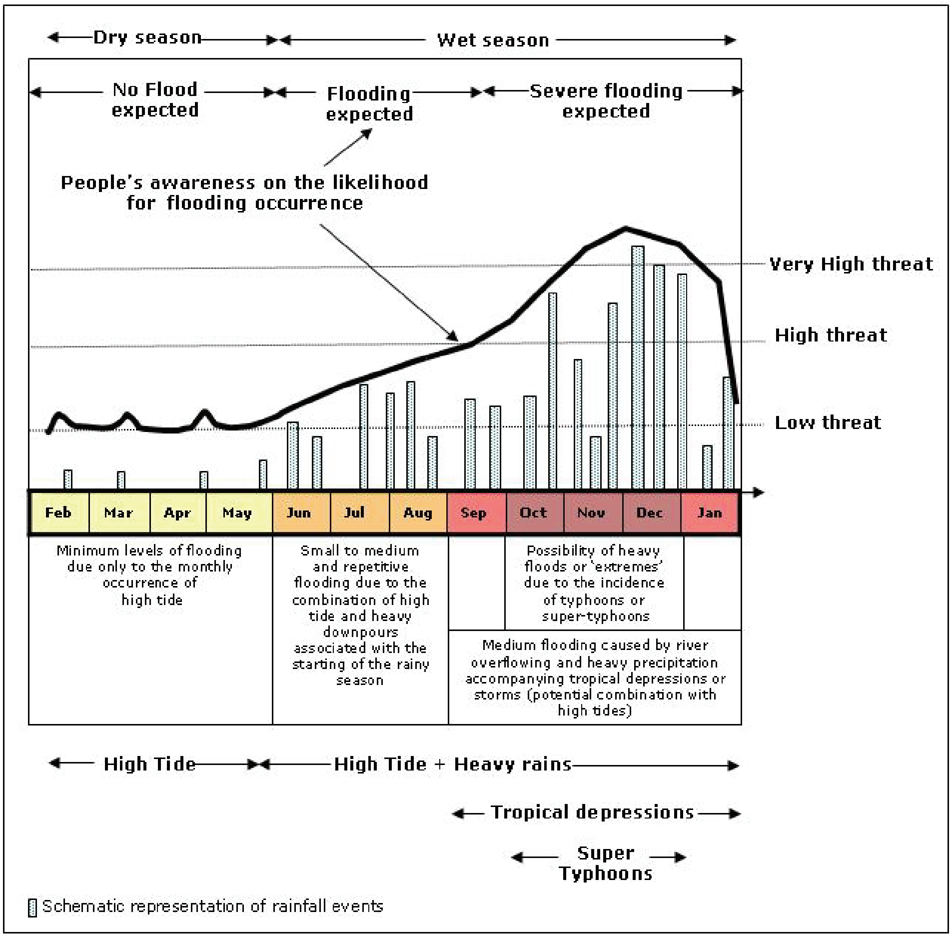


Figure 5.1 Community perception on the relationship between weather-related events and flooding in a yearly time frame.

Although the people in these communities accept that floods and difficult times are highly linked, they also perceive that disasters or calamities have their origin not only on the type of flooding. They are perfectly aware that, besides flood magnitude and recurrence, the character and extension of the impact is determined by the availability, or scarcity, of social and economic resources and opportunities as well.

According to the people in these communities the cycle of wet and dry periods is highly liked to the high or low availability of sources for their economic survival. Moreover, depending on the time they occur inundations may represent a serious threat for the people in these areas because they can interfere, and even impede, the social and economic activities that people require for the pursuit of their 'daily life'.

5.3 Influence of flooding on the wellbeing of the community

As in many tropical areas, in Naga the starting of the rainy season is marked by heavy downpours and thunderstorms that may last from a few hours up to several days of continuous rainfall. In the study area the transition from dry to wet season is not just marked by increasing precipitation; according to the local officers the rainy season is often accompanied by a general decline in the wellbeing of the community. In their perspective the wet season is characterised, among others, by poorer health conditions, an increase in weather-related and water-borne diseases, and reduced economic opportunities. Yet the main characteristic of the wet season is the reduction of their wealth which compromises most of the aspects of their 'normal' life.

In Naga, as in any urban economy, little can be obtained without access to money; and labour is a critical asset. In the researched wards most of the people live on a daily basis and earn their livelihood from unstable, temporal or informal jobs. Consequently, any event or situation that interferes or hinders the regular access to economic activities represents a threat. Nearly all money-making activities carried out in these areas are vulnerable to weather conditions. Such susceptibility is related to the nature of the outdoor activities (i.e. street selling, recycling, and collection of scrap material); the dependency on the affluence of potential customers (sari-sari stores, eateries, tricycles) or the need for fairly good weather conditions for their performance (for instance building construction, maintenance, painting, farming and the like). If heavy downpours occur for several days outdoor workers have to completely stop their economic activities, and have less working hours or even days.

This decrease in working time and opportunities almost immediately results in less income to spend on their basic needs. People do not just fear the arrival of the wet season because of the potential flooding or typhoons it may bring but most of all because they coincide with the arrival of the 'hardship' period. One of the interviewees was straight to the point when clearly stating how '...*poverty starts with the rainy season'.*

One of the first workshops performed in the Barangays focused on identifying this so-called 'hardship' time. The period from August to early January was described as the segment of the year in which life becomes 'even tougher'. Difficulties during the last part of the year were described as partly originated in: a) the end of the growing season (when many people are engaged in rice farming-related duties), b) reduction in the demand of manpower for the construction sector c) widespread decrease in earnings until the next dry season when chances for stabilising their economic situation start again. This difficult period, however, has some breaks or 'windows of opportunity'; one of them is represented in the celebration of the religious 'Peñafrancia' festival that together with lots of tourist and devotees, brings economic opportunities to Naga; the other is related to the second main harvest of rice (*palay*) that occurs during late September- early October (see Table 5.1).

Table 5.1 Relationship among hydrological and 'wellbeing' cycles for both wards in the study area

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Flooding probability in Rainy/typhoon season	**L**	**L**	**L**	**L**	**M**	**M**	**M**	**H**	**VH**	**VH**	**VH**	**VH** **H**
Hardship period in Barangay Triangulo								**PF**				
Hardship period in Barangay Mabolo								**PF**	**RH**			

L=Low, M=Moderate, H=High and VH=Very High probabilities for flooding.
PF= Peñafrancia Festival
RH= Rice harvest

However if rainstorms or inundations coincide with these periods, as was the case with tropical depression Labuyo in September 2005, these chances are missed too. In this respect it was found how losing the rice harvest as a result of flooding had a very negative repercussion for the community in Mabolo ward; firstly for it constitutes a staple food for the families and secondly because in this semi-rural area many households still make their living from this agricultural activity.

The combination of adverse weather conditions, the marginal way of living and fewer opportunities during the long 'wet' season keeps people in these communities in a seasonal cycle of scarcity and survival. Whichever savings and economic reserves households are able to build up during the short dry season become easily exhausted because of the precarious conditions they face during the long-lasting hardship period. Although this situation may also be experienced by other urban poor communities (i.e. those settled in higher lands) the destitute living in low-lying areas have to face not just the constant threat that poverty represents to their 'every day' life (i.e. malnutrition, sickness and homelessness) but the additional threat posed by the repetitive occurrence of floods.

5.4 Awareness, coping and seasonality

Owing to the fragile social and economic conditions present in these two wards there is no requirement for the occurrence of rainfall, flooding, high tides or strong winds with 'extreme' magnitudes to represent a serious threat to the wellbeing of the households. Either combined or in isolation almost every weather-related event has the capacity to disrupt the 'normal' life of these communities in ways not always easy to perceive by outsiders but well known by their vulnerable members.

Eliciting the experiences and, moreover, the perceptions that people in these communities have on the threat that these 'likely to occur' events represent for them was deemed important for this study. By means of several participative exercises with local authorities, leaders and residents from both wards it was possible to identify and moreover to differentiate the elements that shape the way in which the threat from inundations and typhoons is perceived.

Understanding the hazardousness embodied by this type of events required not just determining the way in which inundations and typhoons take place in every ward. It also involved understanding the role played by official and community-based warning systems, the existence of awareness at community level and moreover the efficacy of the social and economic mechanism available at household, ward and municipal level. Jointly these elements may determine the degree of disruption experienced as result of flood events.

5.4.1 Warning signals and community awareness

Flooding episodes in the Philippines are often associated with the arrival of the monsoon rains. This fact is fully acknowledged by all governmental and institutional levels resulting in the fact that the existing official warning system remains active throughout the whole year. The Philippine Atmospheric, Geophysical and Astronomical Administration (PAGASA) continuously watches the environmental conditions and prepares daily forecasts, typhoon watches and flood outlooks that are issued by the media. Depending on the Meteorological conditions the Storm Signal may go from Signal Number 1 for Tropical Depressions to signal Number 4 when an intense typhoon or Super-typhoon may hit the region (based on expected levels through forecasting) as shown in Table 5.2

Table 5.2 Cyclone or Severe Weather warning signals for the Philippines according to PAGASA

Public Storm Signal	Weather Conditions	Wind Speed (Km/h)	Time	Precautionary Measures
No. 1	A tropical cyclone will affect the region	30 - 60	At least in 36 hours	-People are advised to listen to the latest Severe Weather Bulletin issued by PAGASA every six hours at 5:00 a.m., 11:00 a.m., 5:00 p.m., 11:00 p.m.
No. 2	A moderate tropical cyclone will affect the region	>60 to 100	At least in 24 hours	-The sea and coastal waters are dangerous to smaller sea crafts. Fishermen are advised not to go to sea. -Travelling by sea or air is risky. -Stay indoors. Secure properties.
No. 3	A strong tropical cyclone will affect the region	>100 to 185	At least in 18 hours	-People are advised to evacuate and stay in strong buildings. -Stay away from coasts and river banks. -During the passage of the 'eye' do not venture out of a shelter. -Suspend classes for all school levels. -keep children in the safety (strong buildings).
No. 4	A very intense typhoon will affect the region	Very strong winds >185 kph	At least in 12 hours	All the previous ones plus: -Cancel all travel and other outdoor activities. -Stay safety of houses or evacuation centres.

Regarding flooding the Bicol River is continuously monitored by a local telemetric network established by PAGASA across the basin. Data on rainfall and real-time observations of water depths are collected by a telemetric system in the Camaligan station close to Naga City and then transferred to Manila from where the warning signals (herein based on actual levels of the river) are sent back for dissemination across the media. Flood warning bulletins are issued locally when there is a real threat of flooding, in the case of Naga the Local Government Unit has set-up three alarm levels based on river levels measured by the local station along upstream gauges as follows:

- **Alarm Level**: Flood depths between 1-2 feet
- **Alert Level**: Flood depths between 2.1 – 3.5 feet
- **Critical Level**: Flood depths above 3.5 feet

During the wet season the people in the studied wards carefully follow these forecasts; furthermore one of the duties of the Local Barangay officers is to make people aware of the warning signals. This notification becomes particularly useful for people settled in those zones more prone to experience severe flooding and for the poorer households which usually have no access to the media (TV, radio, mobile phones, internet).

Yet, during the workshops it was found that people in the two communities have developed their own parameters and thresholds for monitoring the evolution of flooding episodes. In Table 5.3 the community-based warning levels drawn during one of the workshops in both communities is presented.

Table 5.3 Community-based warning levels and some protective mechanism 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 plastic wrapping of valuable items/appliances 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 raising *above knee depth*	-Listen to radios/TV for forecasts. -Install '*papag*' (movable table) for protecting items. -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. -Local officials ask the Municipality to assist the residents for potential evacuation with trucks.
NO. 3	Signal No 3 + Water at *Waist depth* + strong winds	-Husband or eldest son stays behind to guard the house. -The households that still refuse to evacuate go to roof tops. -Local officers guide people to evacuation centres and make roll calls to count the evacuees. -Some people still at their homes are evacuated. -Light/electricity is cut-off. -Ward and Municipal officers go on rescue usually by means of '*banca*' (wooden boat). -Local officials visit residents that are still in their houses.

The results presented in Table 5.3 show that even if people follow the official warnings they also incorporate their own parameters to monitor the flood behaviour and determine which mechanisms for self-protection are to be followed and the moment to do it. From the second column in this table it can be seen how the community-based system has been developed by people relating the official warnings from PAGASA with their own 'reference parameters' which consists of the association of a person's own body parts with the progressive depth reached by floodwaters. By using this simple, yet useful, 'warning system' local officers and lay people do not exclusively depend on external alarms to start taking precautionary measures. Instead they are able to use their own awareness system which has helped them to survive the continuous and direct confrontation with floods of different origin and magnitude.

Table 5.4 registers the most frequent 'reference' levels found during several fieldwork activities as used by the people to indicate and refer to floodwater depths. Measurements carried out during the mini-survey verified how, in general terms, these reference levels comply with the average Pilipino or '*Pinoy'* Mean Height Values of 1,61 m for males and 1,50 m for females estimated by the WHO and FAO Organisations (see Figure 5.2).

Table 5.4 Community-based reference system for flood depths and their approximate equivalence in English and metric systems

Community-based flood depth reference level in correlation to a person's body parts	**Equivalence in the U.S. system**	**Equivalence in the metric system**
Ankle depth	< 1 foot	< 20 cm
Knee depth	1-2 feet	40 – 60 cm
Hip depth	< 3 feet	70 – 90 cm
Waist depth	3- < 4 feet	80 – 100 cm
Chest depth	<4 - < 5 feet	110-130 cm
Chin-eye depth or higher	> 5 feet	> 150 cm

As discussed during the workshops the average of 10 cm difference in height between men and women may determine differences in the perception of hazard. In order to minimise the inconvenience this could cause the participants agreed and expressed the water depths in ranges, rather than in absolute or sharp values.

The use of the 'community-based' reference and warning systems constitutes a 'practical' approach to monitor the evolution of an ongoing inundation. By these means Barangay officers, but more important the households, are able to weigh up the threat not just for themselves but also for the zone where they are settled and even the whole ward. Additionally these reference levels are identified as 'thresholds' for the type of activities they can carry out. For instance below *Knee depth* is the level until which they can continue performing most of the activities of their 'normal' life, *Hip depth* is associate with the feasibility to still wade in the floodwaters, while water reaching *Waist depth* is the moment for total evacuation.

Figure 5.2 Measurement of Community-based reference levels for flood depth in Metric and american systems during workshops

5.4.2 Flood coping strategies and decision making

As previously shown in Figure 5.1 it was found how among these communities there is an increased awareness on the high potential for flooding during the last part of the year; which in turn helps people to activate diverse self-protection mechanisms to avoid losses from the occurrence of floods.

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

Through workshops, Focus Group Discussions and open interviews it was found that before, during and after a typhoon or flooding strikes a series of coping or self-defence strategies are performed at household level. A detailed inventory of the main coping strategies found among the communities in the study area is presented in Table 5.5 and some of them are illustrated in Figure 5.3.

From this list the high familiarity that people have with flooding occurrence becomes evident. It can be seen how people have developed several strategies for almost every aspect of their everyday life. Depending on their location and their socioeconomic situation each family follow a plan intended firstly to protect their lives and the one of those more vulnerable, secondly their health and wellbeing status and finally their houses, assets and valuables.

Table 5.5 Coping mechanism found in the study area to avoid disruption of some of the main aspects of daily life

Aspect of daily life	Before Flooding	During Flooding	After flooding
Housing	-House in reinforced materials or 2 storeys. -Elevate part of the house/ built mezzanine (Figure 5.3 A - B). -Reinforce wooden/ thatched houses by tying it with wires or nylon. -Reinforce pillars. -Nail walls, windows and put heavy items (tires, sandbags) on top to protect roofing. -Prepare second hand or scrap materials for repair after event.	-Secure housing access to avoid debris and waste intrusion. -Vacate the house to avoid life loss.	-Source relief materials -Repair damages to houses. -Drying of walls with electric fan to avoid deterioration. -Repair house by family members to avoid cost of labour. - 'Leave as ir is'. - Repair the damages little by little. - Earth-filling to elevate room levels.
Livelihood	-Look for additional sources of income. -Stocking shops to have enough supply for selling. -Elevate shop buildings -Save money. -Increase working hours. -Purchase business stocks and agriculture products (farmers). -Gather seeds for next planting season.	-Stop working outdoors. -work overtime. -look for jobs in flood-free areas to meet family needs. -Temporary change in business location (second floor, roof or other safer place). -Use Savings.	-Look for alternative job -Swap labour for food (in farms). -Sell stored items on credit. -work overtime. -Selling of scrap material from damaged houses. -Borrow money from relatives, friends, con men or government. -Pawn appliances and other valuables. -Ask for livelihood to community members.
Food	-Buy stocks to avoid scarcity and increasing prices. -Store basic non-perishable food items (rice, sugar, salt, canned goods). -Collect/store wood for fire and cooking.	-Purchase cheap food items or food stocks in bulk. -Procure cheaper cooked food items in the market. -Buy food items at nearby stores. -Bring enough food to evacuation place	-Change in diet by eating cheaper food. -Decrease in food intake -Fetch wild edible foods. -Lessen cooking time. -Place stocks in containers to avoid damages by rats. -Collect relief items from LGU and NGO's.
Health/ Sanitation	-Purchase nutritious food. -Store drinking water to avoid diseases. -Do not buy perishable goods. -Buy first aid medicines.	-Boil water to avoid illnesses (polluted water). -Practice proper personal hygiene. -Prevent kids from going out/playing amidst floodwaters. -Dispose wastes in plastic bags	-Consult health workers for sickness or injuries. -Ask for medicines to Barangay or NGO's. -Clean the house and surroundings. -Boil drinking water. -Avoid or thoroughly wash after direct contact with stagnated waters. -Avoid use of pumped water for consumption and domestic use.

Safety of Belongings	-Construct/Install mezzanines (see Figure 5.3 B). -Arrange/improvise storage at 2nd floor. -Get metal hooks to hang items. -Build stands for refrigerators and heavy items. -Prepare waterproof containers. -Pack and plastic wrap valuable items/ appliances to be put in safety. -Assemble "papag" (improvised temporary table). -Fix things before evacuating.	-Place belongings at mezzanines, second floor or waterproof containers. -Assemble tables or "papag" (improvised platform). -Hang things using metal hook. -Place appliances at relatives, neighbours or evacuation places. -Take, livestock, poultry and vehicles to elevated roads. -Guard the house to ensure safety of belongings.	-Repair minor damages of appliances. -Dry wet things with an electric fan. -Clean items from flood dirt.
Mobilisation	-Prepare banca (rustic boat) or knowing who owns one among neighbours. -Assemble improvised floaters. -Prepare improvised walkways. -Get ready clothes for walking in the flooded area.	-Place improvised walkways. -Wear flood suitable clothes like shorts and waterproof boots. -Do not walk barefoot to avoid injuries. -Construct makeshift raft. -Build improvised floaters (basin or cans) to carry heavy stuff. -Use boat to mobilise inside the Barangay.	-Do not go out unless necessary. -keep the walkways until is dry (see Figure 5.3 F). -Do not walk barefoot in areas full of debris to avoid injuries.
Overall Safety	-Rise awareness along the rainy/typhoon season (June-Dec). -Follow PAGASA forecast/broadcast through radio/TV . -Participate in community programs for cleaning of the ward and drainage system (RABUZ). -Proper waste disposal. -Ask in advance for temporary refuge at relatives or friends in case of flooding.	-Follow Official safety instructions. -Stop sending children to school. -Reduce frequency of going out. -Evacuate to closest safer area i.e PNR train coaches and along the highway. -Evacuate children, women and elders to temporary shelter at neighbours, relatives place or City Government evacuation centres.	-Solicit support from relatives, friends, or City Government. -Cleaning the canal. - Clear surroundings of debris and dangerous materials. -Helping community members in repairing works. -Participate in community recovering activities.

Figure 5.3 Illustration of the coping strategies for flooding and typhoons in the study area: A and B) Elevated storeys and mezzanines; C and D) Retrofitting of roofs and walls; E) Reaping of wild edible foods; F) walkways G)Loan and pawn shops; H)Relief from the Local Government and NGO's

Aside from the normal protection of life and valuables the analysis of the coping mechanism listed in Table 5.5 several other important conclusions could be drawn. For instance, it was found that even if most of these strategies are temporal or put into practice when the arrival of flooding or a typhoon is imminent, mechanism such as elevated buildings or houses built on stilts are permanently integrated and even characterise the life style of the communities in these wards (see Figure 5.4).

Figure 5.4 Elevated houses as a strategy to minimise exposure to flooding

Depending on the degree of disruption caused several of the coping mechanisms, that were initially meant to deal with a given event, may become permanently incorporated in the households' daily life. For instance, as during inundations vegetables and groceries become scarce and expensive then reaping wild edible crops is a strategy performed to complement the diet of the family (see Figure 5.3 E). 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 apply for 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.

Diversification of livelihood, extending working hours and changing of work and workplace were found as strategies that the households perform in order to increase or extend their economic resistance. In this way they also avoid having to use their savings (if any), borrowing money or selling/pawning valuables such as their few appliances or livestock that most of the times constitute their reserves for other 'critical times' such as illness, unemployment and death.

The moment in which to start performing most of these coping or self-defence mechanisms is based on the severity of the official warnings, the current status of the weather and the knowledge of the household on the potential evolution of the flood or typhoon event in their sector. When a given flood level is reached, for instance when the floodwaters are at '*Ankle*' depth the members of the family start a process of reasoning and decision-making that should lead them to adopt one or several of the diverse protective mechanisms known or at hand.

Based on the activities performed during the workshop for hazard identification it was possible to develop the scheme on Figure 5.5 which shows some of the aspects of the decision-making process performed by the households in the study area (while flooding reaches consecutive stages: Ankle, Knee, Waist, Chest depth and above).

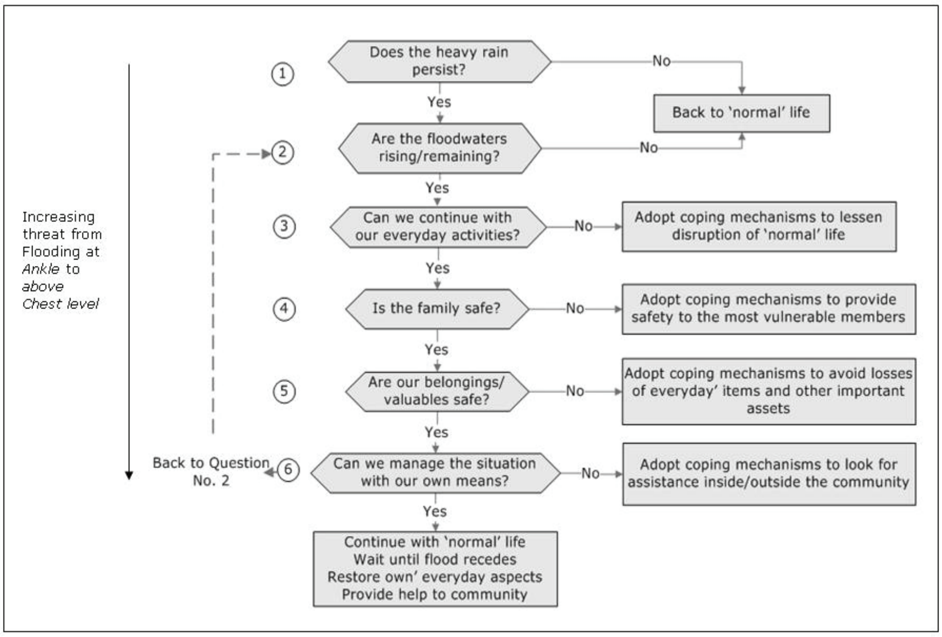


Figure 5.5 Decision-making process performed by the households while flooding reaches Ankle, Knee, Waist depth and above.

By answering these questions 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 how most of the times the households try to delay the evacuation of family members and the shifting of belongings to flood-free areas until the last possible moment. This reluctance to evacuate is related on the one hand with the fact that most of the official evacuation centres are located in the flood-free area far away from these communities; thus people are compelled to stay away from their residences and work place. On the other hand people always hope the situation will 'improve' and therefore they can easily get back to their activities (especially those related with 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 velocity at which flood is raising and the depth of the floodwaters. As previously explained most of the times flooding in these areas is not sudden therefore at least during the first flood stages, *ankle* and *knee* depth, people perceived 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 on weak materials). Yet if the water rises fast or reaches further than knee depth then the family safety becomes the first issue to be solved and then the order of questions 3 and 4 is reversed.

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

- ***Flood behaviour in their own zone*:** the awareness about the possible depth and duration a given type of flood in the surroundings of their house according to previous experiences.
- ***Perceptions of their own spatial location in relation to flooding***: determined by the consciousness about the local variations in the topography of the zone in which their residence is built and the closeness to the paths of flooding.
- ***Awareness on their own levels of physical exposure***: determined basically by the safety that their house can provide to the family members and belongings.
- ***Perceptions about their own socioeconomic capacity*** or resistance to absorb the progressive impact caused by the succession of flood stages.
- ***Awareness on potential environmental problems*** in their area associated with the presence of pollutants, human and animal waste.
- ***Perceptions on 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.

The evaluation of these factors helps to understand the potential plan to be followed by a given household as a result of the decision-making process illustrated in Figure 5.5. The more fragile the status of the family and the smaller their resources the earlier they have to give a negative answer to questions 3 to 6. Furthermore, the situation in which the most vulnerable households may feel they are not able to manage the situation with their own resources does not require the occurrence of a large flood event. 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 decision-making process, particularly for questions 3 and 6, will be asking for external assistance, a state perceived by many families as '*nearly a calamity*'.

5.4.3 Community perception of flood severity

From the workshops and interviews it was found how the duration of flooding (in days or weeks) and the time that floodwaters may remain stagnated also contribute to shape the perception on the threat among these communities. According to the people, the combination of water depth and flood duration is critical. Even small, repetitive and moreover long duration floods can strain the socioeconomic resistance of these communities to the point of disaster.

Part of the activities carried out with the local authorities, leaders and participants in the workshops were meant to characterise the hazardousness represented by the combination of flood depth and duration during a given inundation. Based on their experiences, the participants characterised the threat posed by flooding with progressive depth and duration and the disruption to their normal activities and life. Figure 5.6 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.

Table 5.6 Community-based categories of flood threat in relation to water depth and duration from Triangulo and Mabolo wards

Barangay Triangulo			
Duration / Depth	**1 to 3 days**	**3 to 7 days**	**> 7 days**
Ankle	Normal	Normal but displeasing	Disturbing but they have to get used to the situation
Knee	Disturbing but Manageable	Disturbing	Intolerable
Waist	Hardly Manageable	Highly disturbing	Disastrous
Chest	Unmanageable	Disastrous	Disastrous
Above Chest or Chest + high wind	Disastrous	Disastrous	Disastrous
Barangay Mabolo			
Duration / Depth	**1 to 3 days**	**3 to 7 days**	**> 7 days**
Ankle	Normal	Normal	Disturbing (skin diseases)
Knee	Manageable	Highly disturbing	Unmanageable
Waist	Intolerable	Unmanageable	Disastrous
Chest	Unmanageable	Disastrous	'*Calamidad*' (Calamity)
Above Chest or Chest + high wind	Disastrous (even if lasting less than 5 hours)	'*Calamidad*' (Calamity)	'*Calamidad*' (Calamity)

From Table 5.6 some slight differences can be noticed from the way in which people from the two wards refer to the threat represented by flooding with different depth and duration. However, these differences were found to be more related to the wording used or the label given to each flood 'stage' as the problems were found to be fairly similar. On the other hand, and regarding the boundaries among categories, it should be emphasised how in terms of water depth and duration the limits are not sharp or abrupt.

As the dotted area in Figure 5.6 indicates the transition from one situation to the next may present some fuzziness in time and water depth. The transition will depend among others on the way in which flooding is taking place, the moment at which it stops and moreover the effectiveness of the coping strategies at hand. Some households, for instance, may find they can '*manage*' a 60 cm flood level (above *Knee* depth) for four days as long as it stops raining on the second day and the flood starts receding.

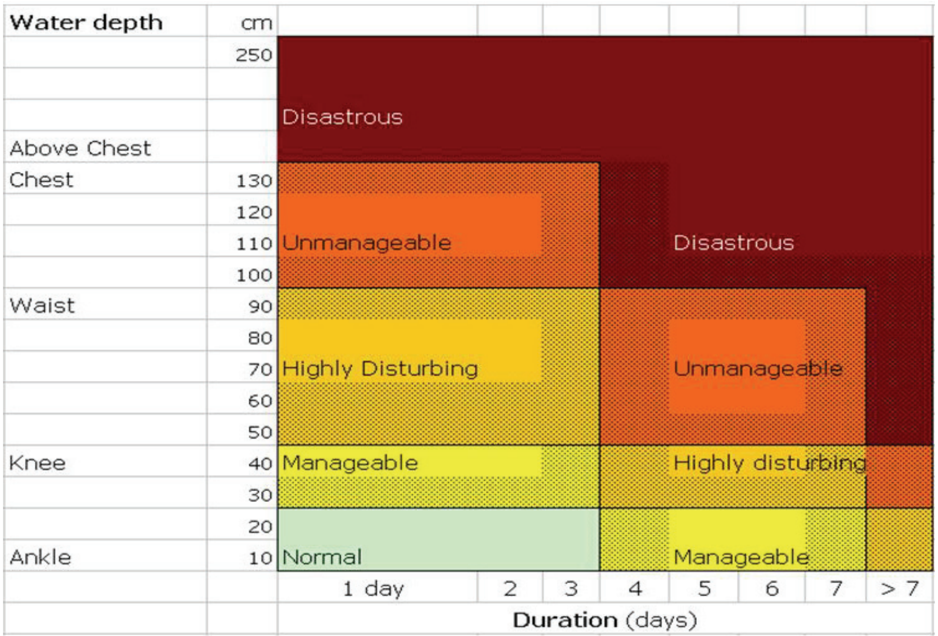


Figure 5.6 Graphical representation of the flood hazard perception by the two communities in relation to floodwater depth and duration

In Box 5.1 some of the differences in flood hazard perception and 'manageability' found during fieldwork are illustrated. These differences depend on the location, socioeconomic status, the coping strategies available and their effectiveness among others.

Box 5.1 Differences on Flood hazard and 'manageability' witnessed during Tropical Depresion Labuyo (September, 2005)

In September 2005, the confluence of Tropical Depression Labuyo and high tide triggered a medium magnitude flood in the lowest-lying wards of Naga. After nearly three days of continuous rains these communities experienced flooding below the *Waist* depth (around 70 cm). During this time it was found that people in the elevated sectors of the study area perceived the inconvenience created by the persistent rains as *Normal* and *Manageable,* in the lowest-lying zones several families -mainly poor elders and some with small children, were ready to evacuate; a strategy performed only when people judge the ongoing situation as *Highly Disturbing* or *Unmanageable.*

As on the third day the rains stopped and the flood started to recede people went back to their activities and finally no evacuation to official places took place. Yet one elderly couple interviewed explain how they were ready to evacuate as remaining in their ground-level house while the rain continues and the water reaches higher depths will represent an extremely high risk for them. Their marginal status do not allow then to further elevate their house, besides the husband is seriously ill and the wife just can make a living from washing other people's clothes. During rainy days she is not able to work and no money is available for their basic needs. Moving early to evacuation centres is a coping mechanism for them as in their own words 'at least there they can assure a bowl of rice during these harsh days'.

For determining the threat represented by these '*flood stages*' people in these wards take into consideration not just the characteristics of the inundation itself; in essence is the degree of disruption it can cause to their daily life activities and the availability of resources to 'manage' these successive stages at household and ward level what becomes crucial.

A general description and definition of each of the categories given by the participants in the exercises is given in the following sections.

5.4.3.1 Normal

According to figure 5.6 these are 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 in three ways:

- 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.
- 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 since the fact they live in a low lying terrain. 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 for instance working people to carry on with their economic activities, students can go to school and likewise people is able to continue with what they call as 'their normal life' (see Figure 5.7).

Figure 5.7 Flooding at 'normal' stages after two days of continuous rain in the study area

During these flood stages people carefully follow the official warnings, afterwards they implement some coping mechanism particularly those intended to facilitate the mobilisation of the people and those meant to 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 stagnated water and water-borne diseases.

5.4.3.2 Disturbing but manageable

According to the participants in the workshops this category can come from two situations (see Figure 5.6):

- Flood stages below or slightly above *Knee* depth (40-60 cm or 1-2 feet) lasting less than three days (see Figure 5.8)
- Flooding at *Ankle* depth but lasting between three days to one week.

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 flooding; however the performance of some coping strategies, particularly at family level, allow them to still *manage* the situation. In the first case the disturbance comes from aspects such as:

- Interruption of normal activities such as schooling. In this case working parents have to allocate time from their normal or economic activities in order to take care of their young.
- Disturbance of domestic and every day activities such as cooking, sleeping, cleaning because of the intrusion of floodwaters in houses that are at ground level or not sufficiently elevated.
- Difficulties for mobilisation as many roads and pathways are flooded
- Decline in the performance of economic activities such as street vending, cloth washing and small 'in house' shops and food stalls etc. which may represent until a 30% cutback in the daily income of many households, especially those settled in the lowest-lying area.
- Higher exposure to diseases as people continue commuting to work or performing some domestic tasks wading amidst stagnated waters (i.e. collecting potable water from flood-free areas); besides it was found that in some sectors children are allowed to swim and play in the polluted waters increasing their chances of getting ill.
- Difficulties in the use of basic sanitary facilities such as private and public faucets, toilets and pumps which stop functioning.
- Extra load of stress to people's daily life

In the second case the disturbing aspects come from the presence of stagnated (usually polluted) waters. Pooled waters provide an ideal breeding ground for mosquitoes and water-borne and skin diseases.

Figure 5.8 Flooding stages described as 'disturbing but manageable' as result of Tropical depression Labuyo (Sept, 2005).

5.4.3.3 Highly Disturbing

Also referred to as 'hardly manageable' or 'intolerable', this category can take place in three circumstances:

- Flood stages below or slightly above *Waist* depth (80-100 cm or around 3 feet) lasting one to three days.
- Flood stages below or slightly above *Knee* depth (40-60 cm or 1-2 feet) lasting between three to seven days.
- Small magnitude flooding at *Ankle* depth but lasting more than one week (see Figure 5.9).

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 livelihood had come to a halt (see Figure 5.9).

During fieldwork it was found that, in the first two 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 or relatives then people move to 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 the threat of an inundation with these characteristics is happening in almost all zones in both wards. Moreover at this stage the threat from flood is not just related with 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 result of the direct and long-term contact of structures with floodwaters. It poses a serious threat for the wellbeing of the entire community.

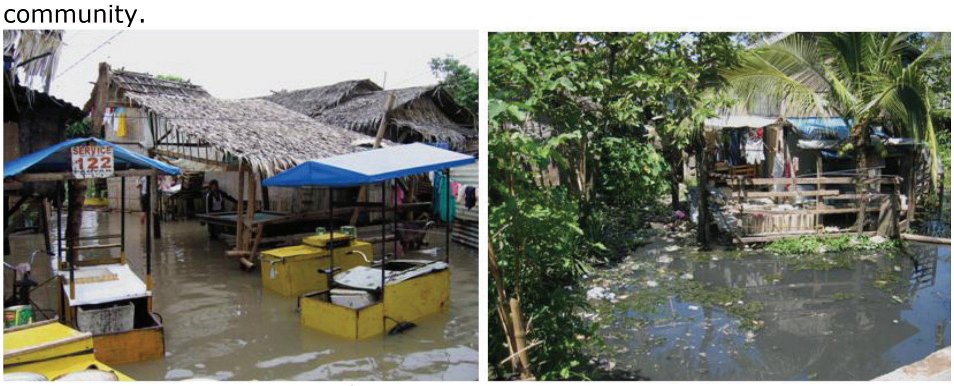


Figure 5.9 Flooding reaching `highly disturbing' categories as result of the depth reached (left) or long-lasting duration of floodwater (right).

5.4.3.4 Unmanageable

This category may take place under the following circumstances:

- Flood stages below or slightly above to *Chest* depth (130 cm or around 4 feet) taking place in a single day and lasting maximum three days.
- Flood stages at *Waist* depth (80-100 cm or around 3 feet) lasting between three days to one week.
- Moderate magnitude flooding below *Knee* depth (40-60 cm or 1-2 feet) that last more than one week.

According to people in the workshops, 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, the social and economic activities have come to a halt and the community as such is 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 to most of the flood-prone areas of the city which comprises 17 out of 27 wards. The disruption at this stage exceeds the capacity for response of most of the wards and creates lots of pressure on the relief and resources available at municipal level.

5.4.3.5 Disastrous

This category is the last and most feared by the people in these wards. It can take place in any of these three situations:

- Regardless of the duration any flood stage reaching above *Chest* depth (>130 cm or > 4 feet).
- Flood stages below or slightly above *Waist* depth (80-100 cm or around 3 feet) lasting more than three days.
- 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).
- Flooding above *Knee* depth (60 cm or around 2 feet) lasting more than one week.

Figure 5.10 Illustrations of the `disastrous' state experienced by the communities in the study area after being hit by Super Typhoon Loleng in 1998 (left) and Durian in 2006 (right).

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 which holds most of the commercial activities. The extent of the physical, social and economic dislocation is such that many people just fail to cope with the situation. In this case extreme mechanisms are adopted such as family disintegration, immigration particularly of the head of household (to bigger cities) or simply remain in a state of marginalisation and destitution for years, which become their 'new' life style.

According to the people this flood stage was experienced in both wards during the pass of Typhoon Rosing in 1995 and Loleng in 1998 (see Figure 5.10). During fieldwork, almost a decade later, the physical damage, threat to life and widespread disturbance caused by this typhoon was constantly recalled by the people in these communities and has become part of their collective memory.

5.4.4 Perception of threat from successive and seasonal events

In this section some other elements that shape people's perceptions of the threat derived from inundations are analysed. For instance, the activities during fieldwork allowed to understand how the threat embodied by any of the community-based flood *stages* described in Section 5.4.3 highly depend on the **period of the year** in which a given inundation take place.

As Figure 5.11 illustrates during the first quarter of the year, equivalent to the dry season, the perceptions on the flood threat remain low.

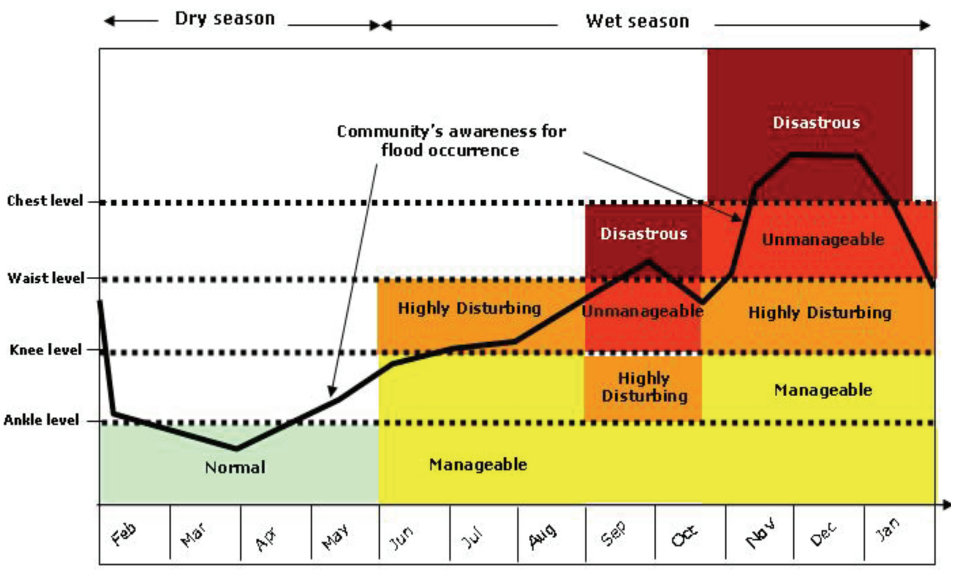


Figure 5.11 Community perception on the threat that flood stages represent depending on the time of the year they occur

This low awareness is based in the low probabilities that significant flooding will occur but moreover because of the presence of economic opportunities and the efficacy of peoples' coping strategies 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 arises partly because the arrival of the wet season brings more recurrent flooding. On the other hand the economic opportunities start shrinking with the arrival of the rains and the coping mechanism happen to be insufficient as the social and economic resources are progressively reduced by every damaging event.

A case in point is the occurrence of inundation at *Knee* depth taking place from September to late October. This stage is perceived as *disturbing but manageable* for most part of the year. However during the mentioned period its occurrence 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 as it is the 'Peñafrancia Festival' and the harvesting of *palay* (rice) crop (see Section 5.3). The decrease in *manageability* levels found during the wet period determine that an inundation, at any stage, can potentially embody high threat for these communities and therefore reach the category of `disastrous', even at comparative lower depths.

The seasonal distribution of community perception on the flood hazard was found to be dynamic as it can also be altered by the occurrence of previous events, for instance in the preceding wet season. During the second fieldwork (which took place nearly six months after the occurrence of typhoon Unding/Yoyong) it was found that nearly 90% of the affected households had not been able to fully restore their livelihood to previous standards. The general feeling perceived 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 more exposed and their dwellings less safe when compared with the same period the year before (see Figure 5.12). It is evident that when the socioeconomic resources and coping strategies of these communities have been seriously affected, reduced or even depleted by an event in the previous wet season; their own perceptions on the capacity to withstand the next season will also change.

The probability that during the wet season several events occur simultaneously, or in combination, leads the people to perceive that the effect of inundations is amplified and that their potential to cause harm is increased. From the classification exercise in Table 5.7 it can be seen how events such as downpours or high tides may not embody a high threat and are even perceived as '*normal'* when occurring in isolation, yet when taking place simultaneously the hazard may get amplified towards more threatening stages*.* The participants considered that they can *manage*, to a certain extent, the effect of certain combination of events, however this will depend on the total magnitude of each single phenomena.

Figure 5.12 State (in October 2005) of several houses that were heavily or partially damaged one year earlier during the typhoon season.

Several examples of these circumstances were found among the accounts of the community. The flooding experienced during fieldwork by Tropical depression Labuyo (2005) constituted a case of coinciding events where tides influence the flood behaviour. If flooding occurs when tides levels are high the water rises much faster. The landfall of tropical storms during peak astronomical tides usually produces higher surge heights and more extensive inundation than when it occurs during low tides.

Another case of increased hazard from combined events took place when three typhoons (Yoyong, Violeta and Unding) and a tropical depression (Winnie) ravaged The Philippines between November and December in 2004. The strong winds (<200 kph) brought by Typhoon Unding hit Naga on November 19 causing widespread destruction. While the inhabitants were still recovering from the onslaught of Unding, the city again was ravaged by the rains of typhoon Yoyong. This new event threatened the lives of the exposed people previously affected by the past typhoon as, according to official reports, the 'flood depth ranged from 2 to 4.3 feet in the lowest-lying wards' which include Triangulo and Mabolo wards (NCDMC, 2004)

Table 5.7 Community-based categories for the hazard that combined events represent for communities in the study area.

Events	High tide	Heavy rain	River flood	Typhoon (rain)	Flash Flood	Typhoon (wind)	Super Typh.
High tide	**N**	**M**	**HD**	**U**	**U**	**D**	
Heavy Rainfall	M	**N**	**U**				
River flood		**U**	**HD**	**D**			
Typhoon (rain)	**U**		**D**	**HD**			
Flash Flood		**D**			**U**		
Typhoon (wind)						**D**	
Super Typhoon							**D**

N=Normal, M=Manageable, HD=Highly Disturbing, U=Unmanageable, D=Disastrous

5.5 Main findings and discussion

Flooding as a hazardous phenomenon has been usually examined merely as a physical and static phenomenon. This chapter however demonstrates the need for including the understanding of the human behaviour, the dynamic of flood hazard and their relationship with people's actions during floods.

This chapter revealed how people in the study area are perfectly aware of the meaning of being settled in a flood-prone environment such as the Bicol and Naga river floodplain. Furthermore they are acquainted with the implications of living in what is called the 'Philippines typhoon belt'. As a result of the annual recurrence of seasonal flooding communities in the study area have developed what has been called in this research as 'local flood risk related knowledge'.

The learning-based approach applied in this research with the communities in both Barangays allowed understanding how the knowledge and perceptions they have about flooding as a threatening phenomenon is a dynamic blend of many factors. Flood hazard is seen not just as derived from the interaction of their everyday life and hydrological cycles; it also comprises the occurrence of these phenomena within their dynamic socioeconomic, environmental and developmental context. This research found how people in these communities have developed their awareness by taking into consideration aspects that range from the physical characteristics of the flooding itself (origin, depth, duration) to the knowledge they have about flood behaviour in their ward, their own levels of physical exposure and moreover the many strategies they have developed to cope with the increasing threat that flooding poses their life.

Part of this large and diverse tacit knowledge present among the members of these communities was structured by means of the participatory activities carried out during his study. Workshops and focus group discussions made it possible to categorised different forms of local awareness, coping mechanisms for dealing with several aspects of their everyday life, decision-making procedures carried out at household level and the like. Furthermore, it was possible to describe the threat of flooding, and its dynamic, from the community's own point of view.

The categorisation of the *stages* in which the occurrence of a flood event is perceived and *managed* by the community constitutes one of the main achievements of this study. Increasing water depth and duration of the flood combined with resources available at household and Barangay level can create differentiated levels of disruption; people's perceptions of these range from *Normal,* via *Manageable, Highly disturbing and Unmanageable* to *Disastrous.* This classification was found useful to portray the differential threats that families can face according to their own socioeconomic resources and coping mechanisms. They also support the analysis of flood hazard as a dynamic process that changes according to the period of the year and as result of the combination of events that may threaten these communities.

A further application of these categories is in the spatial analysis and distribution of flood hazard for the communities in the studied Barangays. The community-based definitions comprise elements of the flooding phenomena (such as water depth and duration) which can be spatially represented in a GIS environment. By knowing the distribution of these features in both wards the management challenges different groups of people face as a result of flooding in their respective areas, can be identified.

The concept and categories of 'manageability' of the flood threat derived from the community's own perception also can help to improve the understanding of the flood problematic for 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 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.

Chapter 6: Flood extent mapping from people's experiences

The previous chapter presented results of the learning approach applied in this research to elicit some of the local knowledge and perceptions about flood risk existing among the studied communities. It revealed how people's perspectives on flood seasonality, intensity, manageability and timing were transformed into criteria that can be integrated into further steps for hazard identification and assessment. This chapter introduces an approach to recover and spatially represent the experiences that communities in these two Barangays had with specific flood events. By means of community-based activities and the GIS-assisted survey described in Chapter 3, their experiences on magnitude and duration of different events in the past were collected and stored in a GIS environment. After validation, these datasets were converted into flood parameter maps and classified according to people's parameters on flood threat. These procedures demonstrated how local experiences can be used in data poor environments to reconstruct and understand the threat posed by floods to communities at local level.

6.1 Introduction

This chapter introduces an approach for recovering and representing the direct experiences that communities in the study area have had with specific flooding or typhoon episodes. During the participatory activities with the communities there were always accounts of significant events that have happened in the past. The description of these events included the differences in flood patterns and behaviour depending on the magnitude of the mentioned event and the features of the zone where flooding took place. These differences are even addressed in the official reports and secondary information compiled from the Municipality. Nevertheless the secondary information (specifically maps) found at the Local Government Unit (LGU) provided just a rough approximation of the average distribution of water depth for several flooding episodes that have hit Naga (see Figure 4.6). In addition there are no records for the occurrence and distribution of small floods and stagnated waters caused by heavy rains in the low-lying areas.

For any hazard analysis it is important to identify both the distribution and variation in flood behaviour. Small differences in the configuration of the landscape may determine that people may be exposed to differentiated flood threat. For instance, people living in areas which may get easily flooded or that are prone to water stagnation experience a different threat from floods as they are exposed to what has been called as 'every day' or chronic character of flood hazard (see Table 2.1) . Flood mapping of all flood events that occur in a locality (including the modest ones) is important as it may help to prioritise actions before, during and after each episode depending on the flood stages experienced in every zone. It may also help to better address the root causes and potential solutions of the problematic derived in the short, medium and long term by differentiating between widespread and localised flood-related problems.

In the absence of suitable information and representation of flooding occurrence at ward level the community-based reconstruction of past events seemed a suitable tool. As mentioned in Section 4.5.2 a similar approach was carried out in the past by the municipality where information coming from the people in different Barangays was retrieved and used for obtaining flood maps displaying average water depth for several events. Regrettably this approach was not repeated again and all previous information that was collected has now gone missing.

In this research an initial approach to those past experiences was carried out by means of a workshop in each Barangay. These activities were meant to identify the spatial distribution and behaviour of flooding episodes for every zone in which the wards are divided. The results, drawn by the participants in each ward, are presented in Tables 6.1 and 6.2.

Table 6.1 Results from the workshop on flood distribution and behaviour in Barangay Triangulo. Refer to Figure 4.13 for the zones.

Type of flood	Zone	Depth	Duration	Time of occurrence	Frequency
Rain + Riverine (Naga + Bicol) flooding	6	Above waist	7 days (no outlet, blocked by CBD II)	-Last quarter of the year (Oct to Dec) -Sometimes since late April (starting of the rainy season)	1 – 2 times in a year
	3	Above Waist			
	5	Waist	2 to 3 days (no outlet, blocked by road and CBD II)		
	4	Waist			
Flash flooding	6	Chest	2-3 days	-No warning -Muddy flood apparently related with opening of upstream Nabua dam gates	2 events on 1997 and 2000: whole Naga was flooded
	3	Chest			
	4	Hips	1 day		
	5	Hips			
Rain + high tide	6	knee	6 hours (no outlet- CBD II and Diversion Road barrier)	-Nearly each month (heavy rains & high tide) -Zones at lower level than Naga river	- Monthly
	3	knee			
Super typhoon	6	> 6 feet	3 weeks	Last quarter of the year during typhoon season (Oct to Dec)	remembered: Sinning (70s) Ruping (80s) Onsang Rosing (95, brought most rainfall) Diding (87) Monang Loleng (96) Unding-Yoyong (04)
	3	> 6 feet	3 weeks		
	4	5 feet	2 weeks		
	5	< 5 feet	2 weeks (no outlet-blocked by roads)		

The results presented in these tables and in Appendixes 6. A show how people in these communities are perfectly aware of the flood problematic in their zones. The proneness of their settlements to diverse types of flooding and the distribution of floodwaters within the various zones of their wards are part of the knowledge accumulated through direct experience and observation.

Table 6.2 Results from the workshop on flood distribution and behaviour in Barangay Mabolo. Refer to Figure 4.16 for the zones

Type of flood	Zone	Depth	Duration	Time of occurrence	Frequency
Rain + Riverine (Bicol) flooding	5	Ankle	1 – 2 days (after several hours of continuous raining)	-Early May (rainy season) - Overflowing of drainage system, clogged canals	2 - 3 times in a year
	1	Waist			
	3	Waist			
	4	Waist			
	6	Waist			
Flash flooding	6	6 feet	4 days (no outlet, blocked by roads)	- No warning - Related to the opening of gates of upstream Buhi and Bato dams	-Last occurrence was on Dec 2000
	5	eye length	2 days		
	3	Chest			
	4	Chest			
	1	Up waist			
	2	Hips	1 day		
Rain + high tide	4	Ankle	4 hours in lowest lying zones closest to the river	High tide during full moon	-Monthly
	3				
	5				
Super typhoon	6	7 feet	4 weeks (blocked by roads)	Last quarter of the year during typhoon season (Oct to Dec)	remembered : Sinning (70) Monang (93) Rosing (95) Unding-Yoyong (04)
	4	> 6 feet	3 weeks (no outlet , block by roads)		
	1	6 feet	2 – 3 weeks (pocket among roads and elevated buildings)		
	5	7 feet	1 week		
	2	6 feet	1 week		
	3	5 feet	1 week		

The workshop results show that people generate their own mental maps of the various flood types. Depending on the floodwaters behaviour or source, they know which zones are more likely to be flooded, the potential depth that floodwaters can reach, their duration and the causes for water stagnation in certain areas.

Regarding frequency of flooding, it was clear that people usually keep mental records of the latest events and moreover of the extremes that have struck their communities during the last decades.

6.2 Procedure for community-based flood mapping

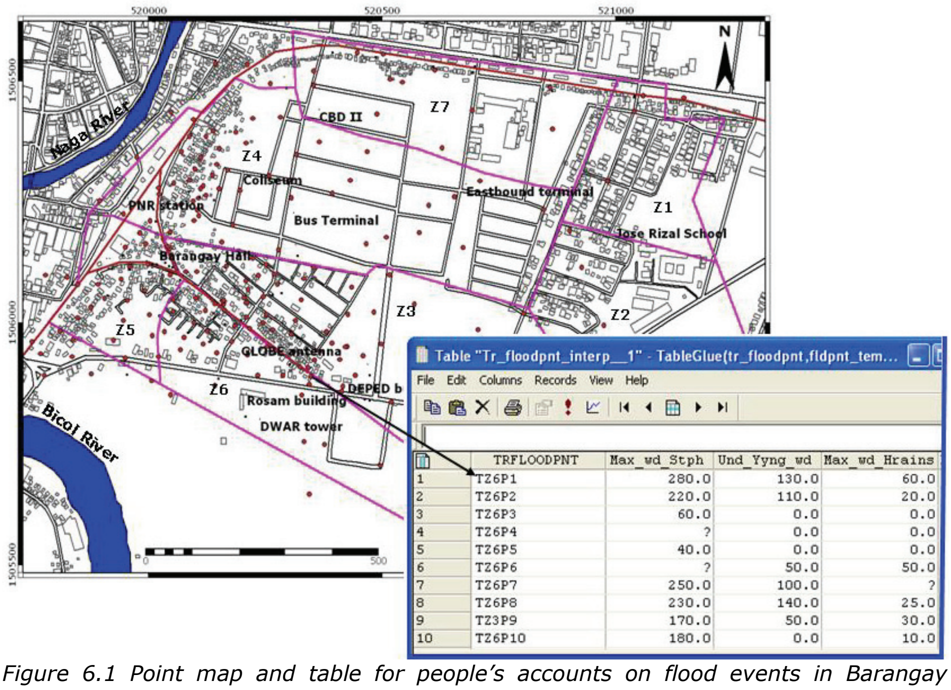
The process of collecting people's memories on past events made it clear that the more events people can recall the easier it is to establish flood patterns and changes in flood behaviour through time. However, in urban settings collecting consistent information using a participatory approach may lead to some difficulties; particularly for events that have happened years, or even decades ago. For instance, one particular problem is in the high mobility of the population, particularly in areas with land ownership and legality conflicts.

In the study area, however it was found that most of the members of the two communities were born or have been settled there for periods longer than 20 years (see Sections 4.6.2 and 4.6.3). This period of settlement guaranteed that, at least, they had direct experiences with several of the flooding and typhoon episodes mentioned in the tables above. In fact, during fieldwork it was evident that mental records on the occurrence of the most representative or recently occurred events were common. This information was found not just between the local officers, leaders or participants in the workshops but also in the accounts of laypeople.

6.2.1 Collecting data on water depth and duration of flooding

The GIS-based survey allowed collecting data on the maximum water depth and duration, inside or outside the house of the interviewee, for specific episodes. This information was compiled in both analogue and digital formats (i.e. a database for being used with a mobile GIS unit). Each interview was given a unique identifier that was later crosschecked and handled in the digital database.

Figure 6.1 shows the GIS-based point map and database created out of the survey in this case for Barangay Triangulo.



	TRFLOODPNT	Max_wd_Stph	Und_Yyng_wd	Max_wd_Hrains
1	TZ6P1	280.0	130.0	60.0
2	TZ6P2	220.0	110.0	20.0
3	TZ6P3	60.0	0.0	0.0
4	TZ6P4	?	0.0	0.0
5	TZ6P5	40.0	0.0	0.0
6	TZ6P6	?	50.0	50.0
7	TZ6P7	250.0	100.0	?
8	TZ6P8	230.0	140.0	25.0
9	TZ3P9	170.0	50.0	30.0
10	TZ6P10	180.0	0.0	10.0

Figure 6.1 Point map and table for people's accounts on flood events in Barangay Triangulo.

The survey revealed how people make use of several means to express their experiences on a given event. Sometimes they correlate the depth of the inundation with structures such as walls, stairs, windows, mezzanines etc. or use their own body to point out the depth reached by floodwaters (See Section 5.4.1). Considering that most of the houses in both areas are built at a certain elevation above ground level this value was measured and added to the one reported by the household as shown in Figure 6.2. The total value was thus registered in the database.

This systematic collection allowed the reconstruction of three main events:

a) **Minor flooding event (HR):** Triggered by heavy rains (HR) and slight riverine overflowing accompanying normal tropical storms on an annual/biennial cycle. During fieldwork this scenario was directly crosschecked when the tropical depression Labuyo hit the Bicol region, including Naga City, during the high tide period from September 19 to 23, 2005.
b) **Moderate flooding event (UY):** Originated in the combined action of Typhoons Unding and Yoyong (UY) that ravaged Naga from November 19 to December 2, 2004.
c) **Extreme flooding event (ST):** Which took place between 30 October to 4 November in 1995 during Super-Typhoon (ST) Rosing. It was always recalled during workshops and interviews as the one that caused the deepest and longest flood in Naga.

6.2.2 Checking the consistency of interview data

The data provided by the households were validated by crosschecking with characteristics of the terrain, direct observation and correlation with data collected with interviewees in neighbouring areas. After this, the normal distribution of the random sampling was checked and statistical tests such as Pearson correlations were carried out for the datasets on depth and duration of each event using the SPSS® statistical package. The reconstruction of events combines, at some point, the probability levels from a number of separate answers. This test therefore was used to prove the degree of association between the data on water depth and duration for each flood scenario that was provided by the interviewees.

For the correlation test it was assumed that data points with deepest flood records in one scenario should also have recordings of deeper levels in the other scenarios, as compared to points with lower values. In other words the *null* hypothesis selected for obtaining the significance test stated that '*responses are <u>not</u> random and that the interviewee, somehow, will <u>not</u> significantly underestimate or overestimate the water depth and duration of the events'.* However, given the level of subjectivity involved in the method some level of over- and under-estimation could be expected in the values although; the aim was that these differences should not be beyond the standard deviations.

Figure 6.2 Measurement of water depth reached by flood events according to people's remembrances (lower two pictures by Saut Sagala).

In order to decide whether or not the sets of data were adequate for performing the mapping procedure proposed in this chapter, it was expected that the answers provided by different households on different events and different parameters should have a *Medium* to *Large* correlation according to the interpretations proposed by Cohen (1998) and presented in Table 6.3.

Table 6.3 Interpretation of correlation coefficients according to Cohen (1988)

Correlation	Negative	Positive
Small	−0.29 to −0.10	0.10 to 0.29
Medium	−0.49 to −0.30	0.30 to 0.49
Large	−0.50 to −1.00	0.50 to 1.00

The results of the test are presented in Table 6.4. The table contains the descriptive statistics and correlations for 6 variables: three are related to water depths (VAR_WdHR, UY and ST) and three to the duration parameters (VAR_DHR, UY and ST) which are related to the aforementioned scenarios.

Table 6.4 Descriptive statistics and correlation values for three flood episodes datasets on water depth and duration collected in the two Barangays by means of a GIS-based survey.

Triangulo

Water Depth

Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
VAR_WdHR	164	,00	80,00	17,8049	20,22265
VAR_WdUY	146	,00	140,00	50,5479	42,84343
VAR_WdST	114	40,00	280,00	157,1930	67,14808
Valid N (listwise)	89				

Correlations

		VAR_WdHR	VAR_WdUY	VAR_WdST
VAR_WdHR	Pearson Correlation	1	,803**	,639**
	Sig. (2-tailed)		,000	,000
	N	164	128	101
VAR_WdUY	Pearson Correlation	,803**	1	,748**
	Sig. (2-tailed)	,000		,000
	N	128	146	100
VAR_WdST	Pearson Correlation	,639**	,748**	1
	Sig. (2-tailed)	,000	,000	
	N	101	100	114

**. Correlation is significant at the 0.01 level (2-tailed).

Duration

Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
VAR_DHR	35	1,00	14,00	2,6857	2,67638
VAR_DUY	74	1,00	15,00	5,7838	3,66124
VAR_DST	59	3,00	30,00	13,8475	7,20827
Valid N (listwise)	28				

Correlations

		VAR_DHR	VAR_DUY	VAR_DST
VAR_DHR	Pearson Correlation	1	,381*	,310
	Sig. (2-tailed)		,029	,102
	N	35	33	29
VAR_DUY	Pearson Correlation	,381*	1	,416**
	Sig. (2-tailed)	,029		,001
	N	33	74	57
VAR_DST	Pearson Correlation	,310	,416**	1
	Sig. (2-tailed)	,102	,001	
	N	29	57	59

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Mabolo

Water Depth

Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
VAR_WdHR	89	,00	50,00	19,1011	14,51022
VAR_WdUY	114	,00	140,00	62,4561	42,27096
VAR_WdST	91	20,00	250,00	165,9341	60,99140
Valid N (listwise)	77				

Correlations

		VAR_WdHR	VAR_WdUY	VAR_WdST
VAR_WdHR	Pearson Correlation	1	,842**	,648**
	Sig. (2-tailed)		,000	,000
	N	91	81	81
VAR_WdUY	Pearson Correlation	,842**	1	,684**
	Sig. (2-tailed)	,000		,000
	N	81	110	90
VAR_WdST	Pearson Correlation	,648**	,684**	1
	Sig. (2-tailed)	,000	,000	
	N	81	90	104

**. Correlation is significant at the 0.01 level (2-tailed).

Duration

Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
VAR_DHR	91	,00	8,00	3,1758	2,45218
VAR_DUY	107	,00	10,00	4,7664	3,06095
VAR_DST	82	,00	30,00	14,8293	7,18848
Valid N (listwise)	57				

Correlations

		VAR_DHR	VAR_DUY	VAR_DST
VAR_DHR	Pearson Correlation	1	,703**	,650**
	Sig. (2-tailed)		,000	,000
	N	65	54	63
VAR_DUY	Pearson Correlation	,703**	1	,734**
	Sig. (2-tailed)	,000		,000
	N	54	84	70
VAR_DST	Pearson Correlation	,650**	,734**	1
	Sig. (2-tailed)	,000	,000	
	N	63	70	89

**. Correlation is significant at the 0.01 level (2-tailed).

N= Number of data points used for the correlation analysis

Based on the table it can be seen that the significance of the correlation exhibited by the datasets for the three events is large especially for water depth. The significance of this variable in Triangulo and Mabolo and duration values in Mabolo is at the 1%-level. The significance for Duration in Triangulo was less (at a level of 5%-level) but still acceptable for the mapping purposes.

The high significance of the correlation found for the data sets could be explained by the fact that people easily remember those events that are especially traumatic for them or for the community as a whole (Super typhoon Rosing as major flood event is a good example). Extreme characteristics of certain events such as most types of rain, the strongest winds and the unexpectedness or the havoc that they brought to the household or the whole community are likely to be kept in people's minds for longer periods. Average events, even if they cause some level of disruption, were found to be just as vividly remembered for a short period, as after some time people's memories got mixed up or replaced by records of new floods. Information on these moderate events may be easily recovered if they have recently occurred. Frequent and small events, such as those produced by heavy rains, are easily recalled simply because they happen every year and people are use to experiencing them.

The smaller levels of correlation among duration for flood events may be the result of a coarser unit of measure (days as compared to centimetres for water depth) but also to the strong influence of the topography and the existence of blockages for water flow which can produce large differences in duration, even at shorter distances. The subjectivity factor involved in the answers provided by the households, particularly for low levels of flooding, and unavoidable errors while the data was collected have an effect on the results as well. Nevertheless (as mentioned before) the correlation values were still found to be significant and therefore the data was deemed adequate for the reconstruction of scenarios.

6.2.3 Translating point data into continuous flood surface

From Figure 6.1 it can be seen that the survey covers most of the area in the two Barangays. However, for many sectors information did not exist or could not be collected. For hazard assessment it is necessary to know, or at least to have the most approximate idea, about floodwater distribution and duration for the whole area during the event. To deal with the data requirements for flood mapping between punctual spots observations some techniques have been used such as contour digitising and interpolation techniques (Badilla, 2002; Peters Guarin, 2003). As explained in Section 3.7.2, the so-called kriging interpolation method available in the GIS ILWIS® software was selected for reconstructing the flood scenarios in this research. The interpolation method required the construction of experimental semi-variograms for the data sets. A variogram is a curve that once fitted through a point data set, displays variance of the variable under analysis versus the separation between pair of points. It determines the rate of change of a regionalised variable along a specific orientation; in the common case all directions are considered the same (isotropic). Semi-variograms are suitable for modelling local behaviour of variables and are defined as the sum of the squared differences between pairs of points separated by a certain distance, divided by two times the number of points in a distance class (ITC, 2001). By plotting experimental semi-variogram values against distance classes in a graph, it was possible to obtain a model or function that fits these experimental semi-variogram values; this model is a continuous function, which will give an expected value for any desired distance. In this case for all the data sets the best fit was found for a spherical model (see Figure 6.3).

Other necessary information used as input for the kriging operation are the model's *Sill, Range,* and *Nugget* parameters that fit experimental semi-variogram values 'best'. At some distance the points that are compared are so far apart that they are not related to each other anymore, i.e. the sample values will become independent of one another. Then, the expected squared differences of the point values will become equal in magnitude to the variance of the variable; this is the range.

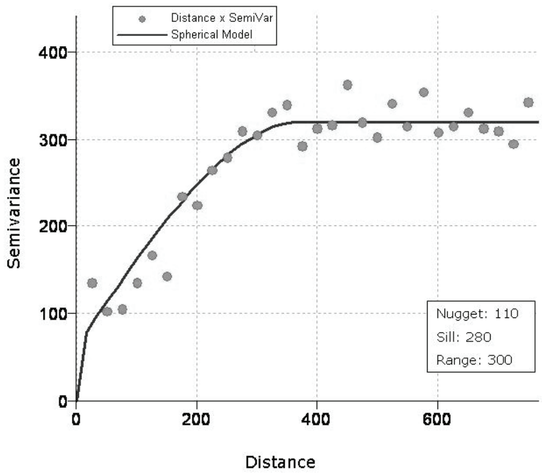


Figure 6.3 Spherical semi-variogram model for the data set of water depth (blue line) for heavy rains in Mabolo. Dots represent the variance of the spatial correlation with the distance.

The semi-variogram no longer increases and develops a flat region, called the *sill*. The sill represents the variation in the data when there is no spatial dependence; this is similar to the overall variance of the variables. The *nugget* represents very short-range variability that cannot be mapped. A nugget effect indicates that the variable is erratic over very short distances or highly variable over distances less than the specified *lag spacing* (distance between points) or the sampling interval (ITC, 2001). The *Sill, Range,* and *Nugget* parameters for the data sets were obtained from the spherical semi-variograms developed for each variable and are presented in Table 6.5.

Table 6.5 Parameters for the experimental semi-variograms for the data sets of water depth and duration for three flood events.

Variable	Scenario	Nugget	Sill	Range	N/S Ratio
Triangulo					
Water depth	Heavy Rains (HR)	170	440	120	0.39
	T. Unding Yoyong (UY)	600	1800	120	0.33
	Typhoon Rosing (ST)	600	1850	170	0.32
Duration	Heavy Rains (HR)	510	1700	140	0.30
	T. Unding Yoyong (UY)	600	1700	100	0.35
	Typhoon Rosing (ST)	600	1690	70	0.36
Mabolo					
Water depth	Heavy Rains (HR)	110	280	330	0.39
	T. Unding Yoyong (UY)	100	1250	250	0.08
	Typhoon Rosing (ST)	220	600	170	0.36
Duration	Heavy Rains (HR)	130	280	310	0.46
	T. Unding Yoyong (UY)	50	325	320	0.15
	Typhoon Rosing (ST)	120	300	240	0.40

Fom the data in Table 6.5 it can be said that in general the variability in all three storms for both areas was very similar. Nevertheless, the range for the sampling points is greater in Mabolo than Triangulo for both variables, and particularly in the two smaller events (heavy rains and Typhoon Unding-Yoyong). This can be explained as result of the presence of obstacles and barriers for the water to move around. The larger variability in the reports for duration in Barangay Mabolo can also be explained as result of the differential time that households are exposed to floodwaters. The compartmentalisation of the floodplain as result of construction of embankments, roads and elevated buildings and industries gives as result that even at shorter distances the reports show larger variations. The data also show that the variability is larger for small events (heavy rains) and decreases for super typhoons which means that with higher depths (i.e during super typhoons) the variations in topography are cancelled, in other words the floodwaters become a homogenous surface, and therefore the variability in range is less.

In general it was found that in both areas the variograms for duration were less correlated than the ones for water depth. This can be explained as result of the different resolution used while collecting the data. Whereas the water depth was measured in centimetres the temporal resolution for duration was expressed in days, therefore increasing the range for variation an uncertainty.

The values in the last column in Table 6.5 (N/S ratio) were obtained after dividing the *Nugget* by the *Sill* values. This relationship expresses the proportion of the variability that could not be explained even at the shortest range; for instance for all the events there is around 30 to 40% of variability in the sampling that cannot be explained even if every household was going to be interviewed. This variability can be result among others of measurement or reporting errors. The proportion of the sampling that could be mapped therefore was between 60 to 70% which was deemed adequate for the purposes of reconstructing the flood scenarios.

After corroborating the proportion of the spatial correlation existing for the datasets the point data on water depth and duration was interpolated in order to obtain water depth and duration maps for the three flood episodes under analysis. The following sections provide a detailed description of the reconstruction of the three flood scenarios, including the accounts and direct experiences from the communities.

6.3 Reconstructing flooding from super typhoon Rosing

During fieldwork accounts on the widespread havoc and disruption triggered by Super Typhoon Rosing were always present. Most of the interviewees vividly remember the occurrence of this typhoon as Rosing hit land in the late evening of All Saint's Day in 1995 (when people were praying to their dead). With few exceptions, all interviewees remembered how the floodwaters covered the whole low-lying area in Naga and neighbouring towns across the Bicol floodplain for several weeks; '*it was like experiencing the Great Flood told in the Bible*' one of them said.

Typhoon Rosing (also referred to as 'Angela') was always described as the worst natural calamity people had ever experienced, and was subsequently classified as the second worst typhoon hitting The Philippines in the last 50 years - as well as one of the strongest and intense typhoons in the history of the Northwestern Pacific Ocean (see Figure 6.4).

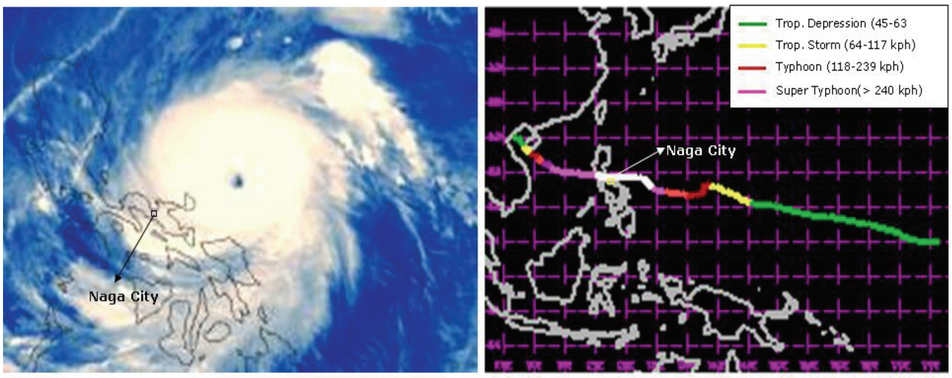


Figure 6.4 Image and track of Super Typhoon Rosing which hit the Philippines and the Bicol Region in 1995 (Source: Typhoon2000.com)

The typhoon unusually maintained winds of at least 240 kilometres per hour (kph) for 60 hours, most of it while over land (Typhoon2000.com.; 2008). In the Bicol region this was the typhoon that brought the most intense rainfall to the area (max. 393 mm in one day); triggering a flood event equivalent to a 20-year return period and wind gusts that reached up to 275 km/h as it approached the Camarines Sur Region (ADPC, 2001).

6.3.1 Flood extent mapping from typhoon Rosing

Figure 6.5 shows the interpolated water depth and duration maps, reconstructed for this typhoon from people's accounts.

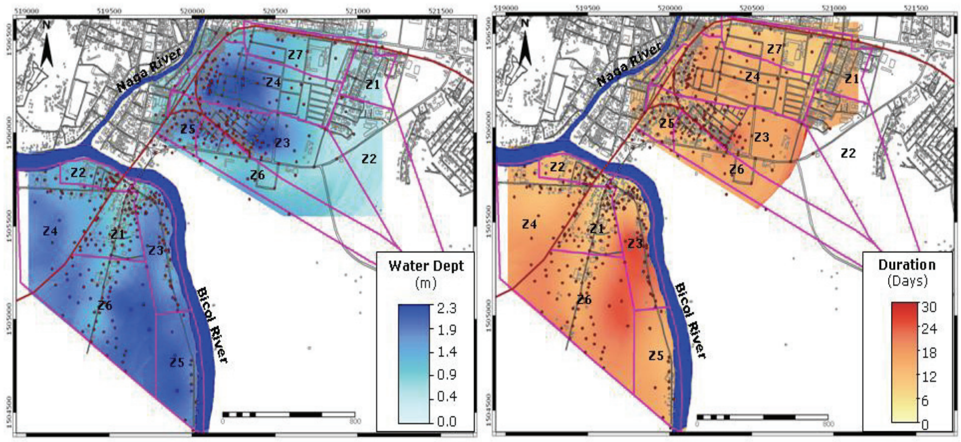


Figure 6.5 Reconstructed water depth (left) and duration (right) maps of the flood episode for super typhoon Rosing (1995).

From these maps it can be seen how during this episode high flood levels were widespread in all zones in both Barangays, and differences in water depth are the result of natural or man-made variations in the topography.

After nearly three days of continuous rainfall the lowest lying Barangays known as Sabang, Igualdad, Mabolo, Triangulo and, Tabuco were flooded. Afterwards they were followed by the rest of the seventeen wards comprising the city's low lying area. According to people's accounts the floodwaters reached seven to ten feet (2-3 m) and lasted more than one month.

In the study areas even elevated structures such as the Diversion Road, the Pan Philippine Highway (PPH) and the Philippine National Railroad (PNR) embankment (elevated 2-3 m above ground level) were flooded at around knee depth (40-60 cm or < 2 feet).

These circumstances made the road network unusable for evacuation and all the rescuing and patrolling work had to be done by boats. Many people indicate that there were sectors more severely flooded than others particularly those which used to act as natural retention areas; where the flooding lasted for weeks. Another factor influencing the severity of the flooding for the residential areas was the existence of barriers created by main roads and elevated structures which, in people words, converted Triangulo in '*a pond with no outlet'*.

The distribution of water depth and duration for every zone calculated out of the recreated flooding episode is shown in Tables 6.6 and Figure 6.6. From these tables and figures it can be deduced how severe the flooding was in both Barangays.

The situation for the community in Mabolo was worse since all zones experienced severe flood depths. According to the households interviewed all their mechanisms for counteracting the disastrous characteristics of this event were ineffective. People just had to leave the area, remain with their relatives in flood-free sectors or evacuate to officially designated centres until the waters receded and the area was cleaned.

In Barangay Triangulo several families coped by staying in stranded train coaches in the National Railroad Station (Zone 4) where the floodwaters were at waist depth. Entire families remained there several days until the flooding receded to a depth in which returning to their places was deemed 'safe'. The rest of the families from severely flooded areas stayed for days and even weeks in evacuation centres, relying on governmental relief and assistance.

Table 6.6 Water depth, duration and percentage of area flooded per zone for Triangulo (top) and Mabolo (bottom) according to the reconstructed scenario for Super Typhoon Rosing.

Barangay Triangulo									
Zone	**Water depth (cm)**		**Area (ha)**	**Percentage of area -per zone- flooded at:**					**Duration (days)**
	Min	Max		Ankle	Knee	Waist	Chest	Above chest	Avg
Zone 1	51	70	7	-	-	100	0	0	11.3
Zone 2	50	78	13	-	-	100	0	0	13.4
Zone 3	50	247	28	-	-	40	17	43	18.1
Zone 4	56	237	25	-	-	20	15	65	16.8
Zone 5	77	209	6	-	-	5	22	73	15.2
Zone 6	72	201	14	-	-	13	62	25	15.8
Zone 7	60	169	13	-	-	45	38	17	12
Barangay Mabolo									
Zone	**Water depth (cm)**		**Area (ha)**	**Percentage of area -per zone- flooded at:**					**Duration (days)**
	Min	Max		Ankle	Knee	Waist	Chest	Above chest	Avg
Zone 1	0	68	10	-	-	10	45	45	14.5
Zone 2	6	92	7	-	2	11	50	37	8.9
Zone 3	8	81	16	-	-	3	6	92	15.2
Zone 4	30	83	20	-	-	-	3	97	17.4
Zone 5	47	75	16	-	-	-	-	100	15.2
Zone 6	0	65	32	-	-	-	5	95	18

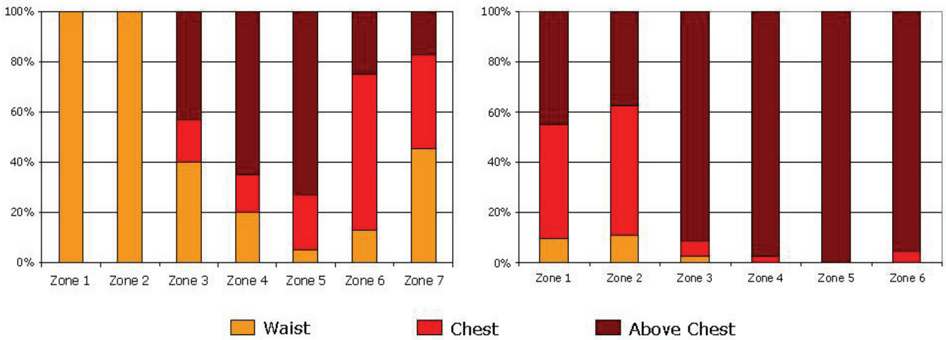


Figure 6.6 Percentage of area flooded per zone in Triangulo (left) and Mabolo (right).

6.3.2 Community flood perception for typhoon Rosing

The flooding brought by typhoon Rosing had such magnitude and duration that this episode was a disastrous experience for both communities. In fact through all the participatory activities carried out it was always referred to as such.

The exercise of reconstructing flooding episodes implemented in this research included an attempt to spatially represent the hazard posed by flooding from the communities own point of view. Therefore, after obtaining the interpolated water depth and duration maps the next step consisted of applying the perception of the communities on the flood threat, as previously described in Section 5.4.3.

The procedure for mapping or representing the flood episode according to people's perception was carried out in ILWIS® software. By applying conditional (if) rules the water depth and duration maps were combined in order to obtain the spatial distribution of the flood hazard stages characterised in the aforementioned section. Table 6.7 provides the set of classification rules that were used for the combination procedure in ILWIS.

Table 6.7 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 **'Manageable'**
If water depth (in range 20,40 cm) and duration (in range,3,7 days) then **'Highly Disturbing'**
If water depth (in range 20,40 cm) and duration > 7 days **'Unmanageable'**
If water depth (in range 40,90 cm) and duration < 3 days then **'Highly Disturbing'**
If water depth (in range 40,90 cm) and duration (in range, 3,7 days) then **'Unmanageable'**
If water depth (in range 40,90 cm) and duration > 7 days then **'Disastrous'**
If water depth (in range 90,130 cm) and duration < 3 days then **'Unmanageable'**
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'**

Figure 6.7 illustrates the result of this exercise for the Typhoon Rosing flooding episode.

The figure evidences how widespread the disruption was in the study area. Although no official records are available on losses caused by this event, ADPC (2001) estimated that, to some degree, the whole population in the low-lying areas was affected.

The reports in the survey showed that most of the economic and social activities in both wards stopped during the whole flooding period. The Central Business District (CBD-I), where most of the economic activities took place by then, was flooded above chest level, therefore most of the vendors and informal workers were not able to commute to work. In addition people were busy rebuilding their own houses and taking care of their relatives; as a consequence many households did not have a daily income for more than one month.

Regarding damage the local officers reported how the direct contact with deep floodwaters during such large period caused the total destruction of houses built with light materials and even severely affected those houses built with stronger materials such as reinforced concrete. After this traumatic episode those who had the means decided to rebuilt their previously flimsy houses using bricks or reinforced concrete systems (see Chapter 8 for a more detailed description).

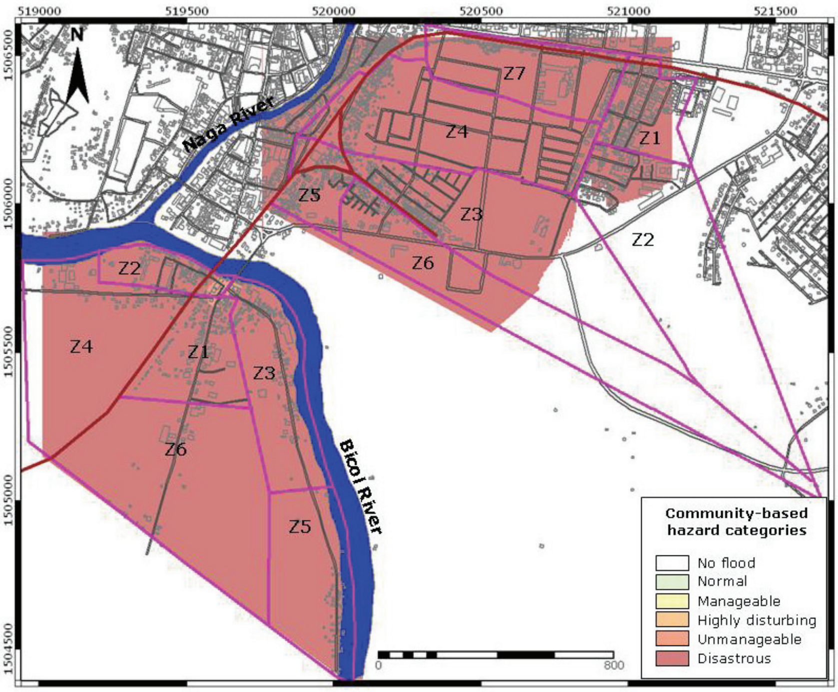


Figure 6.7 Characterisation of the flood episode caused by Super Typhoon Rosing (1995) according to people's perception on the threat from flooding (water depth vs duration)

People indicated that this coping mechanism will allow them to reduce the disruption of their normal life by such longer periods; they will avoid staying in evacuation centres and will reduce the probability of becoming homeless in case a similar event happened again. From the survey it was found that on average it took nearly 3.5 years for the people to recover from the disastrous outcome of super typhoon Rosing.

Regarding the occurrence of new events with a similar magnitude to super typhoon Rosing, it is important to highlight how since this flooding took place in 1995 many aspects in both wards have changed. For instance, during the last decade a large portion of the city's expansion has taken place in these Barangays. Secondly, most of these new urban developments have being constructed by raising considerable portions of the floodplain between two to three metres above the original ground level. These modifications are decreasing the, once available, room for floodwaters. It should be expected that in the present time the occurrence of a flooding comparable to typhoon Rosing will differ in aspects such as water depth, duration and distribution from the one analysed herein.

On the other hand the population and patterns of settlement in these areas have also evolved. In the past most of the houses in these Barangays were built with light materials and owned by farmers and workers of the national train company (PNR). After the construction of the Central Business District Two compound (CBD-II) in Triangulo and the industrial expansion in Mabolo many people from rural neighbouring areas have migrated to these wards. Most of this occupation has taken place in illegal and very precarious conditions in the empty spaces still found in these wards. The municipality has also established several on-site and relocation programmes for the Urban Poor in some of the lowest-lying areas in these Barangays. Given these changes one should be careful in straightforward predicting the flood scenarios of such past events based on the experiences of the community. Nevertheless this is one of the objective behind this type of reconstruction of scenarios occurred through time. In absence of other detailed information they help to address and monitor the negative and positive consequences of the many changes in the physical, morphological and socioeconomic aspects of these areas.

6.4 Reconstructing flooding from typhoons Unding-Yoyong

Between 14 November and 4 December in 2004 typhoons Unding, Violeta and Yoyong and the tropical depression Winnie hit the northern part of the Philippines, creating widespread chaos and disturbance in most of the Bicol Region and particularly in Naga City (see Figure 6.8).

According to people’s accounts the first phenomenon that took place during this period was Typhoon Unding. The heavy rains released kept the study area, and some other low-lying sectors of Naga City, flooded at ankle depth for five days (14 to 18 November). Nevertheless, it was the strong wind blowing at nearly 130 km per hour that caused widespread destruction on the evening of 19 November.

Through interviews and open conversations with local and municipal officers it became clear how the people in these communities were completely unaware of the danger. Many people blamed the governmental office, PAGASA for not issuing official warnings on time and, moreover, for confusing the people. According to Padua (2005) the PAGASA bulletin that went out at around 5:30 pm issued a warning signal Number two when, according to the wind velocities, it should have been Number three (refer to Table 5.2 for a description of these categories). Because of these inadequate warning signals most people were not able to prepare in advance and to protect their valuables and dwellings and therefore destruction was widespread.Just one week later when the affected communities were still trying to recover from this disastrous episode the occurrence of three new events named as tropical storm Violeta (22-23 November), tropical depression Winnie (27-30 November) and typhoon Yoyong (28 Nov – 4 Dec) added far more destruction to the despair than previously caused Typhoon Unding.

These successive events affected nearly the same people that were previously hit by the former typhoon; some people reported how they had double losses as by the time that typhoon Yoyong arrived they had already repaired the damage from typhoon Unding.

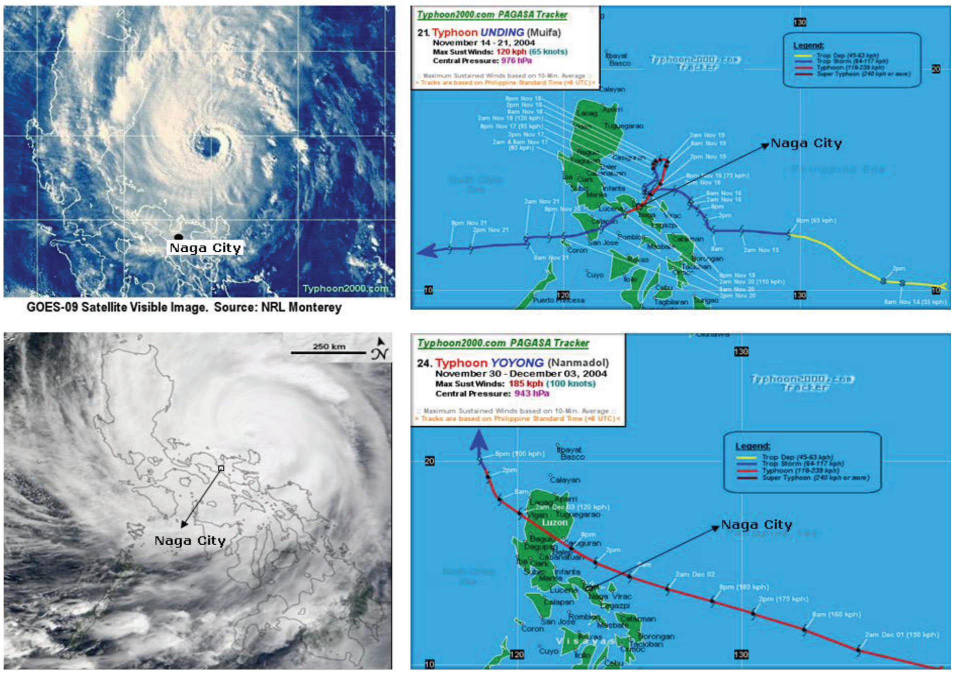


Figure 6.8 Track of two events crossing the Bicol Region in less than one month during the typhoon season in 2004: typhoons Unding (top) and Yoyong (bottom) (Source: Typhoon2000.com)

6.4.1 Flood extent mapping from typhoons Unding-Yoyong

The spatial reconstruction of these aspects for the flooding episode is shown in Figure 6.9

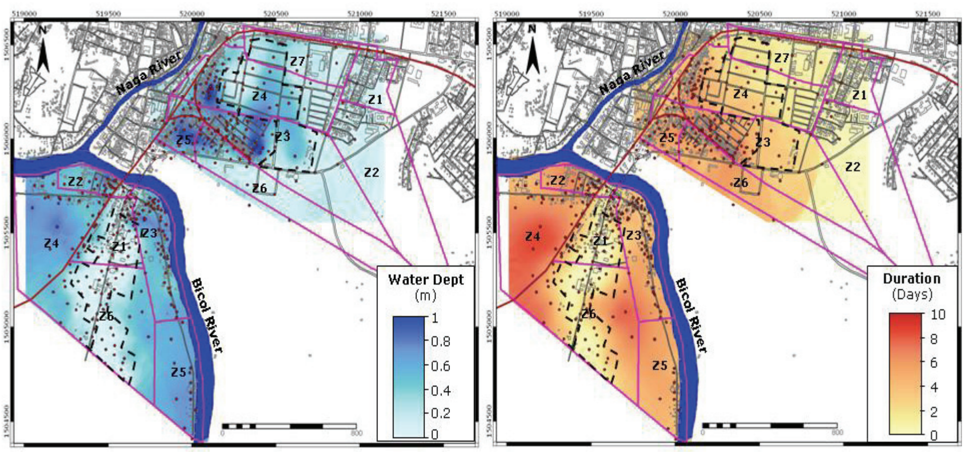


Figure 6.9 Reconstructed water depth (left) and duration (right) maps of the flood episode for the typhoon season in November 2004.

Flooding produced by the combination of events did not reach the extreme characteristics of the one triggered by typhoon Rosing; nevertheless the communities in the low lying areas were left struggling with the effects of flooding for nearly two weeks after the event. During this episode people living in Zones 3 to 6 in Triangulo and Zones 2 to 5 in Mabolo experienced severe flooding, which in some sectors reached chest depth and lasted nearly one week (see Figure 6.10). However, in other sectors such as Zone 1 and 2 in Triangulo and part of Zone 1 in Mabolo, the interviewees confirm that flooding just reached *Ankle* depth.

A closer analysis of Figure 6.9 shows that, during this episode, those areas that have been raised were almost free of flooding. In Triangulo some marginal flooding could still be observed in the raised areas particularly in empty lots.

Figure 6.10 Flooding levels in Zone 3 and Zone 6 in Triangulo during typhoon Yoyong.

Data on the percentages of flood depth per zone is presented in Table 6.8 and Figure 6.11.

During fieldwork it was found that the most disastrous outcome of this combination of events was among others the heavy damage and destruction of numerous houses -predominantly those built with light materials.

Reports also talk about the interruption of services and facilities because of the collapse of energy and communication towers as well as the disruption of transportation because of falling trees and debris. People in both Barangays mentioned how during these events '*lights went out, the water taps ran dry, the floodwaters rose, and streets became impassable*'.

Table 6.8 Distribution of water depths, duration and percentage of area flooded per zone according to the recreated flood scenario for typhoons Unding/Yoyong at Triangulo (top) and Mabolo (bottom).

Barangay Triangulo									
Zone	**Water depth (cm)**		**Area (ha)**	**Percentage of area -per zone- flooded at:**					**Duration (days)**
	Min	Max		Ankle	Knee	Waist	Chest	Above chest	Avg
Zone 1	0	21	7	100	-	-	-		1
Zone 2	0	20	13	100	-	-	-		1
Zone 3	0	114	27	52	12	34	2	-	4
Zone 4	0	111	25	30	27	41	2	-	4
Zone 5	14	97	5	1	14	73	12	-	5
Zone 6	0	94	14	60	20	20	-	-	5
Zone 7	6	44	13	50	46	4	-	-	2
Barangay Mabolo									
Zone	**Water depth (cm)**		**Area (ha)**	**Percentage of area -per zone- flooded at:**					**Duration (days)**
	Min	Max		Ankle	Knee	Waist	Chest	Above chest	Avg
Zone 1	0	68	10	60	24	16	-	-	3
Zone 2	6	92	7	8	7	84	1	-	4
Zone 3	8	81	16	2	10	88	-	-	4
Zone 4	30	83	20	-	1	99	-	-	6
Zone 5	47	75	16	-	-	100	-	-	5
Zone 6	0	65	32	41	26	33	-	-	4

Figure 6.11 Percentage of area flooded during typhoons Unding/Yoyong per zone in Triangulo (left) and Mabolo (right).

The official records reported two casualties caused by hypothermia and one from drowning after they refused to evacuate. Furthermore the losses account for PhP 60 Million pesos damage in crops, livestock and infrastructure, residential houses built with light materials and forests (CDMO, 2004).

A partial report on losses and casualties is shown in Table 6.9.

Table 6.9 Report on Damages and casualties as result of typhoons Unding/Yoyong in 2004.

Ward	Damaged houses			People		
	Partially	Heavily	Totally	Affected	Evacuated	Injuries & Casualties
Triangulo	330	126	29	2910	762	1 killed (Zone 4) 1 injured (Zone 6)
Mabolo	369	44	39	2776	-	1 killed (Zone 5)

Source: Naga City Social Welfare and Development Office (CSWDO)

Apart from the direct damage to houses reports on the loss of income, intrusion of sediments and rubbish in the houses, the presence of foul smells and stagnated and polluted floodwaters were also present. The proliferation of skin infections and gastrointestinal, respiratory and waterborne diseases were some of the main secondary effects resulting from this flood period.

Owing to the period of the year in which flooding by this combined events happened, the losses reported by farmers in Barangay Mabolo were relatively small. By late November to early December harvesting of the wet season rice crop had already taken place and therefore, the floodwaters just spoiled a small harvest locally known as '*daginding*' which constitutes a secondary yield- with minor inputs, obtained around November-December. When no typhoon or flooding takes place this 'residual' harvest represent extra income and profit for farmers.

Regarding the time for recovering, during the survey carried out nearly seven moths after the event it was found that from the total number of families whose houses were reported as 'totally damaged' just four households in Triangulo and six in Mabolo had the means to rebuild them again. Less than 40% of the families living in dwellings reported as heavily or partially damaged had been able to slightly restore them. Even in these cases most of the restoration was inadequate as the owners just could afford using relief items (e.g. *nippa* leaves) and second hand or scrap materials (see state of housing in Figure 5.12).

The general feeling obtained while carrying out the survey was that by that time people had not been able to fully restore both their dwellings and livelihood to previous standards. Nearly 90% of the people interviewed felt they were '*poorer than before the typhoon season started*'. In addition they perceived their houses were less safe because of their lack of means to adequately repairing them or rebuild using stronger materials.

6.4.2 Community flood perception for typhoons Unding-Yoyong

During the interviews the situation experienced by many households across this period was characterised as '*difficult to manage*' or a '*calamity*' - particularly by those settled in the low-lying portions of the study area.

However, it was also found that in certain sectors some families did not experience any damage or the situation just reached levels they considered as *normal* or *manageable* with their own resources.

The areas in which the combination of flood depth and duration leaded to any of the community-based stages of flood threat were obtained by following a procedure similar to the one carried out for super-typhoon Rosing. In this case the categories for hazard were obtained by applying the same set of rules established in Table 6.7.

An approximate representation of the hazard embodied by the Unding-Yoyong flooding episode is portrayed in Figure 6.12. From this map it can be seen how in Zones 1 to 4 in Triangulo and 1 and 6 in Mabolo there are sectors where the situation could be classified as *Normal* or even no flood occur at all. They correspond to raised areas for affluent residential and commercial developments. It should be noted how in the previous section (where flooding from typhoon Rosing, occurred nearly one decade before, was reconstructed) these areas exhibited hazard categories related to heavy flooding. However, for the current episode they remained completely flood-free or just experienced marginal flooding. This situation originated in the modification of the topography, and implies that those areas surrounding the raised sectors experienced deeper flooding and longer duration.

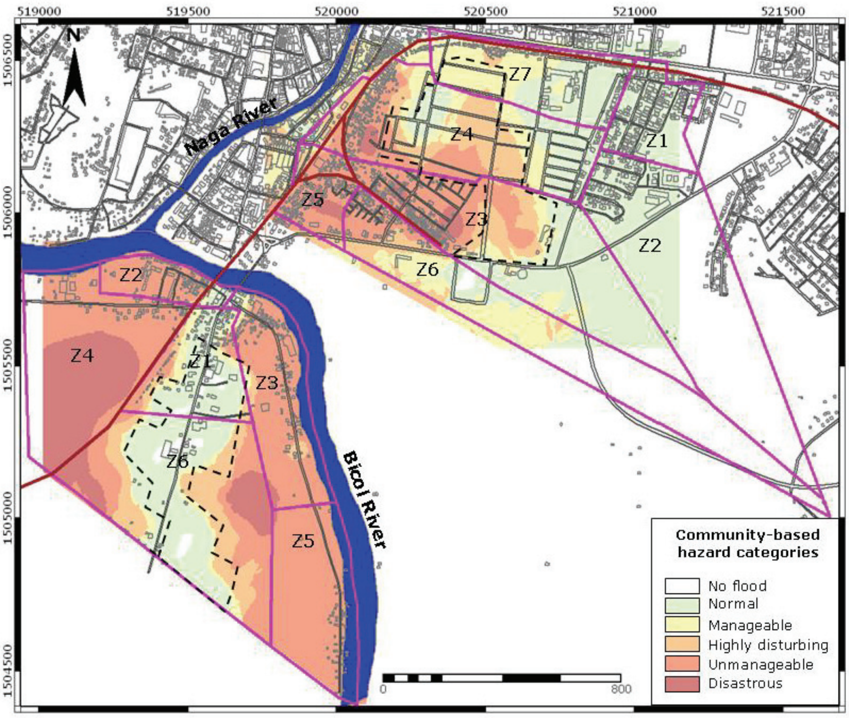


Figure 6.12 Characterisation of the flooding episode caused by typhoons Unding and Yoyong according to people's perception on threat (water depth vs duration).

In the interviews people recalled this increase as one of the negative effects derived from earth dumping practices. Unfortunately, the data on water depth and duration collected during the survey did not provide this level of detail. Therefore, the reconstruction exercise does not provide spatial information in order to corroborate these perceived changes in flood behaviour. Nevertheless, it is expected that with time the compilation of data from new events and the reconstruction of similar episodes (once they occur) can provide the local actors with suitable scenarios for comparison. The compilation of data on water depths and duration trough time will ease the detailed assessment of this type of issues based on community's experiences.

6.5 Reconstructing flooding from tropical depression Labuyo

According to the interviewees, 'normal' heavy rains brought by tropical storms and depressions may cause significant levels of flooding in the lowest lying areas; 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 to wetlands in the Bicol and Naga rivers floodplain. This situation has been worsened by the lack, or inadequacy, of drainage systems and infrastructure that help to drain the runoff from the impervious areas created by urban expansion.

As explained in Section 2.2.2 mapping and analysing small flood events is usually dismissed in conventional hazard analysis. Yet, for this research knowing the distribution and duration patterns of these episodes was deemed equally important. The survey showed that because of their high recurrence they constitute what has been called `every day' or `chronic hazards' for the communities in the study area.

Regarding the mapping of flood parameters associated to torrential rains the data collected comes from two sources: firstly, the GIS-based survey, where the interviewee was asked about the usual depths of flooding caused by heavy rains. The second source originated from the occurrence of tropical depression Labuyo (Damrey) which hit the Philippines and Naga from 19 to 23 September (2005), during the second fieldwork stage of this research. This event provided an opportunity for direct observation and crosschecking of flood depth and distribution; it also favoured, at some point, the direct observation of communities' behaviour when such events take place.

During 2005's wet season and while crossing the Camarines Sur region, Labuyo was categorised as a common tropical depression which brings mostly heavy rains. However, in the northern part of the country this phenomenon increased its category to a 'Tropical storm' causing landslides and flash floods in the mountainous areas with deadly results (see Figure 6.13).

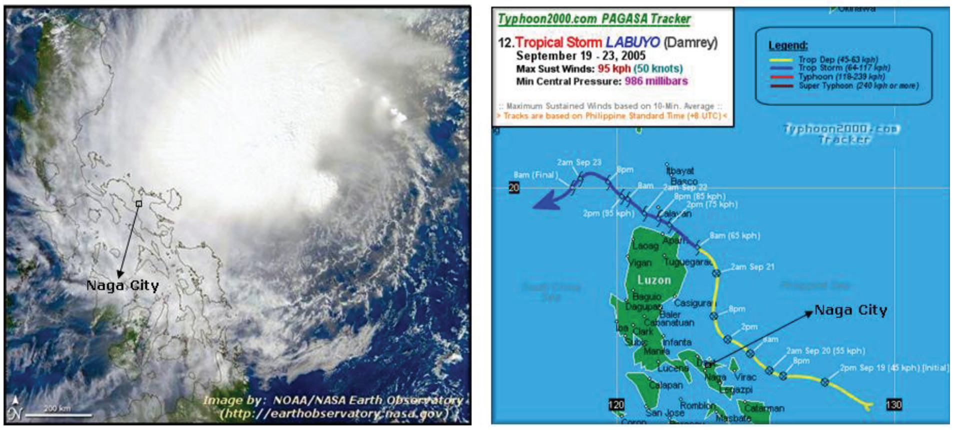


Figure 6.13 Track of Tropical storm Labuyo flanking the Bicol Region and Naga - September 2005 (Source: Typhoon2000.com).

6.5.1 Flood extent mapping from tropical depression Labuyo

Around Naga, tropical depression Labuyo manifested itself as three to four days of continuous rainfall, reaching 175 mm as maximum precipitation in one day (measured in the nearby Camaligan station according to PAGASA, 2005). Unfortunately these heavy rain showers coincided with a high tide surge period which worsened flooding in the lowest-lying sectors of Naga and neighbouring municipalities.

In the Bicol region this event had many negative consequences, not because of the water depths reached but as a consequence of the particular coincidence of flooding with the pre-harvesting stage of rice (*palay*) and other crops.

From the report given in Box 6.1 it can be seen how the agricultural sector was one of the hardest hit, with almost '*no chance for harvest recovery*'.

During this episode all seventeen wards located in the lowest-lying sectors of Naga experienced diverse flooding depths. According to fieldwork direct observations the inadequate drainage capacity of the city highly contributed to worsening the situation. The lowest portions of these Barangays cannot be drained naturally and lack drainage systems. However, by the time this event took place a drainage system was under construction in Triangulo. Yet, according to observations and simulations made by Stek (2005), the drain seemed fairly ineffective in alleviating the flood situation as the whole area is nearly two metres below the level at which water can be properly drained.

Box 6.1 Report on damages to agriculture sector in the Bicol Region by Tropical storm Labuyo

PRESS RELEASE
Department of Agriculture Region 5 (Bicol)
http://bicol.da.gov.ph/News/2005news/press_release/sept28.html
September 28, 2005

Pili, Camarines Sur – The projected good harvest this cropping season may not be attained in the Bicol region as result of continuous rain wrought by typhoon Labuyo. As a consequence, some 17,473 hectares rice fields in various growth stages in the three provinces of the region have been submerged under water. The Department of Agriculture through its Command Centre reported that Albay has a total of 3,8944 hectares of rice fields affected with 2,121 hectares with no chance of recovery. The province of Camarines Sur has 11,086.2 hectares of rice fields affected and 6,452 hectares lost. Camarines Norte reported 2,493 hectares with 1,114 hectares with no chance of recovery.
For rice alone the estimated cost of damage was PhP 91,281,947. Meanwhile, some 1,652 hectares of corn were also affected by the flooding and 618 hectares of which have no chance of recovery with an estimated production loss of Ps 6,935,608. Vegetables were also greatly affected with 786 hectares damaged and 434 hectares have no chance of recovery valued at PhP 17,499,715.
According to Executive Director of the Agriculture Regional, for crops alone, the region had a production loss of Ps 115,717,269 for livestock and PhP 676,160 for poultry. All in the entire agriculture sector in Bicol incurred a total production loss of PhP 116,393,429.

The water depth and duration maps reconstructed for these events are shown in Figure 6.14.

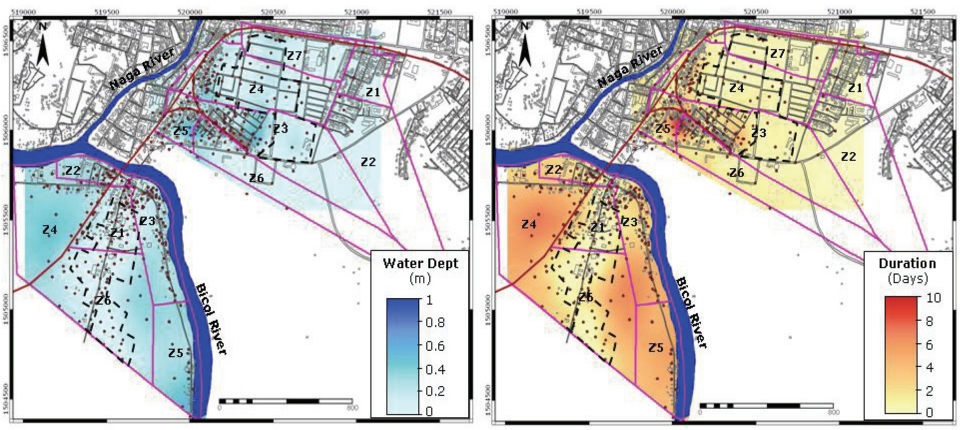


Figure 6.14 Reconstructed water depth (left) and duration (right) maps of the flood episode of the tropical depression Labuyo in 2005.

From these maps it can be observed how the lowest-lying areas experienced deep flooding 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* 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. Percentages of areas flooded per zone with different water depths and duration are presented in Table 6.10 and Figure 6.15.

Table 6.10 Distribution of water depths, duration and percentage of area flooded per zone for the flood scenario for tropical depression Labuyo in 2005 in Triangulo (top) and Mabolo (bottom).

Barangay Triangulo									
Zone	**Water depth (cm)**		**Area (ha)**	**Percentage of area -per zone- flooded at:**					**Duration (days)**
	Min	Max		Ankle	Knee	Waist	Chest	Above chest	Avg
Zone 1	0	3	6	100	-	-	-		0.1
Zone 2	0	5	12	100	-	-	-		0.5
Zone 3	0	55	26	77	18	5	-	-	3
Zone 4	0	45	24	87	12	1	-	-	2
Zone 5	2	58	7	55	33	12	-	-	5
Zone 6	0	57	13	80	16	4	-	-	5
Zone 7	2	25	12	92	8	-	-	-	0.5
Barangay Mabolo									
Zone	**Water depth (cm)**			**Area (ha)**	**Percentage of area -per zone- flooded at:**				**Duration (days)**
	Min	Max		Ankle	Knee	Waist	Chest	Above chest	Avg
Zone 1	0	32	10	88	12	-	-	-	3
Zone 2	2	31	7	18	82	-	-	-	2
Zone 3	1	35	16	26	74	-	-	-	3
Zone 4	21	45	20	-	85	15	-	-	4
Zone 5	24	55	16	-	81	19	-	-	5
Zone 6	0	36	31	62	38	-	-	-	3

Figure 6.15 Percentage of area flooded per zone during TD Labuyo at several community-based levels in Triangulo (left) and Mabolo (right).

6.5.2 Community flood perception for tropical depression Labuyo

Characterising the hazardousness of this flooding episode requires slightly different criteria if the flood threat is going to be addressed according to the community-based flood hazard perception. As mentioned in Section 5.4.4, besides the intrinsic parameters such as flood magnitude and duration, the hazard (associated with any flood event) also has a time component. This time factor is related to the period of the year in which they take place. Acording to this criterion the episode triggered by tropical depression Labuyo embodied a particular high threat for some groups in the studied communities for it occurs 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 (such as the religious festivity of Our Lady of Peñafrancia and the *palay* (rice) harvesting). Flooding spoiled some of the few economic opportunities that people in these Barangays have during the so called *hardship* period (see Section 5.3). Flood stages that in other moment in time would be regarded as *Normal'* or *Manageable* turned into *highly disturbing* and *unmanageable* simply because people have their economic opportunities for the hardship period at stake. The losses experienced did reduce the capacity to *manage* the disruption caused by other flood events during that whole typhoon season and most probably the one the year after (2006).

In order to better address and visualise the influence of the time or 'period of the year' factor on the community-based characterisation of flood threat a double classification exercise was performed for this episode. Initially the reconstructed flood and water depth maps were combined following the same set of rules applied to previous episodes and presented in Table 6.7. A representation of the typical hazard embodied by this type of events was obtained by these means.

In a second step a new set of rules for combining water depth and duration maps were developed based on the community's perception of the threat according to the period of the year in which flooding take place, as illustrated in Figure 5.11. The new set of rules developed is presented in Table ***6.11***.

Table 6.11 Community-based criteria used for classifying flood events during the period September to late October

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'**

In this case, the hazard categories were increased in order to represent the higher threat that inundations occurring during this specific period of the year may represent. The final step consisted of the classification and mapping of both scenarios, which are portrayed in Figure 6.16.

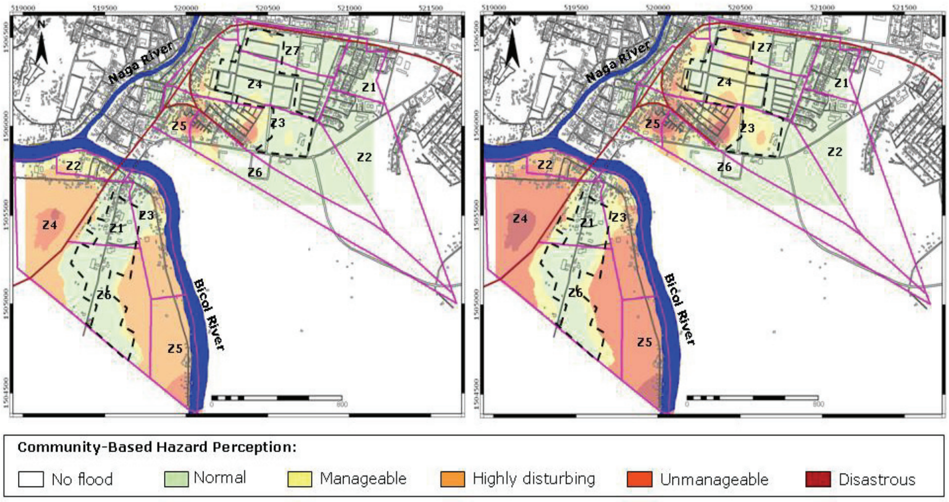


Figure 6.16 Two classifications on the flood threat depending on the time of the year in which inundations occur. Left: community perception during normal wet season, Right: community perception of threat during September-October.

It became evident how the areas classified as unmanageable and disastrous particularly in Zones 3, 4, 5 and 6 in Mabolo, corresponded 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 in Mabolo were not insured. Numerous labourers and workers, earning their livelihood on marginal activities related with harvesting, drying and packing of rice also lost their daily income as very little of the harvest could be saved.

A set of illustrations of the multiple and diverse circumstances taking place during the flooding episode in 2005 is presented in Figure 6.17. This arrangement provides a closer look to the differences in flood threat embodied by this event. As mentioned, the time of the year when it occurred and the different groups of people that were affected create a differential pattern of damage and disruption within the same geographical and administrative area (see Figure 6.17).

In Triangulo several people complained about the poor performance of the new drainage system which was supposed to avoid or lessen flood levels triggered by this sort of floods. Households living close to the structure did see their houses flooded almost up to *unmanageable* levels as, because of the lowest elevation of the terrain, the runoff could not enter the drain structure (see Figure 6.17). Households settled in flood-free areas, and interviewed during this week, considered the inconvenience as *normal* as for them just few of the social and everyday activities were disrupted as result of the heavy downpours.

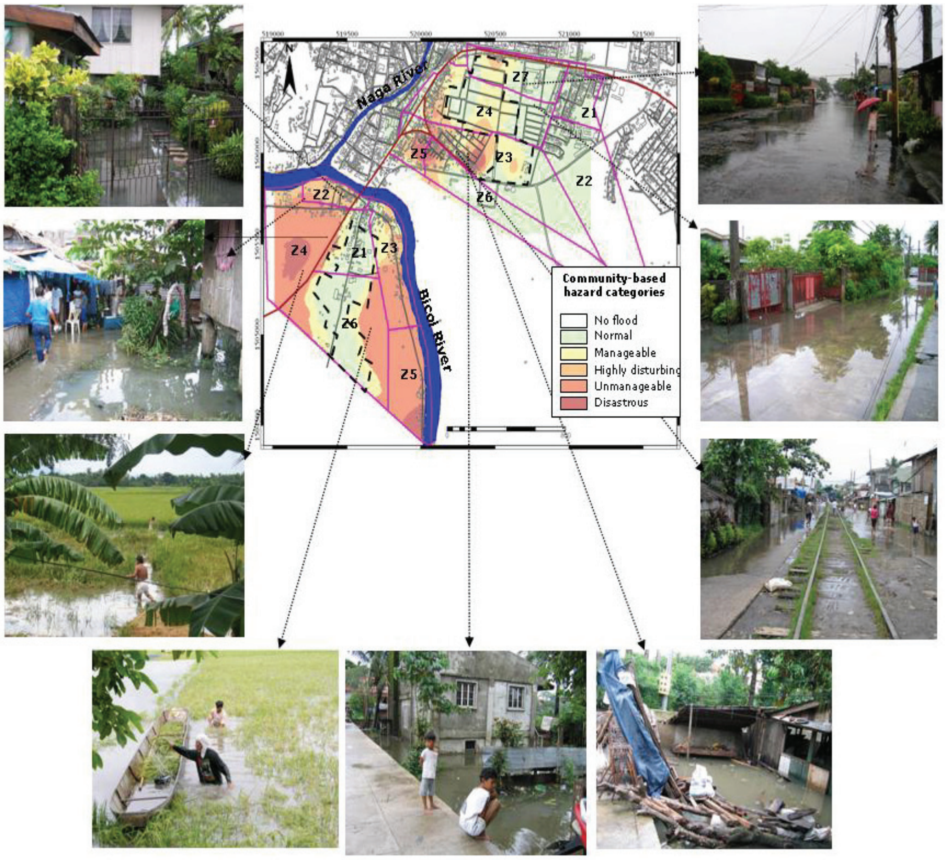


Figure 6.17 From Normal to Disastrous: Illustration of the hazard and disruption embodied by the flooding episode triggered by tropical depression Labuyo in both wards.

The opportunity provided by the occurrence of tropical depression Labuyo helped to illustrate the importance of including these small events as part of flood hazard analysis. The second set of rules and categorisation developed could have been also applied tor typhoon Rosing; which also took place around the same period of the year (1 November, 1995). However, it was found that owing to the extreme depth and duration observed during that event the categories would remain the same, with the whole area displaying *Disastrous* levels of flood hazard. Variations in flood threat then become more visible when moderate to small events occur. If continuous data on these events can be collected they can largely help to understand and moreover to portray and communicate the hazard that these events embody for different groups inside urban and semi-rural communities.

6.6 Main findings and discussion

Usually the kind of flood analysis carried out by means of hydraulic modelling requires significant amounts of data and large budgets, which are not always available in developing countries. However, it is not only a matter of quantity of money or data. Data collection for the application of such modelling exercises generally ignores the perception of those affected by the hazardous events as the central theme of this research underlines.

The mapping and reconstruction of flood events performed in this chapter illustrate the potential of the combined use of local knowledge and experiences and geospatial analysis and methods to bridge this information gap. The use of purely community-based methodologies, statistical and spatial analysis and secondary sources of information (carried out as part of this research) can provide local actors in small cities and data poor environments with opportunities. As demonstrated the combination of their knowledge and technical resources can support a joint work on processes of hazard identification and analysis.

Nevertheless, the method based on information gathered directly from the people in the wards, who suffered the effects of the past events, could have a subjective component. To check for the consistency of the interview data statistical and spatial correlation tests were performed. From these, it was concluded that the community-based data sets displayed a high correlation among themselves; therefore, the resulting maps could be used to facilitate a better understanding of the hazardousness that different flooding episodes represent. Moreover, it was found that the reconstruction of the three flood events analysed showed a good fit to the real situation. They also could be used to analyse and visualise both the physical characteristics of the events themselves (in terms of water depth and duration) and the overall behaviour of the inundation. Furthermore, they can also be used to visualise and understand the threat that these events represented in the past for the people in these communities based on their own perceptions and accounts.

The combination of methodologies used in the approach followed in this study provides new ideas for tackling two old problems at the local or community level: lack of data and the need for detailed hazard assessments, for further mitigation and prevention programmes.

The municipal authorities in Naga have earlier already tried similar approaches in order to tackle these problems. However, these good practices did not continue and therefore much information existing among their communities is at risk of being lost. Implementing methods to continuously collect the data on past events from the affected people and structure them into adequate databases could be implemented as a joint action of the Disaster Management Unit and the Electronic Data Processing office (EDP) of the Local Government Unit. The municipality has the technical and human resources and means to carry out the same type of data collection and analysis as performed in this study. On the one hand, the data obtained by these means can be of interest for a large and diverse number of offices and departments in the municipality, such as the Social Welfare and Development, City Engineering Office, Department of Agriculture, Environmental and Natural Resources, City Health Office, Urban Poor Affairs (office) just to mention a few. On the other hand, the flood scenarios thus reconstructed could provide the municipality with entry points for debate ad discussion with the communities living in the flood-prone Barangays.

The use of similar approaches and information can help them to jointly identify the causes of the flood problematic and search for solutions and potential management approaches.

Chapter 7: Analyzing flood hazard dynamic from a community-based perspective

This chapter focuses on the combined use of community-based methods and hydrodynamic modelling approaches for improving the understanding of flood hazard as a dynamic phenomenon. Under the influence of social dynamic processes, such as urban expansion, the morphology of the study area is being severely modified. Changes in topography lacking adequate measures, isolated structures that do not comply with a comprehensive plan and uncontrolled construction of massive buildings contribute to changes in the flooding behaviour and moreover the hazard they pose to the people in the study area. The community is aware of these changes; therefore combining their observations and perceptions with flood modelling approaches is assumed to be the most adequate way to evidence the hazard dynamic and its significance in the community's present and future wellbeing.

7.1 Introduction

The analysis presented in the previous two chapters demonstrates that it is possible to elicit and structure the local knowledge of communities at risk. Particularly, the approach used in chapter 6 (where local experiences with past flood events were analysed and historic flood events were reconstructed in a GIS environment) demonstrate that integrating peoples' perceptions and experiences into GIS-based flood hazard analysis and mapping is feasible and useful. Nevertheless, even if these community-based methods are very helpful for obtaining flood related information, they also have clear drawbacks. On one hand the scenarios depicted in Figures 6.5, 6.9 and 6.14 are like 'snapshots' depicting the singular occurrence of a concrete flood episode at a particular point in time.

On the other hand the collective memory of the communities can only provide reconstructions of recent flood events, or at best of the maximum flood event that occurred within the last decades. These experiences in the *past* cannot be directly used for assessing flood hazard and risk in *future* circumstances, for instance because of changes in flood hazard and peoples' vulnerability associated to new urban developments. In addition global warming trends make any previous magnitude-frequency relationships unreliable for any future estimation.

To be able to make adequate estimations of flood hazard and risk for future development scenarios the results of the community-based methods should be combined with other flood forecasting methods. In this particular case the research made use of a hydraulic modelling approach that allows for the generation of simulations of future flood scenarios in a dynamic environment.

This chapter specifically focuses on the combined use of local knowledge and hydraulic modelling approaches for improving the understanding of flood hazard as a dynamic phenomenon. Active processes such as urban expansion and economic development modify the treat from flood through time.

As mentioned earlier the practice of raising the ground level by earth filling (locally referred to as *dumping*) has become a standard method for new urban developments. This practice reduces the flood problem in the new areas, but also leads to the redistribution of the floodwaters and the increase in water depth and flood duration in other sectors of the study area; particularly in the low-lying parts where the poor communities live.

The approach followed in this chapter used community's experiences and flood risk-related knowledge in combination with flood modelling in the hydrodynamic programme SOBEK. This two-dimensional (2D) model is able to provide information on flood-related spatially distributed parameters such as water depth, flood extent, flow velocities and duration of flood episodes based on user-defined time frames (refer to Section 3.7.3).

The procedure for evaluating urban expansion practices as a cause for negative changes in flood behaviour is shown in Figure 7.1.

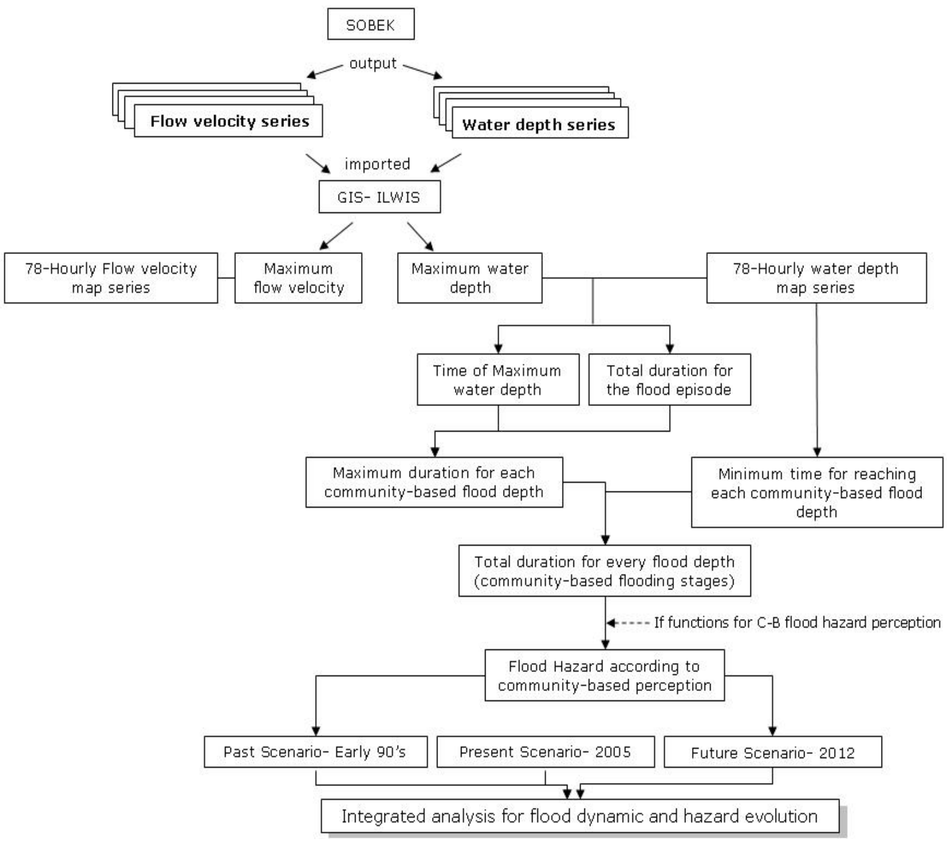


Figure 7.1 Flowchart for integrating SOBEK outputs and community-based parameters for flood dynamic and hazard analysis

7.2 Identifying flood dynamics with local actors

Through various participatory activities it was found that at both administrative and community levels the effects of land use changes and urban expansion on the natural conditions of the floodplain and flood behaviour were acknowledged. In both Barangays the former swamps and paddy (rice) fields have been replaced by private-owned buildings for commercial and industrial purposes; this process often involves elevating the terrain 2-3 metres from the original ground level. Municipal authorities are conscious of the changes and have also recognised how in the surroundings of the coliseum and the Commercial Business District II (CBD II), their policy for development and commercial expansion has exacerbated the flood threat in several zones. Nevertheless, this awareness has not been translated into protective policies, regulations for the development of new expansion projects and in land use plans. The practice of 'elevating the ground level' continues to be widespread and is even the officially recommended method to foster the economic development of the low-lying areas in Naga.

In order to identify the main probelatic issues, related to urban expansion, from a community's perspective, several participatory tools were applied such as workshops, interviews and transects across all zones in both Barangays. In the workshops, for instance, the participants expressed that selective land filling has created local barriers and compartmentalise the area into several retention pockets leading to higher levels and long lasting duration of floodwaters for days or even weeks. Once it become stagnant this water can easily get polluted with human waste and agrochemicals from the remaining rice fields. They also turn into mosquito-breeding areas, thus increasing the risk of water-borne diseases. Another major concern derived from the expansion and new developments is related to the filling and blockage of natural drainages and small creeks that in the past used to facilitate fast drain of flood waters, for instance in Zone 4 in Triangulo where the CBD-II compound was raised.

Finally it was observed how these new developments are decreasing the available open areas were people used to fetch wild edible crops and even grow some vegetables and fruits for selling or fortheir own consumption, particularly after flooding when some staple foods become scarce or over-priced (refer to analysis of coping mechanism in Section 5.4.2). This mechanism practiced by many people to complement the food intake and nutrition of the family members is at stake. Though this negative effect is not easy to identify it threatens the capacity for flood *manageability* and survival of some of the poorest people in these communities.

As mentioned the transecting with local Barangay officers and interviews with residents in different zones allowed to identify both the way in which the poorly planned development process is increasing the flood threat for the community as well as some of the sectors where these phenomena are taking place. Some of these situations are illustrated in Figure 7.2 and further discussed in the following sections.

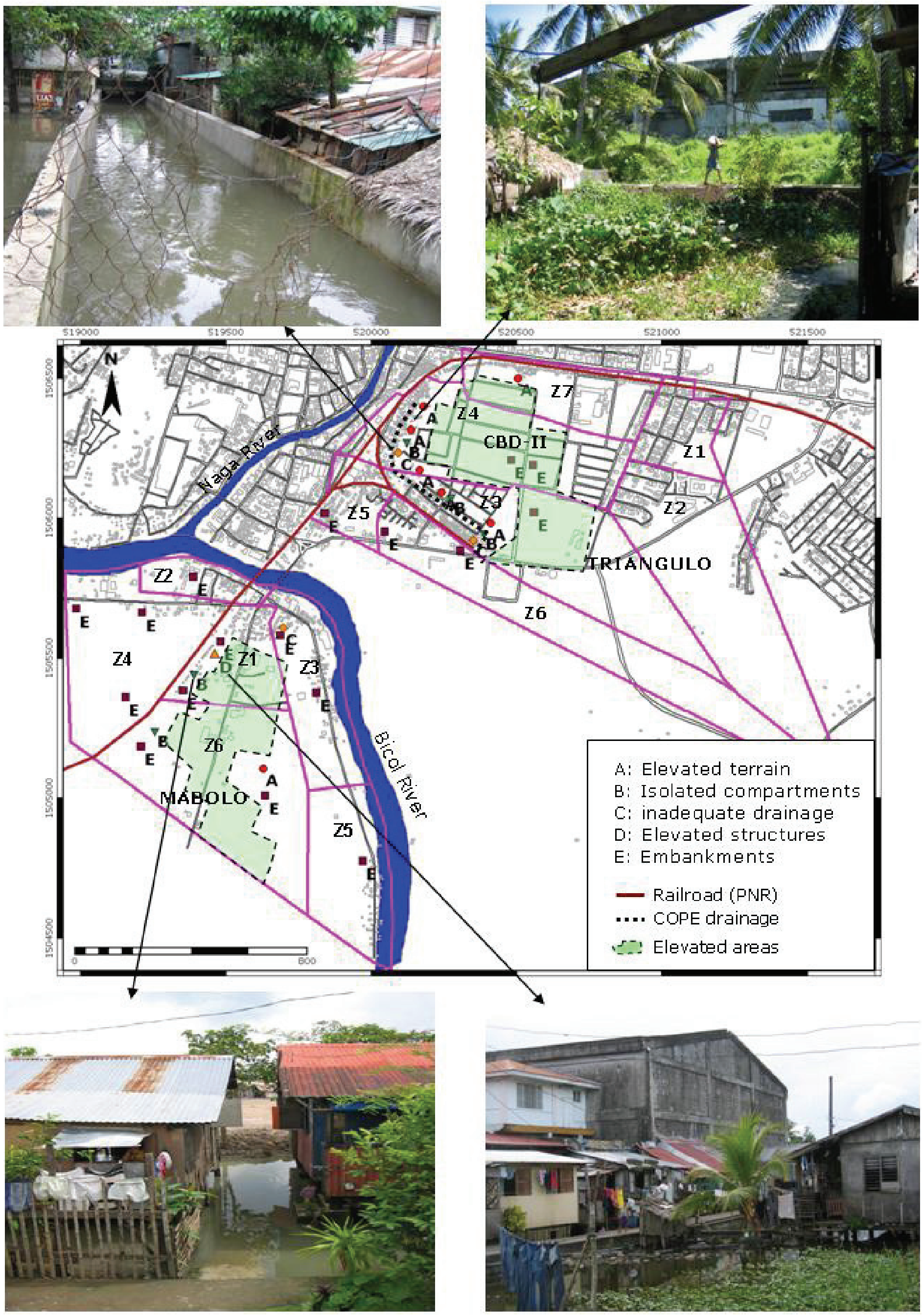


Figure 7.2 Illustration of urban developments that have an effect on flood hazard: Top left: COPE drainage; top right: elevated terrain for urban expansion and massive structures; bottom left: isolated compartments between raised structures; bottom right: mixed industrial and urban poor residential sectors.

7.2.1 Elevation of newly developed areas

The coexistence of contrasting land uses such as industrial and commercial with residential sectors often increases the chances of flooding, especially in the sectors occupied by the poor. Frequently, those who have the means such as well-off citizens, commercial or industrial firms elevate the terrain to protect their investments from flooding, and thereby shift their own risk to the less wealthy members of the community. The poorer households usually have no other option than to keep occupying their original positions in the lower terrains or get trapped in pockets created by the raised buildings (see Figure 7.2).

The existing Naga City Comprehensive Land Use Plan (CLUP), drafted in 1996, encouraged the conversion of open spaces and agricultural fields into commercial and residential zones. Some of the changes in landscape originated in the urban development can be seen in Figure 7.3 where aerial and oblique photographs from 1993 and 2005 allow comparing the evolution of the two study areas.

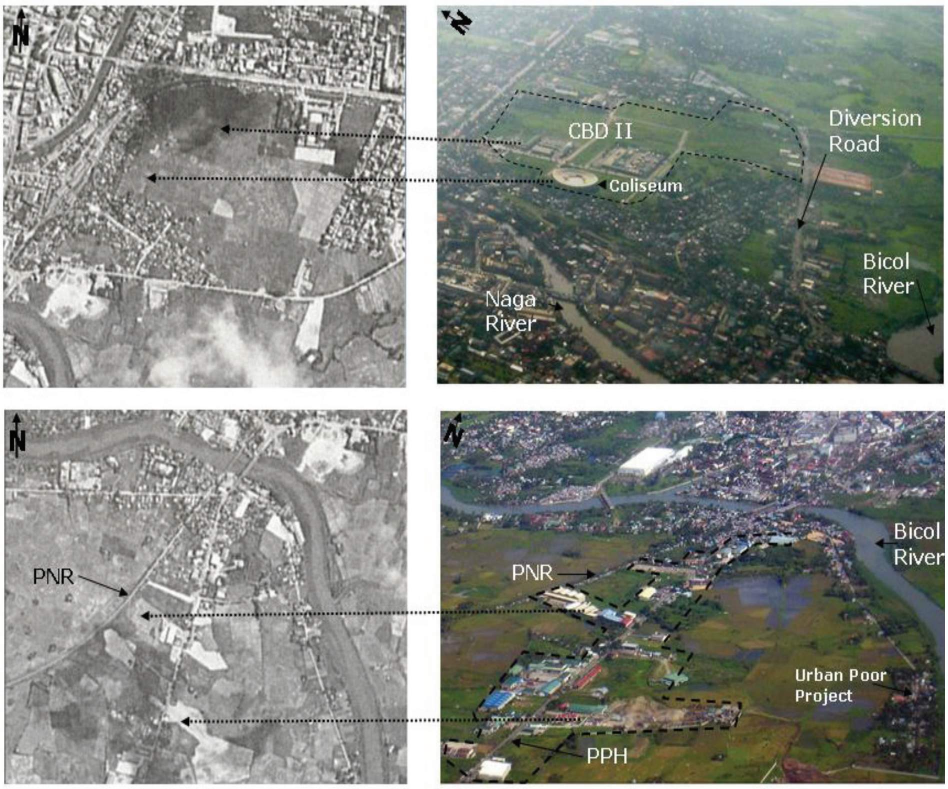


Figure 7.3 Multi-temporal comparison of changes in land use and topography for Triangulo (top) and Mabolo (bottom). Aerial photos (left) show the situation for both areas in 1993, oblique photos at the right show the state of the expansion process for the year 2005. The arrows and dashed lines show the sectors where the original ground level has been elevated for large buildings and commercial and industrial purposes.

In Triangulo a complex which houses a market, shops, a bus terminal and a large coliseum was built in what used to be a swampy area. In order to avoid flooding the whole area was raised nearly three metres above ground level. Despite its size this development was carried out without implementing systems that helped to drain the runoff-rain water and furthermore that avoided spreading floodwaters to neighbouring areas (ADPC, 2001).

Besides compartmentalising the former floodplain this expansion process also blocked portions of various creeks connected with the Bicol River which naturally drained the area. The hazard for the residents settled in the surroundings (Zone 3 and 4) has been exacerbated because these sectors often experience low levels of flooding every time it rains, which means almost the whole wet season. In these areas people are experiencing a bigger hazard because of the prolongued exposure to deeper and long-lasting floodwaters but also as result of the longer exposure to perennial stagnated, and often polluted, waters.

7.2.2 The COPE drainage system

During the second fieldwork stage (2005) a drainage system was under construction as part of the Community Organisation of the Philippines Enterprise (COPE) project in Barangay Triangulo. Naga does not have a Master plan for storm drainage management and therefore the drainage built in this zone was not considered in any long-term and comprehensive programmes. Although the projects' main intention was to support the drainage of Triangulo and other neighbouring wards, the local people became concerned about its effectiveness during a flood episode. They feared that the construction in such a low-elevated area most probably floodwaters would not be able to flow from the terrain into the drainage.

According to some project engineers the whole terrain, including houses and infrastructure, should have to be elevated more than one metre above the current level for the drainage to work. During interviews it was found that this new structure generated a lot of apprehension and distress among the community as it created several new situations that the local people had to face. Firstly there was a lot of uncertainty about the performance of the drainage during a flood. Fears about higher depths as a result of the backflow from the Bicol River and longstanding waters were widespread. Secondly the need to raise the terrain or their dwellings to catch up with the unbalance created by the structure put a lot of strain on the family income. Owing to their poor socioeconomic conditions most of the households would not be able to allocate resources to elevate their houses. Lastly, the project increases the possibilities for expanding the urbanisation process towards this sector once the terrain has been raised. As a consequence, it also increases the chances for eviction since nearly 90% of the dwellings are illegal.

The flooding episode triggered by tropical storm Labuyo during fieldwork (September 2005) tested, in part, the performance of the COPE drainage. While most of the households from zones 3 and 4 complained about deeper flood levels, in other zones the general feeling, especially among the Barangay officers, was that the whole flood episode lasted shorter than previous ones. However for the lowest lying areas (zones 4 and 6) most of the fears, in particular those regarding longer duration of low-level stagnated waters were confirmed. The COPE drainage simply could not 'drain' and besides acted as a barrier that impedes water to freely flow. The top left image in Figure 7.2 shows how floodwaters reached the same depth inside and outside the structure. According to researches carried out by Stek (2005) and Rahman (2006) the drainage project will not be very effective; its main contribution may be on changing the future behaviour for small magnitude floods (between a 2 to 5-year return period). According to these authors its contribution to decrease the magnitude of severe flood episodes is almost negligible.

7.2.3 Elevated buildings and embankments

The construction of large isolated elevated buildings and structures makes the flood patterns and behaviour very complex. In Mabolo the construction of massive elevated and unconnected buildings for instance private schools, hotels and rice storehouses, are creating a divergent pattern of development. The axis of this expansion is obviously located along the connection routes, in this case the Pan Philippine Highway (PPH) that links Naga City with Manila and the southern provinces. Once flooding takes place this centrifugal pattern pushes the floodwaters outwards in the direction of neighbouring low-lying areas usually occupied by urban poor settlements and marginal agriculture fields (See Figures 7.2 and 7.3).

Another experienced problem is caused by the construction of infrastructure for transportation (roads, railroads) without adequate complementary engineering works. The absence of drainages, culverts and other structures required for draining the runoff transforms the roads embankments into barriers thus contributing to the long-lasting duration of stagnated waters and increasing the exposure of the inhabitants to water-borne diseases. This problem can transform small levels of flooding, initially deemed as *Normal* by the community, into *Disturbing* and even *Unmanageable* as result of longer-standing periods. The train track, the Pan Philippine Highway and the diversion road are typical examples of barriers that favour the accumulation and stagnation of floodwaters in most of the zones in both Barangays (See Figures 7.2 and 7.3).

7.3 Using SOBEK and community-based parameters for flood hazard modelling

In order to be able to model and analyse the dynamic of flooding and flood hazard identified with the local actors the following steps were taken. Firstly the local perception of flood threat analysed in Chapter 5 was integrated with the occurrence of the three flood episodes, reconstructed before in Chapter 6. Secondly, three scenarios were formulated: a ***Past*** scenario representing the areas in the earlier 90s when most of the developments have not yet taken place; a ***Present*** scenario which depicts the state of affairs for the year 2005, and a ***Future*** scenario, depicting the expected development situation by year 2012.

As mentioned before in Section 3.7.3 and 7.1 the SOBEK software was selected for the hydraulic modelling. The main reason for selecting this programme was its capacity to model flood extent, water depth and flow velocity at different time intervals. Besides it also allows including various scenarios of river discharges, tidal effects and differences in topographical elevation. The spatial data required to run the model, presented in Figure 3.10, included a Digital Terrain Model (DTM) or a Digital Surface Model (DSM) if buildings and other structures are to be included in the modelling (as was the case for this research); the channel network and a land cover map (transformed into surface roughness coefficients). Inflow discharge and water levels constitute the non-spatial data. This section discusses how these input data were collected.

7.3.1 Digital Surface Model (DSM)

The joint identification transects made it evident that buildings and embankments strongly influence the behaviour of floodwaters once they enter the study area. In this study it was decided to use a Digital Surface Model (DSM) that closely resembled the situation at the ground. The DSM included most of the structures in the areas such as embankments and main buildings with their elevations above ground level. The DSM used in the modelling was derived by Rahman (2006) based on a multi-source approach for integrating several datasets (i.e analogue and digital contour line maps, spot height measurements, as well as height information for embankments). The study included a step-by-step selection and integration of the datasets in order to reduce the variance and overlapping of the diverse datasets. By making use of error reporting techniques (i.e. nominal accuracy, accuracy ratio, RMSE test) the best elevation value was selected from the available data to represent the closest-to-real terrain elevation model. As there was insufficient available data for generating a reliable DSM, a topographic survey was also carried out (See Figure 7.4).

Figure 7.4 Data collection on elevation points within Naga using geodetic levelling (Photos by Rahman, 2006)

After reducing the disagreement among the datasets an Ordinary Kriging interpolation method was performed in order to generate the terrain model.
The building footprint map provided by the EDP office in the Municipality was used to include the heights of the main buildings. However, owing to the date

of the information this map had to be updated as well by means of field survey, oblique pictures and integrating development plans. In his research Rahman (2006) also determined the convenience of including buildings as solid blocks in the DSM. When these structures are treated as rough surfaces they cause an overestimation of flood extent, velocity and depth. Thus, the DSM that was generated had a 5 m resolution and was used to represent firstly the situation before the construction of the elevated areas, termed as the *Past* situation (See Figure 7.3). Secondly in order to represent the *Present* situation the Digital Surface Model (DSM) was updated with the newly elevated areas to represent the topographic situation of the low-lying zones by the year 2005. In this case conventional levelling was carried out, together with functionaries of the CEO office, in the areas that have been raised and claimed from the wetlands. Thirdly the *Future* situation was included based on the developments envisaged for year 2012 and the current land use plan (See Figure 7.5).

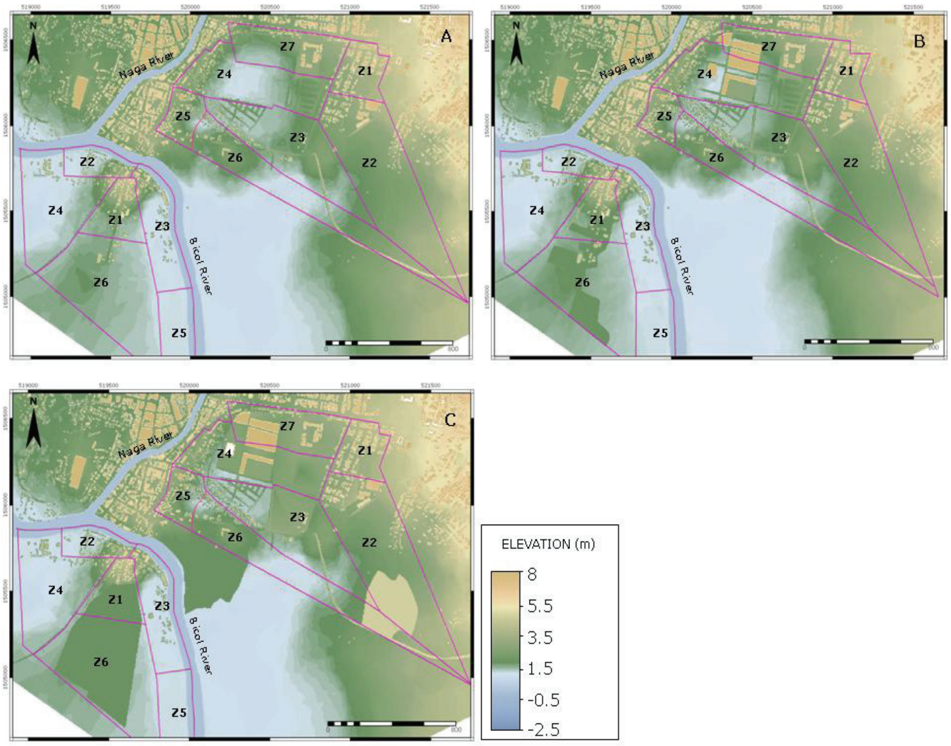


Figure 7.5 Representation of the Digital Surface Models generated for the study area for three different situations. A: Past representing the situation in the early 90s; B: Present situation of 2005; C: Future situation as envisaged for 2012

In this case a projection was made alongside the areas that are currently undergoing expansion in both wards. It was then assumed that if these areas are going to be occupied by commercial and industrial purposes then most probably they would be elevated at least two metres above sea level in order to avoid recurrent flooding (see Figure 7.6).

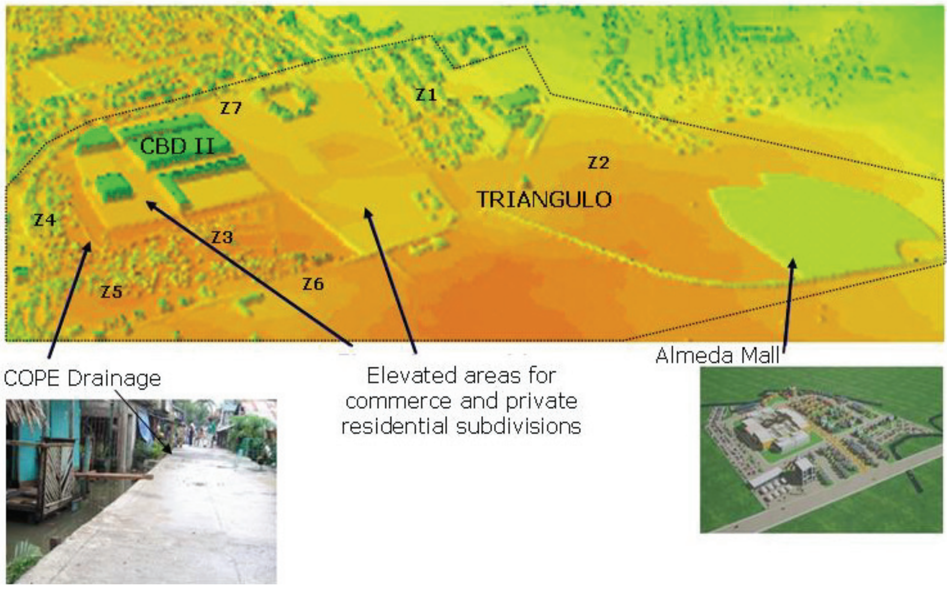


Figure 7.6 Illustration of the Digital Surface Model including the planned development in the surrounding of Triangulo (Source: Rahman, 2006)

7.3.2 Surface Roughness coefficients

In flood modelling, the resistance to flow as result of the interaction water-surface is required to show the flood behaviour, in this case in a floodplain. The roughness map represents the resistance to flow and the slowdown of the water movement exerted by the vegetation and other land covers present in a given area. However, in order to understand the relationship or effect that different land covers have on the floodwater motion it was important to input the distribution of land covers present in the Bicol and Naga Rivers floodplains under the form of roughness coefficient. The Manning's resistance coefficient is widely used owing to the large volume of reference data available to correlate resistance coefficients with boundary conditions (USACEArmy, 2001).

The Manning's coefficient in a floodplain area is a complex function of flow velocity and depth, vegetation type and density, dimension and flexibility; it depends on the types of land cover and must be specified by the user. The resistance coefficients for Naga city were derived by Tenakoon (2004) and Rahman (2006) by testing three sets of Manning's coefficients, which where in turn adopted from previous detailed surveys carried out in the area by the Asian Institute of Technology- AIT (1975) and BCOM consultants (1991).

In Table 7.1 the Manning's coefficients used for the flood modelling in this research are provided. These values were linked to the land cover categories present in the map provided by the EDP unit and applied to the land use map of the study area for the past, present and future scenarios.

Table 7.1 Manning's coefficients used as input for the flood modelling

Land Use	Manning's coefficient
Agricultural (paddy field)	0.025
Commercial	0.032
Industrial	0.032
Residential	0.032
Swampy area	0.025
Roads and Railway	0.025
Buildings	1.0

7.3.3 Boundary conditions

The input hydrographs and tidal data used in the modelling are shown in Figure 7.7.

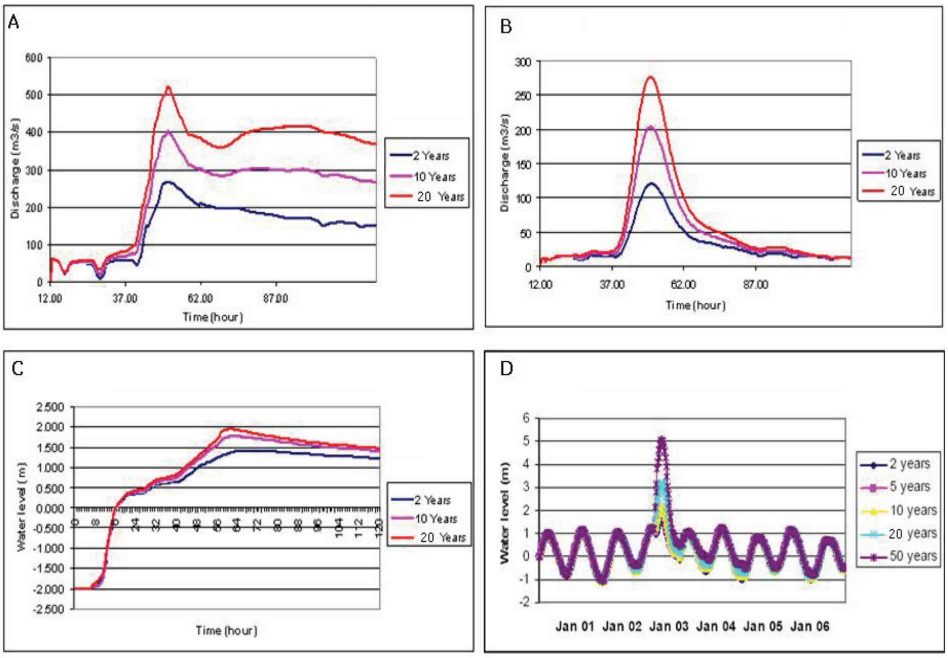


Figure 7.7 Boundary conditions for the 2, 10 and 20-year return period flood scenarios A: hydrographs for the Bicol river where it enters Naga; B: hydrographs for the Naga river where it enters Naga; C: water level fluctuations in the part of Bicol river downstream of Naga; D: tidal fluctuations in San Miguel Bay (Source: Rahman, 2006 and Bin Usamah, 2005).

The boundary conditions for the hydraulic modelling consist of the water level data in the upstream and downstream limits of the study area. Discharge data for the Bicol and Naga Rivers were derived by Bin Usamah (2005) from a regional study performed by the NIPPON KOEI (2003) mission in the Bicol Basin.

This study used the MIKE 11 simulation programme in order to generate discharge hydrographs at the upstream boundaries of the study area for flood events with 1.25, 5, 10 and 25-year return periods (BCEOM Consultants, 1991; NIPPON KOEI, 2003). Where, the discharge values for the 2 and 20-year return period floods were derived by Rahman (2006).

The downstream boundary conditions for both rivers which include the tidal fluctuation in the San Miguel Bay were derived by Bin Usamah (2005) based on the NIPPON KOEI (2003) data. In the present study, scenario floods for only three return periods (2, 10 and 20 years) were used in order to limit the number of calculations.

7.3.4 Rainfall Data

Besides the discharge data the hydraulic model also required data on local rainfall falling during the modelling period. The rainfall distribution for storms with 2, 10 and 20-year return periods were derived from the BCEOM Consultants study (1991), the NIPPON KOEI mission (2003) and Stek (2005). The datasets correspond to the rainfall events for which information was available, and s such are presented in Table 7.2.

Table 7.2 Characteristics of the storms used as input for the rainfall distribution used in the hydraulic modelling.

Observed Storm	Year	Max. 1 day rainfall (mm)	Return period (years)
Typhoon Rosing	1995	393	20
Typhoon Monang	1993	292	10
Tropical depression Labuyo	2005	168	2

The curves were generated by taking the hourly rainfall data existing for these typhoons on a 3 day (78 hours) scenario for every storm as shown in Figure 7.8.

The records show that most of the rain occurred in a 3-4 days period; hence despite the long computational time required for running the 2D model a period of 78-hours was selected as modelling time threshold in order to preserve the original rainfall patterns as much as possible.

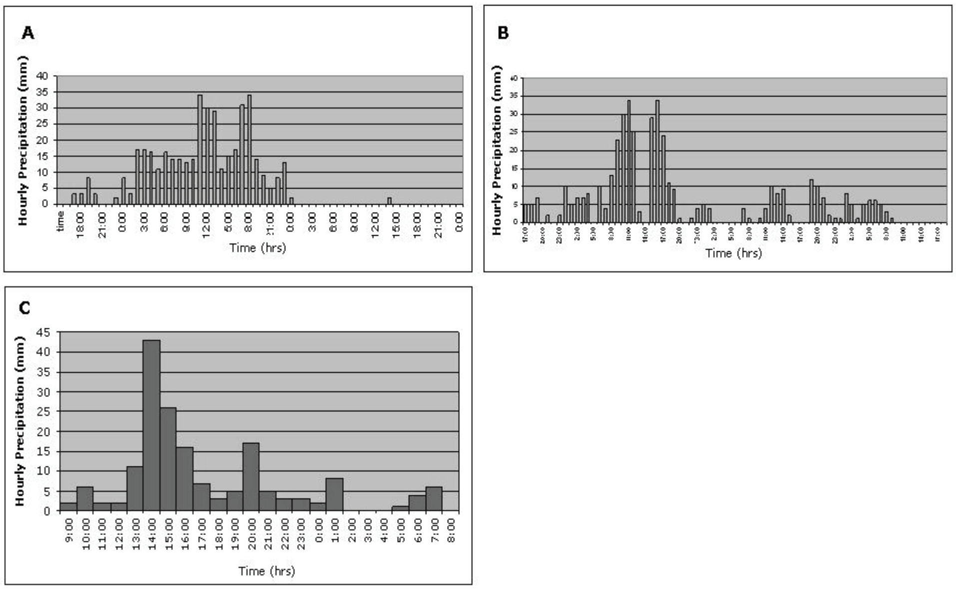


Figure 7.8 Hourly rainfall distribution for typhoons Rossing (A), Monang (B) and tropical depression Labuyo (C).

7.4 Model schematisation

Modelling in SOBEK is carried out using several modules which are linked to each other using a network editor called NETTER. This interface allows the schematisation of the flood model components on top of a GIS layer reference.

Building the model is done in stages. Firstly the dataset of the DSM (in ascii format) is schematised in the 2D network. After this the flow boundary conditions are defined in the 2D network as well. In this scheme node-like features, called history stations, are used to determine the exact values of the modelled parameters (i.e. water level variation with time).

The schematisation of the 1D network represents the properties and layout of the river system. The river system is defined in NETTER by straight lines. The 1D system should also contain cross sections of the river profile. Then SOBEK interpolates values between the cross sections to assess values for all points within the river system (WL|Delft Hydraulics, 2006).

The cross sections used as input in the model were derived by Rahman (2006) and are added along the river network at 150 m intervals. Figure 7.9 shows the complete schematisation for the modelling. In order to model the flood episodes in the past, present and future situations the corresponding DSMs were used as input in the 2D grid system.

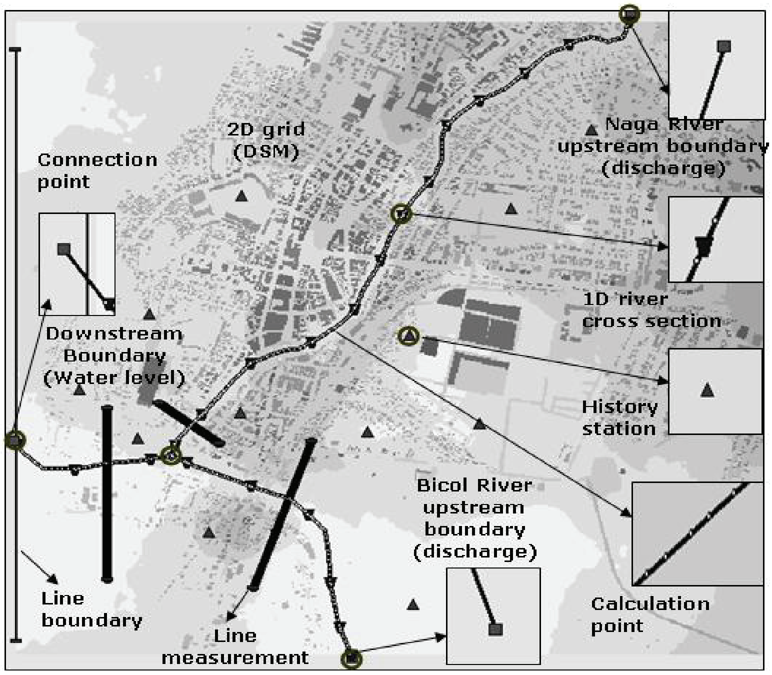


Figure 7.9 1D and 2D Model schematisation in SOBEK for the Present situation

7.5 Output maps from SOBEK modelling

SOBEK generates several types of outputs. For every user-defined time step the spatial-temporal dataset are generated which display the spatial distribution of water depth and flow velocity (WL- Delft Hydraulics, 2001). From these two data sets additional maps containing the maximum water depth and maximum velocity in each cell (pixel) can be generated (see the flowchart in Figure 7.1).

Given the time-frame used in this study the modelling resulted in a series of 78-hourly maps for the each one of the *Past, Present* and *Future* flood scenarios and each of the three return periods of flooding. These maps, in ASCII-format, were imported into a GIS (ILWIS) for further analysis and visualisation. The final data set included:

a) Water depth series comprising 78 hourly-maps for the three developmental scenarios and three return periods (3*3*78 = 702 maps).
b) Flow velocity series comprising 78 hourly-maps (also 702 maps)
c) Maximum Water depth maps for the three temporal scenarios and three return periods (3*3 = 9 maps). These maps were generated by taking the maximum water depth from the 78 hourly maps for each scenario and each pixel. The maximum water depth maps were classified using the community-based criteria for water levels as indicated in Figure 5.6
d) Maximum flow velocity maps for the three temporal scenarios and three return periods (9 maps).

From these maps two other datasets were derived: *flood duration* and *time to flooding* maps as described in the following sub-sections.

7.5.1 Flood duration

The flood duration parameter is to estimate the time that water remains at a given location. This is not a direct output produced by SOBEK. It depends on the modelling time specified by the user which not always coincides with the total duration of flooding. To do so it required to obtain both the total duration of the flood episode and the total duration of particular flood depths. The last parameter was required to assess the hazardousness to the community-based flood stages described in Section 5.4.3.

The total duration for each flood episode was defined as the time where the linear extrapolation of the maximum water depth and the water depth at the T=79 intersects zero metres as shown in Figure 7.10. In order to obtain the total duration of each flood the following formula was used:

*Total duration = (((T (79) – T (wd max)) * wd (79))/ (wd (max) - wd (79))) + T (79)*
[Eq. 7.1]

After obtaining the total duration for the whole episode the maximum duration values for every flood depth (*Ankle, Knee* etc.) were obtained by using the aforementioned procedure.

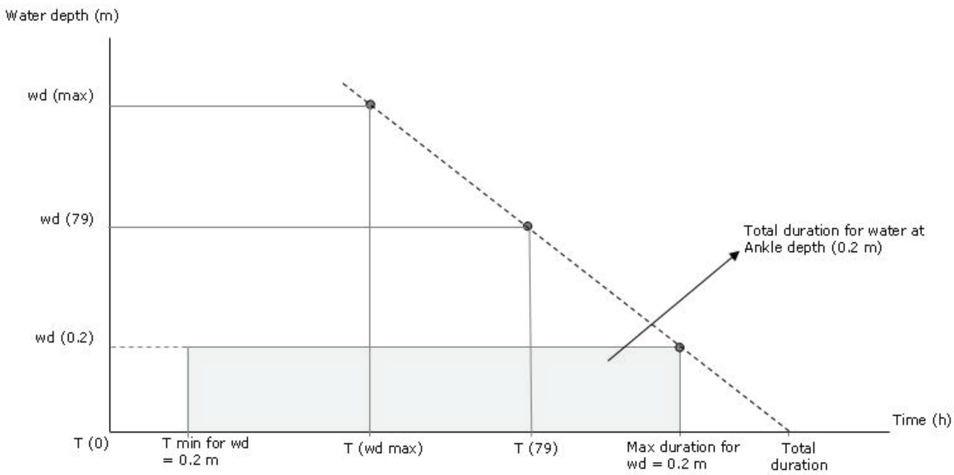


Figure 7.10 Estimation of total duration for a flood episode and each community-based flood water depth

Finally the total duration for each flood level was calculated by subtracting the minimum time for reaching this water level from the maximum time it remained, as follows:

Total duration for flood at ankle level = (Max duration for wd 0.2) – (Tmin for wd =0.2)

[Eq. 7.2]

The outputs were divided by 24 in order to express duration in days.

7.5.2 Time to flooding

This parameter represents the time at which the floodwaters in a given point reaches a certain level (i.e *Ankle, Knee* depth) for the first time after the start of the flooding episode. This parameter was firstly used to identify the total duration of each flood stage and secondly to analyse modifications in time for flooding as result of changes in the topography. At municipal level these maps can also be useful for indicating the time at which flooding reach dangerous categories such as *Highly Disturbing, Unmanageable* and moreover *Disastrous* conditions within every Barangay.

Figure 7.11 illustrates the type of outputs generated throughout the aforementioned processes; corresponding to maps for maximum flood depth, flood duration and time to flooding.

7.6 Validation of the flood modelling outputs

Like any model, fruitful application of hydrological models require validation of the representation with respect to real flood events. According to Alkema (2007), very few studies have been made to evaluate the performance of inundation models by comparing them with events that have actually happened. In this research the community-based datasets collected during the GIS-based survey (and presented in Chapter 6), were used to calibrate some of the outputs from the flood simulations in SOBEK. Both sets of water depth and duration for the 2, 10 and 20-year return period obtained from SOBEK were compared with those for the three flooding episodes identified during fieldwork in the following way:

1. The output for the 2-year return period flood in the *Present* scenario (2005) was compared with records from tropical depression Labuyo.
2. The 10-year return period flood in the *Present* scenario (2005) was compared with data from combined typhoons Unding-Yoyong.
3. The 20-year return period flood in the *Past* scenario (early 90s) was compared with the datasets for Super typhoon Rosing. The *past* scenario was used here to avoid the effect of newly elevated areas in the DSM.

Table 7.3 shows the results of the comparison among these datasets. For every Barangay the results from the community-based model were subtracted from the SOBEK results for each flood event. As it could be expected there were areas where the SOBEK model overestimated the results of the community-based model (positive values in the *Over* column) and areas where the first model underestimated the outputs from the second one (negative values in the *Under* column). The total average represents the difference between models when absolute values were average over the whole area. This procedure allowed to estimate the differences in water depth among the two datasets but moreover it helped to evaluate the under or overestimation of one model with respect to the other.

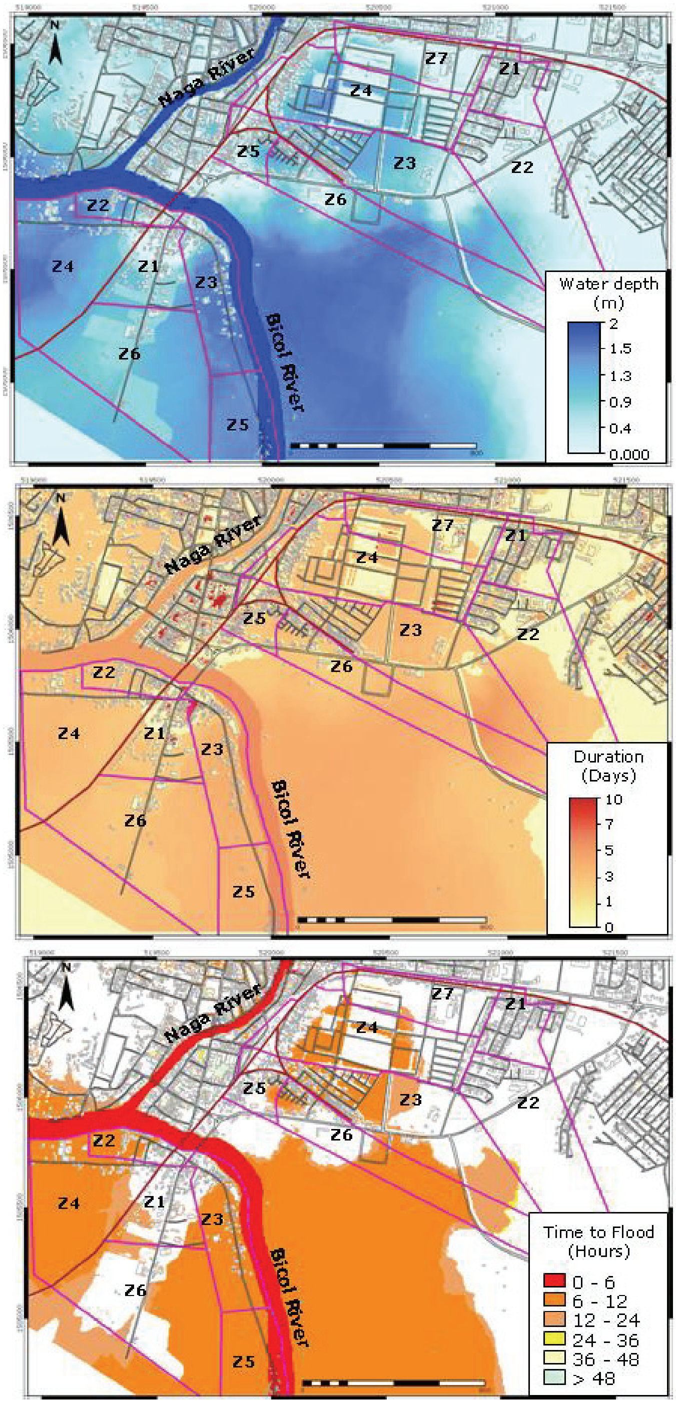


Figure 7.11 Some examples of SOBEK output maps: maximum water depth (top), total duration (middle) and minimum time to flooding at Waist level. The examples are for the 10-year return period flood in the Present scenario.

Table 7.3 Differences between water depth and duration for the dataset community-based survey (CB) and the results from SOBEK modelling (SOBEK) for three flood scenarios.

Event/ Return period	**Water depth (cm)**							**Duration days**
	Triangulo			**Mabolo**			**Total Avg** both wards	**Total Avg**
	SOBEK-CB			SOBEK-CB				SOBEK-CB
	Over	under	Total Avg	Over	under	Total Avg		
Labuyo (2-y)	19	-25	22	10	-22	16	19	1.79
Unding/Yoyng (10 y)	30	-33	31.5	35	-38	36	34	1.61
Rosing (20 y)	44	-48	46	42	-35	38	42	3.94

Avg= Average

The validation of the community-based results and the SOBEK results must start with a critical discussion of differences. This may yield a better understanding of the situation in reality as well as of the merits of the different methods rather than the decision that one method is better than the other. The figures on Table 7.3 show how in average the community-based values were found larger than those simulated by SOBEK. This can be caused by a number of reasons. The community-based method might lead to an overestimation of the flood depth owing to some degree of subjectivity. The interpolation method used to reconstruct the flood event might have an additional increasing effect as well. Additionally, it can be noticed that the larger events show also larger differences among the datasets; this might indicate that when the rising waters reach certain flood levels (above chin or eye level) the community-based measurements become less precise as people miss their reference points.

On the other hand, it can also be argued that the hydrodynamic modelling underestimates the water depth values because of the multiple assumptions done. Underestimations in flooding depth by SOBEK are plausible because of difficulties in representing the complex topographical and hydrological situation leading to flooding in the study area and the limitations in data availability.

For instance, as explained in Chapter 6, the Unding-Yoyong event was a combination of several typhoons bringing heavy rains in a two-week period. Yet, this event was simulated herein by using the data available for a single event as input for the 10-year return period in a 78 hours time period. Another issue is that in the 2-year return period scenario the high tide backflow effect was not included in the modelling, which may explain the total average 19 cm difference in water depth for both wards during this event (see Table 7.3). Regarding the differences in the duration of the two datasets it is noticeable how the SOBEK model overestimated the duration of the 2 and 10 year scenarios, by one and a half day. In the 20-year return period event the SOBEK model underestimated the total duration of the event by nearly 4 days. The aforementioned reasons were also found valid in explaining these differences.

Maps on Figure 7.12 show the differences in flood hazard between the two datasets, as classified by the combination of depth and duration according to categories on Figure 5.6.

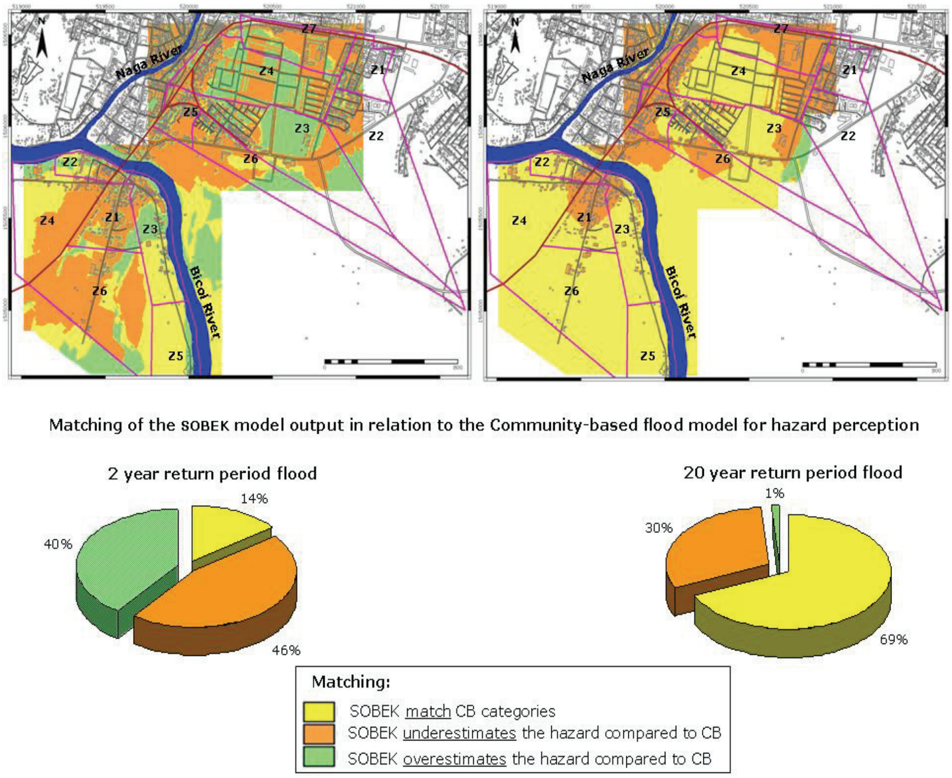


Figure 7.12 Differences in hazard classes between the community-based and SOBEK results for 2-year (left) and 20-year (right) return period floods. The over-and underestimation is related to the Community-based survey.

Compared with the results from the SOBEK model the Community-based hazard maps tend to either match or overestimate the threat. For the 2 and 10-year flood episodes the overestimation outcome was mostly because of the influence of water depth differences in low hazard stages such as *No Flood* and *Normal* categories particularly for elevated areas. The underestimation was mostly the result of differences in duration to which hazard stages such as *Highly Disturbing* and *Unmanageable* happened to be more sensitive. Nevertheless, even if the two datasets did not fully match, they show a significant correlation and some of the errors can be corrected by refining and improving the datasets used for both methods. This comparison illustrates the need to carry out combined approached of community-based surveys and flood modelling. Community-based methods, when carried out without additional modelling, will only allow reconstructing historic scenarios, and only as far as the people remember them. Therefore, it can be concluded that running hydrological models without community-based input may lead to underestimation of the hazard as was proven in this section.

7.7 Applying community-based concepts and SOBEK outputs for flood dynamic and hazard analysis

The most conventional use of hydrological models in hazard analysis is the identification of areas prone to differentiated flood magnitudes as well as the assessment of hazard categories according to parameters such as water depth, flow velocity or the combination of both. Conventional hazard maps obtained from these models are mostly used in the design of urban and land use plans, emergency response and disaster management programmes among others. However, in this research the versatility of the hydrodynamic modelling was applied primarily to analyse the effect of landscape and topography modifications in the dynamic of flood and the hazard they represent for communities in the study area.

As mentioned at the beginning of Section 7.3 joining together communities' flood risk related knowledge, conventional modelling and GIS-based analysis were all seen in this research as a double-aimed practice. On the one hand the GIS-based analysis seeks for assisting communities to communicate their concerns and perspectives about issues that may affect them. On the other hand it was meant to demonstrate that the use of parameters and perceptions derived together with at-risk communities may help to broaden the general understanding of flood as a threat. Particularly at municipal administrative levels this type of analysis may raise awareness about the implications of urban and development-related process and interventions as threats that change or amplify the hazardous burden that communities in flood-prone environments already have to bear. Thus, in order to achieve these two purposes community-based hazard maps were calculated for the *Past* and *Present* scenarios for each of the return periods modelled (i.e. 2, 10 and 20-year) by using the water depth and duration criteria as shown in the preceding sections. In this section the resulting maps are compared in order to identify areas where increase or decrease in hazard categories has taken place.

In Naga, raising the level of the terrain by dumping earth and land filling has been considered an efficient and cost-effective practice. Wealthy families, business investors and official sectors often use these methods to avoid or mitigate the risk of flooding for their private or public investments. The modification of the topography alleviates the flood problematic in, comparatively, small areas but shifts the risk towards other zones and social groups with less resources and capacities to manage the increased threat. In the last decade this harmful practice was the way in which urban expansion and economic development took place in the former floodplain of the Bicol and Naga rivers. Despite their acknowledged harm these practices still remain as the model for development-oriented expansion in low-lying areas. Being able to reveal how these practices have worsened the already precarious situation for some of the groups settled in the study areas was then considered important for at least two reasons: firstly it may present communities and municipal authorities with new insights to understand the danger embodied by these practices and secondly it may provide these actors with new entrance points for decision-making processes where economic development can still be achieved without compromising the wellbeing of the communities settled in the area.

To determine how the encroachment of urbanisation has influenced the dynamic of floods and flooding threat hydrological models for *Past* and *Present* scenarios were run using two different Digital Surface Models or DSM (see Section 7.3). The first model reflected, as much as possible, the situation of the study area in the early 90s; when the area was still considered as a swampy-agricultural oriented sector. The second model represents the situation in the year 2005; when the land use had been orientated towards more commercial and industrial purposes (see Figures 7.3 and 7.5).

7.7.1 Analysis of SOBEK results for past and present scenarios

After obtaining every set of hazard maps for the *Past* and *Present* scenarios an analytical, statistical and GIS-based comparison was made for the three flooding episodes. In the following section the main differences between the two temporal scenario and the three return period scenarios will be analysed.

Figure 7.13 illustrates the changes in maximum and average water depth and duration for three return periods and for the *past* and *present* scenarios, for all zones in Mabolo (Mb) and Triangulo (Tr). The radar graphs help to identify those zones where topographic modifications have influenced, either negatively or positively, water depth and duration behaviour.

As seen from the radar graphs in Figure 7.13, the modified landscape has influenced the behaviour of the flood aspects that represent a threat for the communities. However, with regard to the depth that floodwaters can reach, notice how in Triangulo floodwaters has increased for all scenarios, in particular for the 2 year return period. The increase in nearly 0.5 m in these small but recurrent scenarios implies that people will be increasingly exposed to the negative effects of flooding. This increased threat is also evidenced by the graphs on the right, where it can be seen that *Total Duration* of flooding has increased for all return periods. For Zones 4, 5 and 6 in Triangulo and 2, 3, 5 and 6 in Mabolo the nature of the modifications in flood dynamic has been mostly negative. This fact becomes particularly distressing if one considers that these are the zones where the poorest groups of households are settled and where the municipal programmes for housing and on-site resettlement for the Urban Poor are taking place.

An overview of the positive or negative impacts, in terms of increase or reduction in magnitude of the flood parameters (water depth and duration) for the flood events with three return periods is presented in Table 7.4.

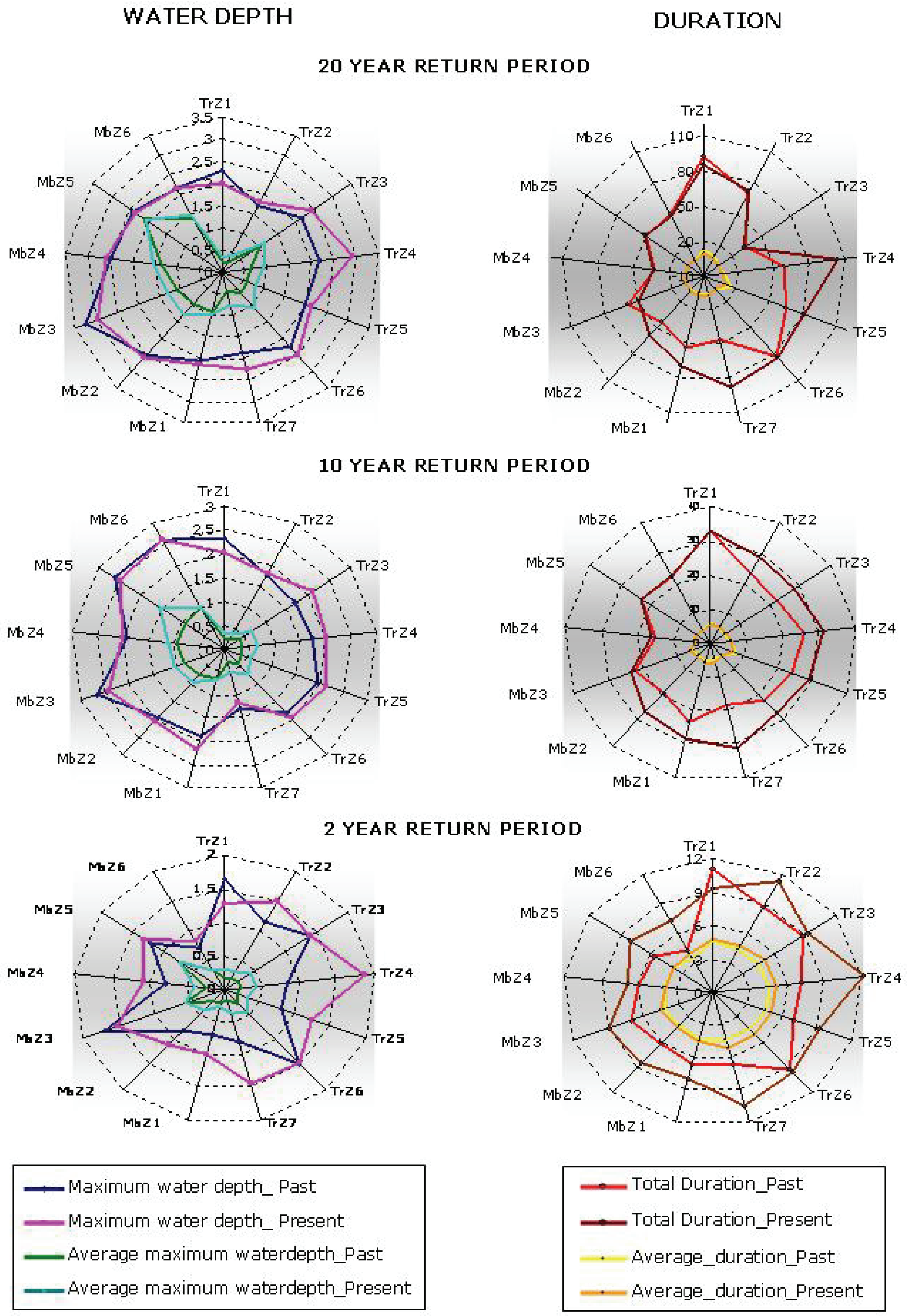


Figure 7.13 Radar graphs showing the changes in maximum and average Water Depth and Duration for the Past and Present situation for three scenarios (20-yrp flood: above, 10-year return period: middle, and 2 year return period: below) - for each zone in Mabolo (Mb) and Triangulo (Tr) .

Table 7.4 Characterisation of the change in flood hazard factors as result of topographic modifications for the two wards. (-): worsening of hazard situation of the present as compared to the past; (0): no change; (+): improvement of the hazard situation.

Return period	Flood parameter	Zones						
Triangulo		**Z 1**	**Z 2**	**Z 3**	**Z 4**	**Z 5**	**Z 6**	**Z 7**
20 years	Max. Water depth	+	0	–	–	–	–	–
	Average Water depth	0	0	–	–	–	–	–
	Total Duration	+	0	0	–	–	0	–
10 years	Max. Water depth	+	0	–	–	–	–	+
	Average Water depth	+	+	–	–	–	–	–
	Total Duration	0	–	–	–	–	–	–
2 years	Max. Water depth	+	–	0	–	–	0	–
	Average Water depth	–	–	–	–	–	–	–
	Total Duration	+	–	–	–	–	0	–
Mabolo		**Z 1**	**Z 2**	**Z 3**	**Z 4**	**Z5**	**Z 6**	
20 years	Max. Water depth	0	0	+	0	0	0	
	Average Water depth	0	–	–	–	0	0	
	Total Duration	–	–	+	0	0	0	
10 years	Max. Water depth	–	0	+	0	0	0	
	Average Water depth	0	–	–	–	–	0	
	Total Duration	–	–	–	0	0	0	
2 years	Max. Water depth	–	–	+	–	–	–	
	Average Water depth	–	–	0	–	0	0	
	Total Duration	–	–	–	–	–	–	

For the flood event with a 20 year return period, mostly negative impacts regarding flood depth and duration can be observed in most of the zones, although several zones showed now a change between the past and present situation. For instance Zones 4 and 5 in Triangulo exhibit negative impacts for all parameters implying that next time when a flood with this return period would take place the communities settled in these areas will face an increased threat. Considering that Zone 4 in Triangulo is one of the areas that have undergone more drastic modifications in topography (for the CBD-II and other commercial buildings) one would expect that positive effects would prevail. However the predominance of negative impacts implies that residents in the remaining low-lying sectors of this zone will have to endure higher flood levels next time a 20-year flood would occur. In Barangay Mabolo the topographic alterations have not caused a major increase in the parameters for flooding with a 20 year return period. This difference in behaviour between the two Barangays, despite the fact that in both areas significant portions of the terrain were elevated, may be partly caused by the configuration of the terrain and the direction in which expansion is taking place. Mabolo is located in an open portion of the floodplain where the development process is taking place in a centrifugal pattern (see Section 7.2.1). The flood-prone portion of Triangulo occupies a small back-swamp basin that has been artificially enclosed by roads and other man-made interventions and its expansion has followed an inward pattern. In Mabolo the floodwaters still have open space available for spreading, therefore no major modifications for depth and duration could be found. The opposite occurs in Triangulo where there is less space to allocate the same amount of water;

therefore flooding generally tends to be deeper and remain for longer periods of time.

For the 10-year return period, negative impacts for Zones 4 and 5 predominate. The harmful effects also reach Zones 3 and 6. The difference with the 20-year flooding is caused by the fact that the water depth was already high in the past situation for this large event, and changes in the topography produce smaller changes than for the 10 and 2 year return periods. In Mabolo, the negative effects in the 10-year flood parameters are more evident than for the 20-year flood magnitude. In this case it was found that low-lying sectors in Zones 1, 2 and 3 are enduring the negative impact shifted from adjacent elevated areas while open spaces in Zones 4, 5 and 6 are still effective in counteracting the harmful effects. For the 2-year return period Zones 2, 4, 5, and 7 in Triangulo and 1, 2 and 4 in Mabolo present the most harmful effects as all the parameters experience negative changes, with implications for the communities settled there.

7.7.2 Analysis of flood hazard dynamic using SOBEK results and community-based criteria

The results of the SOBEK modelling were classified using the community-based criteria presented earlier in Table 6.7. These set of rules correspond to the community's perception on the manageability of flood threat they can achieve with the resources and coping mechanisms they had, taking as baseline the situation by year 2005. The manageability criteria were assumed to be static through time, meaning that the same manageability options could be used today as 10 years ago (i.e. in 1995 during super typhoon Rosing); which probably might not be the case. For one the wealth, resources and strategies of any community are dynamic too and, as it was evidenced in the reconstruction of flood scenarios in Chapter 6, after every episode people in the studied communities have the perception that they are becoming poorer and less able to deal with new events. In that sense one may argue that ten years ago the manageability or resource band of many households in these Barangays was possibly larger. On the other hand the dynamic of the economic development in the study area, Naga city and the Bicol region in general has also modified the characteristics of the hazard and hence people's resistance to inundations. For instance, during the workshops, it was found how decades ago, when the number of people settled in these areas was less numerous and less industries and commercial establishments had been established nearby, the floodwaters used to be less polluted. People then were more able to manage low levels of standing flooding for longer periods without being adversely affected, which is not the case now.

A set of rules on the perception of threat for flood episodes in the past could not be obtained during fieldwork; therefore the same set of rules was applied for the different periods analysed.

Figure 7.14 helps to identify changes in flood hazard distribution for the study area.

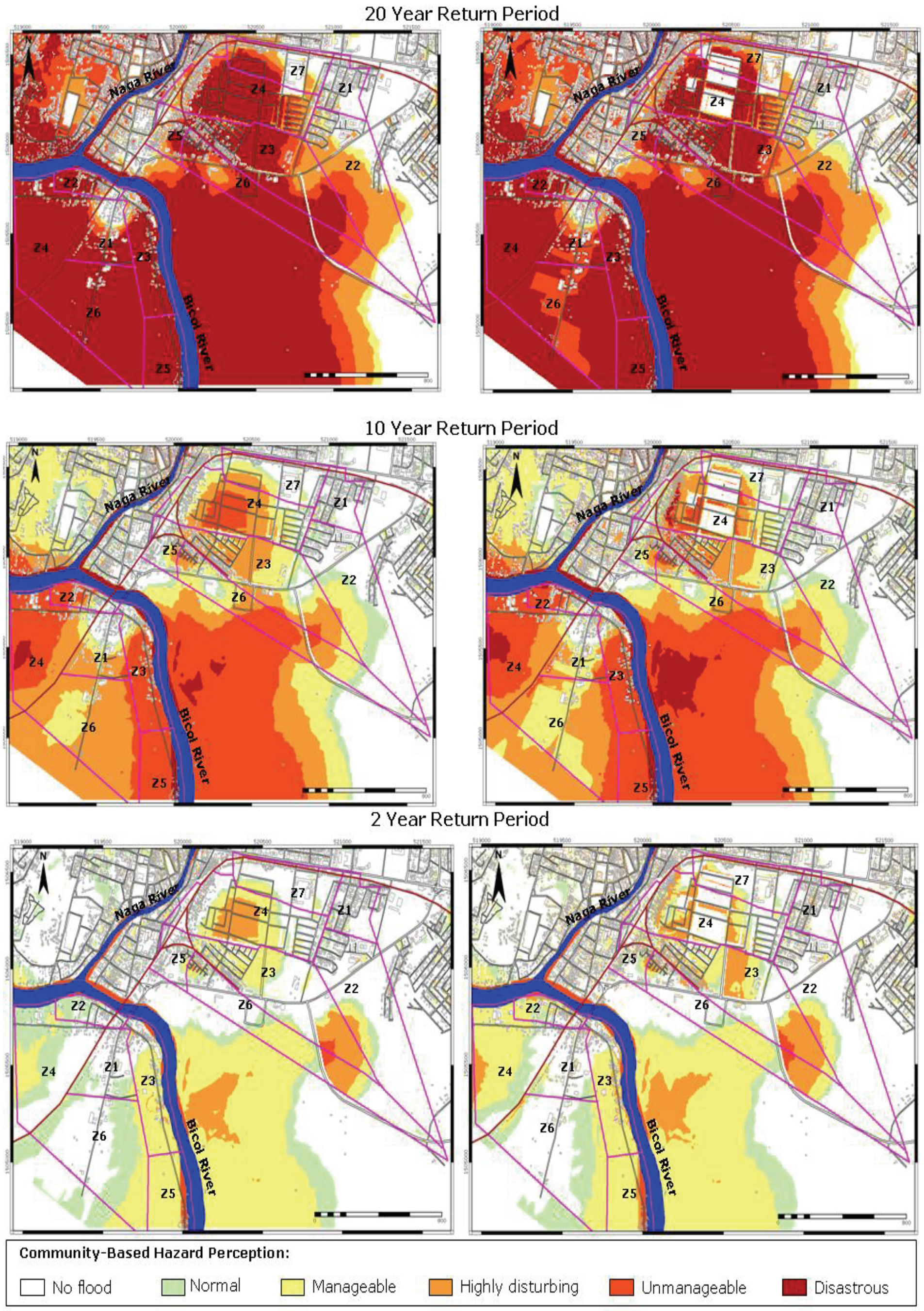


Figure 7.14 Maps of the flood modelling results classified using Community-based criteria for the scenarios in early 90s (left) and 2005 (right) and for 3 flood events (20, 10 and 2 year Return Periods).

The figures show the spatial distribution of the flooding using the classification according to community-based categories of manageability explained in Section 5.4.3. A 20-year return period flood taking place in the current situation will reach a *Disastrous* category for communities settled in 50% of the area corresponding to Triangulo and 90% of Mabolo. The recently elevated parts of Zones 4 and 7 in Triangulo will most probably experience no flooding a all (No Flood) or flooding at *Normal* stages even during this large flood event. Communities settled in the newly elevated sectors in Mabolo (part of Zones 1 and 6) will face flooding at *Manageable* stages probably as result of long-standing rather than deep floodwaters. Nevertheless the lower portions of these zones will all reach *Disastrous* flood stages.

For the 10-year return period, the positive effects (derived form modifications in the topography) are limited to the elevated sectors where the threat from floods disappeared or is decreased to *Manageable* levels; associated probably with the permanence for several days of flooding at low (*Ankle*) depth. The most negative effects found were associated with the appearance and increase in extension of flooding with *Unmanageable* and *Disastrous* characteristics particularly in heavily occupied areas in both Barangays.

For the 2-year flood event, the most considerable variations are related to a small increase in flood-free area, particularly in Triangulo (from 63.0% to 64.1%) and disappearance of the flood threat in raised areas where sectors categorised as *Unmanageable* were improved to No Flood or *Normal* hazard. In Mabolo several sectors previously classified as *Manageable* and *Highly Disturbing* now display *No flood* or *Manageable* categories. For this return period it was found that most of the positive effects were limited again to the newly elevated areas.The negative impacts found however were more widespread and harmful as they were related to the emergence of hazardous classes such as *Highly Disturbing* and *Unmanageable* in areas where before flooding was marginal. These threatening categories extended towards adjacent low-lying areas that besides are heavily populated.

Figure 7.14 displays the overall assessment for flood hazard dynamics by comparing variation in flood threat between the *Past* and *Present* scenarios. A Positive effect implies a decrease or lowering effect in the community-based hazard category assessed; areas with negative impact are those for which the category of hazard will increase. This analysis shows that, once again, the positive impacts will take place in the recently elevated sectors in both Barangays while households settled in the remaining low-lying areas will face higher or similar hazard categories than those experienced in the past.

The evaluation of aspects that have been modified by urban development processes included the analysis of the minimum time in which floodwaters will reach the various water depths used by the communities as a warning and reference system (see Figure 5.6). A delaying effect in the time at which flooding will arrive to a specific flood threshold was considered as a positive impact as it will give people more time to react and protect themselves and their valuables. The opposite situation, speed-up of the time at which a given flood level is reached, was considered as a negative impact because the time available for reacting and taking self-protective measures is reduced.

Figure 7.15 Effect of landscape modifications in flood hazard dynamic estimated by changes in Time for flooding. The maps of the 20-year return period show the time to reach Chest level. Maps of the 10-year return period show time to reach Waist level, and maps of the 2-year return period show time to reach Knee level.

Regarding the 20-year return period episode, the most significant impact was found in the time required by the floodwaters to reach *Chest* level (around 130 cm). According to Figure 7.15, a delaying effect for this threshold will take place mostly in elevated areas where this category will not be attained again, at least during flooding of this magnitude. The negative impact represents a 1-3 hour speeding up effect that will affect communities in Mabolo particularly those settled in Zones 2, 4, 5 and 6 where the poorest groups, included those taking part in the Municipal Urban Poor programmes for housing and on-site resettlement, will find how the time at which they start facing flood threat with *Disastrous* characteristics has decreased.

For the 10-year return period it was found that communities in the lowest-lying sectors will experience a speeding-up effect of nearly 1 to 4 hours for all flood stages. The map in the middle of Figure 7.15 shows the areas were positive and negative effects on the time for flooding to reach *Waist* depth can be expected during flooding with this return period.

The current topographical circumstances determine that, during the occurrence of 10-year return period floods, communities settled in Zones 3 and 4 in Triangulo and 3, 4 and 5 in Mabolo will see a reduction in the time for performing the required self-protective decisions and actions. The decrease in time for the flood to reach this depth (around 90 cm) is particularly critical as this is the threshold at which most vulnerable households need to look for external assistance and protection. Moreover, *waist* depth was found as the stage at which the dislocation created by flooding start to reach *Unmanageable* status at ward level.

For a 2-year return period event, the impact of a modified topography is related to a speeding-up effect of nearly half a day (12 hours) for most of the community-based flood depths. The bottom map in Figure 7.15 displays the spatial analysis for flooding to reach *Knee* depth (around 40-50 cm). As seen positive effects were found in the newly elevated areas and some adjacent sectors, probably because it will take longer time for the water coming directly from the river to reach these areas. The negative effects are distributed in low-lying areas and are particularly noticeable in Zones 3 and 4 in Triangulo and 2 and 4 in Mabolo where people will have less time to react.

In general diminishing the time at which floodwaters will reach different flood depths have a direct impact on the outcome of flooding. The communities in the study area have developed protective mechanism based, among others, on the slow onset at which flooding use to take place. Therefore, having less time to react and, for instance, moving their utensils, furniture and other belongings to safer or elevated structures will increase direct losses and the hazardousness represented by flooding even at earlier stages.

This representation of the Past and Present scenarios determined how among the three return period analysed herein, the highest dynamic in terms of redistribution, expansion and emergence of community-based hazard categories was found for the 2-year event. The results of the analysis show how inadequate practices are contributing to worsening the threat embodied by flooding and pushing communities to deal with increasing hazardous stages for which their tolerance and resources may become insufficient.

7.8 Flood hazard assessment

The hazard assessment is the ultimate outcome of the process of identification, analysis and mapping of flood events. A hazard map should address the direct and indirect damage that the depth, duration, velocity, sediment load and pollution carried by waters can cause to a community, their valuables, the physical structures where they live and work and the social and economic activities they depend upon.

The use of community-based categories supported the analysis of the negative effect of floods on households and the community but they do not provide direct information on how flood can inflict damage to buildings, crops and other economic activities. In order to achieve comprehensive risk assessments for a community this information is required. Hazard maps that directly address the capacity to harm of a given flood stage can then be combined with vulnerability maps and stage-damage curves in order to obtain risk spatial analysis and quantitative damage assessment.

Although flood hazard is a multi-dimensional concept, very often it is assessed and mapped only considering its spatial (areal) distribution. Spatial extent and depth of inundation are the most popular parameters use for flood hazard mapping nowadays. However, the community-based analysis in this research has shown that other parameters such as duration and velocity are required to address the level of hazard embodied by a given flood.

Duration of inundation is an important parameter for flood risk assessments, however it is not considered in many flood hazard studies mainly because of difficulties and cost involved in its estimation. As explained earlier in Session 7.5.1 duration of flooding is not a direct output of conventional hydrological (pixel-based) models and therefore its calculation requires data and expertise that is not always available when using conventional hydraulic models and software.

In this research, however, information on water depth and duration could be derived from the participatory work carried out in both communities. By combining the duration and depth files obtained as output from SOBEK the hazard that flooding represent was assessed for the Past, Present and Future scenarios for the three return period floods that were simulated. By using these categories the final hazard assessment was undertaken for two different situations:

1. The *present* situation of the topography, representing the baseline situation in 2005, and using the Digital Surface Model explained earlier in Section 7.3.1.
2. The future situation which includes the areas that are projected to be elevated by the year 2012, according to the Naga development plan (see Figure 7.5).

Table 7.5 summarises the hazard categories and the associated community-based classes.

Table 7.5 Categories for Flood Hazard assessment based on water depth and duration

Flood parameters		**Hazard category**	**Characteristics**
Depth	Duration		
0-0.2 m	< 3 days	Low	-No damage to structures. -Nuisance to daily life activities. -Indirect threat to health from stagnated waters.
0-0.2 m 0.4-0.6 m	> 3 days < 3 days	Medium	-No structural damage to buildings in concrete and bricks. -Plaster in walls may need some reparations and painting. -Wooden houses may undergo some damage. -Frames and other structures in organic materials may get damaged as result of long-term immersion. -Damage to crops sensible to deep and long-lasting immersion. -Drinking water supplies may -Basic services and transportation may be disrupted. -Indirect threat to live derived from long-standing flooding. -Increased exposure and contact with stagnated and polluted waters.
0.4-0.6 m 0.9- 1.3 m	> 3 days < 3 days	High	-Concrete buildings may undergo some damage to wooden doors and frames, plaster, and painted walls. -Sediments and dirt have to be removed from inside buildings. -Houses in light materials may suffer total damage in pillars, frames, walls, floors and doors. -Direct threat to physical elements. -Shortages of food and clean-up Supplies. -Jobs may be lost due to the disruption of services and business. -Secondary and tertiary effects to health and wellbeing.
0.4-0.6 m 0.9- 1.3 m > 1.30 m	> 7 days > 3 days 1 day	Extremely High	-Direct threat to human life and community wellbeing -Extended damage to buildings in concrete and bricks -Total destruction of houses in light materials

7.8.1 Hazard assessment for the present situation

The hazard assessment was performed using the outputs from the hydrodynamic modelling for floods with three return periods in the *Present* scenario. This set of maps represents the behaviour of flooding under the current topographical circumstances found in the study area.

Figure 7.16 provides the three hazard maps for the present situation.

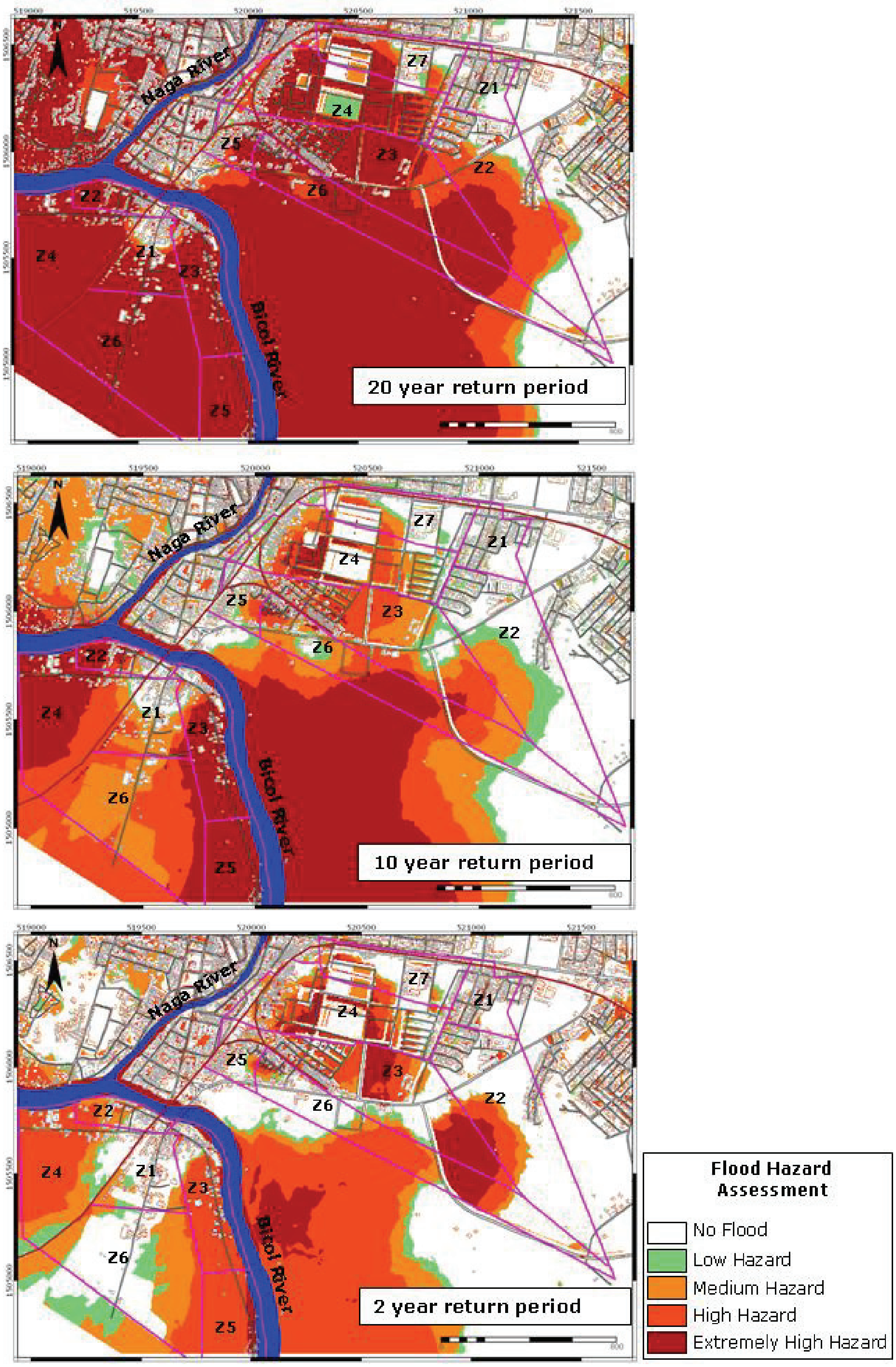


Figure 7.16 Flood hazard maps showing the flood hazard assessment, based on water depth and duration, for the Present situation.

The flooding associated with a 2-year return period closely resembles a situation of everyday or chronic hazard; as such events happen very often. According to the analysis in Section 2.2.1 the chronic hazard represented by high frequency flooding is associated with deterioration in environmental and health conditions, progressive erosion of social and economic resources, and an increase in people’s vulnerability to bigger events.

From the hazard map in Figure 7.16, it can be seen that for people settled in Zones 1 and 2 in Triangulo and 1 and 6 in Mabolo this 2-year flood will not represent high levels of hazard. The opposite, for people in Zones 3, 4, sectors of 5 and 6 in Triangulo and 2 to 5 in Mabolo the combination of water depth and duration represent a high hazard and may particularly threaten those families whose livelihood is related to agricultural labours and related activities. In addition people in these areas are undergoing growing threat as result of deeper levels, longer duration and increasing time at which flooding is taking place as derived from previous analyses.

The threatening circumstances that, according to the communities, moderately to severe flooding can cause are related to a serious disruption of everyday life, the propagation of water-related diseases to serious illness or injury, significant economic losses and structural damage leading to a contribution to the poverty-trap effect. This type of flooding is regularly associated to floods with a 10-year return period, such as the one presented in Figure 7.16. It should therefore be noticed that most of the people settled in the lowest-lying sectors of both Barangays will face high and very high hazard during flooding of this magnitude. However, people settled in zones 1, 2 and 7 in Triangulo and elevated sectors in zones 1, 3 and 6 in Mabolo will experience low to medium threat. Communities in zones 3 to 6 in Triangulo and 2 to 6 in Mabolo on the other hand will face moderate levels of hazard as result of deep floodwaters standing for days or even weeks. The threat faced by people in all zones may imply that both wards, particularly Mabolo, may need external municipal assistance when floods of this magnitude happen.

The most feared circumstances, related to the occurrence of 20-year return periods, can be summarised as widespread physical and structural damages. Normal life activities are disrupted for weeks and even months, and water-related diseases will lead to serious illness and death. Flooding will lead to significant economic losses for all social groups and sectors, and a large portion of the people are driven into poverty and marginality. Flooding of this magnitude will create circumstances in which *Disastrous* situation will be widespread not just in almost every zone in the study area but moreover in the whole low-lying area of the city. According to Figure 7.16, only communities settled in small elevated portions of zone 1, 4 and 7 in Triangulo and zone 1 of Mabolo will not experience direct flooding but most probably will be affected by the widespread disturbing and disastrous circumstances around. A 20-year return period will severely affect 17 out of the 27 Barangays of Naga. Thus, the potential disruption may exceed the resources and manageability band of the whole municipality and therefore a city-level disastrous situation may arise. In this case the city will need external assistance most probably from regional and national level.

7.8.2 Hazard assessment for the future situation

Figure 7.17 provides the three hazard maps for the future situation.

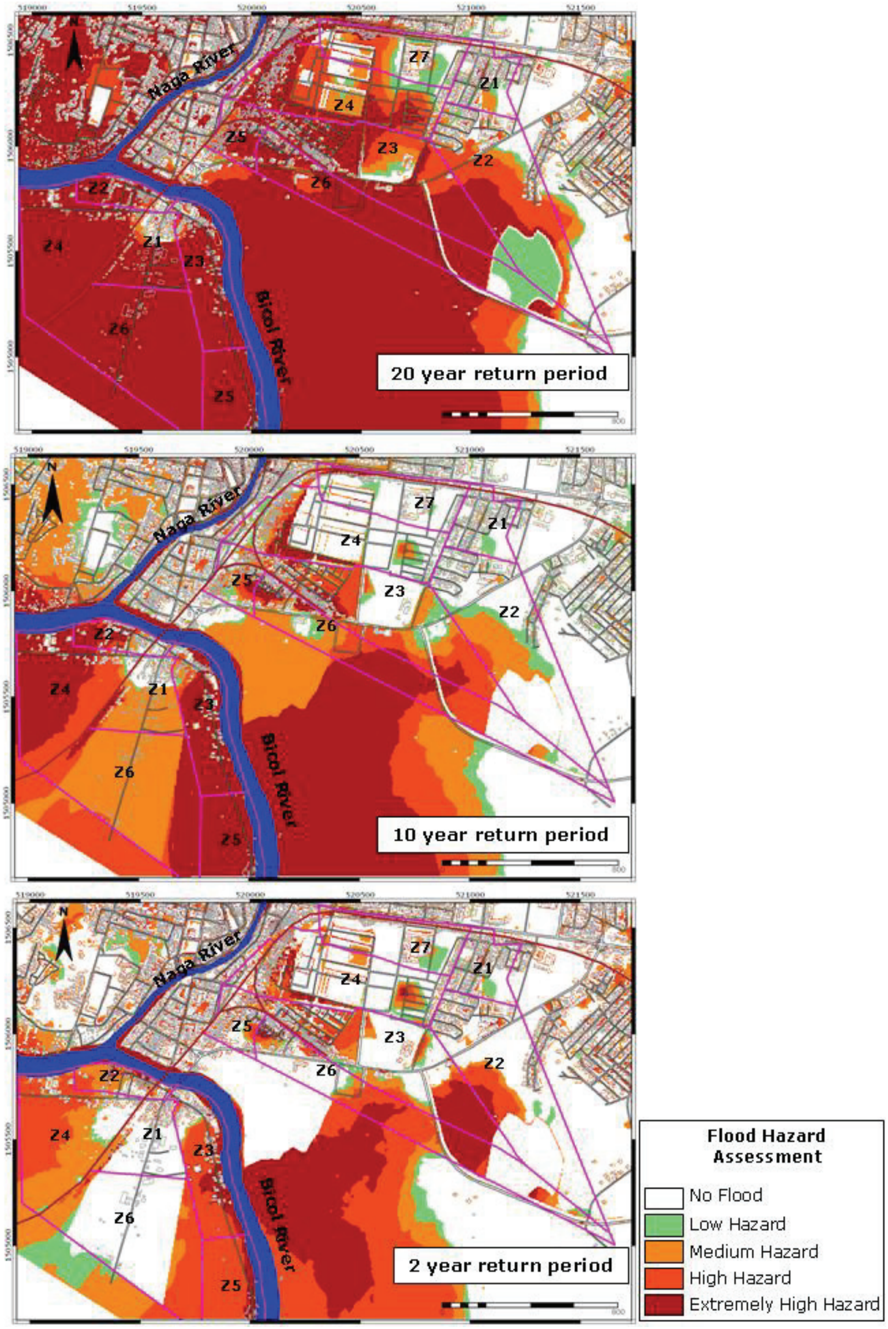


Figure 7.17 Flood hazard maps showing the flood hazard assessment, based on Community-based criteria, for the Future situation.

The hazard assessment was performed using the outputs from the hydrodynamic modelling for floods with three return periods in the future scenario, which represents the situation in 2012 according to the Naga development plan. Regarding changes in hazard categories the situation is comparable to the previous analysis for the present situation; meaning that the newly elevated areas will experience a drastic change in hazard categories at least during more frequent inundations such as those related to the 2o and 10- year return period. During extreme events, such as the one represented by a 20-year event *High* and *Extremely High* hazard categories can be reached; mostly as result of long standing floodwaters. The other drastic effect derived from the modifications in the terrain is the redistribution of flooding and the patterns of flood hazard previously experienced by the communities. As can be seen from Figure 7.17 Zones 1, 2, 3 and 7 in Triangulo and Zones 4 to 6 in Mabolo will see their patterns of flooding severely modified particularly for the 2 and 20 year return period events.

These changes in both the flood behaviour and its hazardousness have implications for the people settled in these areas. Increasing threat implies higher losses, longer disruption of their everyday life and fewer possibilities to cope making use of their own social and economic resources. Changing patterns of flooding can render the coping strategies (already in use by the people), as inadequate. Yet another area of concern is putting the people who have been living in flood-free areas in harms way, by making them face flooding and their negative consequences without the time and the experience to develop appropriate survival strategies.

Finally another significant consequence of the unplanned and inadequate development model evaluated herein is related to the alteration of the flood pattern in those wards adjacent to the study area. Communities settled in Barangays Lerma, Tabuco and Sabang will also undergo increasing flood depth, duration and consequently hazard shifted from the elevated areas in Triangulo and Mabolo. Particularly during small but recurrent events (2 yrp) the flood extension, duration and threat will be increased in the areas adjacent to the right side of the Bicol River, and both sides of the Naga River especially the areas close to the Central Business District (CBD).

7.8.3 Summary of hazard assessments

A summary of the flood hazard assessment for the three scenarios of urban development (past, present and future situations) and for the three flood events with return periods of 2-, 10-, and 20-years is presented in Table 7.6

From this table several important issues regarding flood hazard assessment can be concluded. Firstly, it can be observed that there is a clear increase in the *No Flood* Category especially for the 2 and 10 year return period in both wards. From the hazard point of view this can be interpreted as a positive effect of the development related modifications as more flood free areas represent a decrease in the overall flood threat. Furthermore, it can be observed how in the *Extremely High* category the figures for these two types of events are decreasing.

Table 7.6 Summary of the flood hazard results, showing the percentage of the two Barangays affected by the various hazard classes for the past, present and future development scenarios and three return periods flooding.

Scenario	**Return period**	**Ward**	**Hazard levels**				
			No Flood	**Low**	**Medium**	**High**	**Extreme high**
Past (1995)	2 years	Triangulo	47	7	19	10	17
		Mabolo	26	2	27	36	9
	10 years	Triangulo	38	11	21	21	9
		Mabolo	9	2	9	34	46
	20 years	Triangulo	20	2	5	20	53
		Mabolo	7	5	1	2	85
Present (2005)	2 years	Triangulo	54	3	12	18	13
		Mabolo	30	6	18	35	11
	10 years	Triangulo	42	11	21	18	8
		Mabolo	14	1	17	25	43
	20 years	Triangulo	24	4	7	21	44
		Mabolo	6	8	1	3	82
Future (2012)	2 years	Triangulo	60	4	11	14	11
		Mabolo	35	2	17	30	14
	10 years	Triangulo	52	9	16	14	9
		Mabolo	17	1	30	12	40
	20 years	Triangulo	22	2	5	20	53
		Mabolo	5	2	4	5	84

However, in the overall analysis in this chapter it has been remarked how these apparent positive consequences are achieved at the expense of increased threat in areas where people can not afford to elevate the terrain.

In the figures, the total area of hazardous categories may not increase, they may even decrease, however what becomes important is that the threat is being confined to the lowest lying areas where, as has been already mentioned, the poorest groups in these communities can be found.

Another aspect to highlight is that despite the fact that in the present and future situation the new developed areas were raised around three meters above the original level, they still continue to be susceptible to experience severe hazardous categories (*High* and *Extremely High*) during severe flood events such as the 20-year return period. In order to avoid being affected by these or more severe events, the owners of commercial and business activities and the wealthiest households, may decide to raise even more the terrain in which their investments are placed; particularly if, as becoming evident, by effects of global warming these floods will happen to be more recurrent and severe. If these modifications are not accompanied by the corresponding alleviating measures, such as drainages or water storing areas, it should be expected that flood behaviour and threat will increase in neighbouring areas and those that are not elevated and protected from inundations with the corresponding consequences for the people settled there.

From the summary in Table 7.6 it can also be concluded that analysis merely based on percentages of flooded and non-flooded areas may overlook, and even mislead, the hazard assessment. Figures on distribution of hazard categories need to be accompanied by spatial distribution, community-based and flood dynamic analysis, as those performed through the present chapter; in order to provide a richer and more accurate picture of the situation at hand.

7.9 Main findings and discussion

This chapter shows that the systematic application of participatory methods combined with mobile GIS and hydrological modelling is a useful approach for enhancing the understanding of flooding as a dynamic hazard for communities in the study area. The integration of local knowledge into GIS-based methods revealed aspects about flood hazard dynamic and evolution that are not usually addressed when these methods are performed in isolation or by merely using technical approaches. Furthermore it has broadened the understanding about how floods become a threat that people in these two Barangays have to face as part of their 'daily life'

Many of the changes in flood behaviour are only perceived through time and by the direct experience of the people affected, particularly by small events (such as heavy rains or small scale floods). Because of the direct observation and walks that are part of their everyday or working routine, or by talking with people about their concerns or in discussions with zone leaders and other members of the community local officers and lay people remain constantly aware of these changes. Moreover they also perceive and deal with the increased hazardous circumstances derived. If this information is systematically collected and structured, it may constitute a great support for the local communities and municipal authorities. Hazard assessments and maps can be kept up to date, preparedness and emergency plans can be adjusted to the changing situations and, moreover, the information coming from these combined analyses can improve the way in which plans and decisions for urban expansion and land use conversion are taken.

The combined analysis carried out in this study provided comprehensive information, affordable analysis and innovative entrance points to the flood problematic. A joint effort between local and municipal authorities and communities can help to decide, for instance, whether the development models selected, in this case for urban expansion, are the most adequate ones. Modifications in the terrain and hazard avoidance that benefit some groups of the community at the expense of others need to be discussed as part of the flood risk management strategies in each ward. Moreover if the same government that causes or permits those developments, is responsible for providing relief, shelter and assistance to the people affected by the increased hazards due to such modifications.

This analysis can also help the municipality to decide on their programmes for housing and resettlement for the Urban Poor. In the areas where these programmes are being established, the communities were the most prone to experience *Unmanageable* and *even Disastrous* situations. Furthermore, the modifications in the landscape are worsening the natural situation by increasing the water depth and duration, changing the flood behaviour and increasing the velocity at which seriously threatening flood stages are reached. An increased threat implies more losses, disruption and marginality which at the end of the day make people much poorer, vulnerable and dependent on government assistance. Thus, all these negative effects triggered by the model selected for urban expansion towards these areas have a direct incidence on the coping mechanism, survival strategies and socioeconomic resources of the poorest groups against flood hazard.

Chapter 8: Analysing vulnerability to floods from a household perspective

Chapter 8 is mostly a conceptual chapter. Participatory tools, a GIS-based survey and statistical analysis were used to identify and analyse some of the aspects that increase or decrease the households' vulnerability to flood. These elements constitute people's 'resource band' against flooding, and therefore the analysis in this chapter scrutinises the way in which the social, economic, physical, environmental and developmental factors interact and determine the differential vulnerability to flood found among the researched communities.

8.1 Introduction

The previous chapters evidenced how communities in the study area perceive that a big share of the threat from flooding is represented by the dislocation of their daily life beyond *manageable* levels. The flood stages described in Section 5.4.3 indicate that, at local level, floods may disrupt people's life in different ways. As analysed the differentiated impact is partly a result of physical characteristics of flooding such as depth and duration and partly the result of a differentiated access to resources such as secure income, safe housing, adequate basic and social services and healthy environment among others.

In this research it is emphasised how, at household level, the difference between experiencing a *Normal, Manageable, Highly Disturbing or Disastrous* situation depends partly on the existence and quality of these aspects. The stronger (i.e. stable, safe) the resources and circumstances under which a family develops their 'normal' life the less dislocation they may experience when flooding arrives and as such as they are less vulnerable. In contrast families having weak, unstable or unsafe socioeconomic conditions will start to be badly affected by earlier flood stages (i.e. *knee depth*) and it will take longer for them to recover after each flooding therefore increasing their vulnerability to subsequent events.

In this chapter some of the social and economic elements that determine the vulnerability to flooding of the households in the studied Barangays are evaluated. Several participatory and GIS tools such as workshops and particularly GIS-assisted transects with local leaders and ward authorities were used to identify, map and discuss the vulnerable conditions of the households and its causes. This qualitative data was then complemented with a GIS-based Survey in which the socioeconomic characteristics of the households as well as the coping mechanism performed by them were collected and analysed (see Section 3.6.7 and Appendix 3.A).

8.2 Identifying vulnerable households at ward level

The identification and analysis of some of the main aspects of households everyday life, how they may get disrupted when flooding takes place and the extent to which they contribute to a family's vulnerability to flooding were derived during the second workshop held in each ward and Focus Group Discussions (FGD) with Barangay officers and leaders. It was found that people in these communities were not familiar with terms such as vulnerability, vulnerable, coping mechanism and the like. Rather they describe the characteristics of the 'people that during floods and typhoons suffer the most and those for which recovery takes longer time'. Table 8.1 displays the results of the characterisations obtained by ward.

Table 8.1 Community-based characterisation of the people that are most affected by floods

TRIANGULO		
Aspects	**Characteristics**	
	Urban	
Livelihood means	Porters small scale vendors	
Housing	light materials semi-permanent houses	
Household composition	8 to 10 members (father, mother, 5 to 7 children, in-laws)	
Land tenure	Squatters Poor people that have moved from other municipalities and do not own the land	
Zones	6, 4 and 3	
MABOLO		
Aspects	**Characteristics**	
	Urban	**Rural**
Livelihood means	-Construction workers -Porters -Small scale fish/vegetable vendors	- Poor farmers (they have to wait for another crop season) - Rice field/rice drying labourers
Houses	Light materials	Light materials
Household composition	10 to 12 members (father, mother, 6 kids, in-laws)	10 to 12 members (father, mother, 6 kids, in-laws)
Land tenure	Squatters	Tenants
Zones	Distributed across the Barangay	5 and 4, part of zone 6

These profiles evidence that even without managing the technical terms and concepts of risk, the people in the study area are very much aware of the aspects that contribute to make people more affected by the natural phenomena that hit their communities every year. Their understanding of the 'flood problem' is so comprehensive that they are even able to establish differences between those living in different contexts such as people in the urban and the semi-rural environments.

Based on the information on local 'vulnerability' learned from the participants in the activities the second step aimed to support the quantitative and spatial analysis of some of the aspects listed in Table 8.1 which was performed by virtue of a GIS-based survey. The aim of the interviews and data collection accompanying this survey was to enhance the understanding on the influence that factors such as those related to livelihood, housing, access to land, education, health and basic services, and environmental quality have on the vulnerability of households. Moreover, the inclusion of the geo-referencing component was intended to support the exploration of spatial relationships between the presence and quality of the aforementioned aspects and flood vulnerability.

Therefore, the following sections provide an insight into the influence that the existing socioeconomic, physical, environmental and developmental conditions in both wards have on making people '*suffer the most and prolong recovery time when floods occur*'.

8.3 Socioeconomic status, sources of income and households livelihood arrangements

A close view to the communities in the study area revealed how the socioeconomic status attained by a given family unit has a large influence on their vulnerability to flooding. Families belonging to the poorer clusters, deriving their livelihood from informal activities, with very low and irregular income are more likely to be badly affected even by heavy rainfall and small inundations.

In contrast, a family relying on adequate and secure income sources will not experience major disturbances in their normal life, unless large scale flooding takes place. Even in these cases they will be more able to protect themselves, recover earlier and quickly return to their everyday lives. Narratives given in Box 8.1 illustrate the relationship between income source, susceptibility to weather conditions and flooding and the differentiated vulnerability arising from it.

The analysis of the data collected among the communities made it possible to determine that besides income aspects such as type and nature of livelihood, the number of workers and family members depending on them influence the way in which flooding disrupts the 'normal' life of a family. A categorisation of these aspects was then performed in order to provide a more comprehensive profile of the factors contributing to increase or decrease the households' chances to be affected by floods and typhoons.

8.3.1 Sources of Income

This aspect was analysed by considering all the economic activities that contribute to a family income, as were requested in the interview. The analysis of this aspect is based on general profiles for the most common livelihood activities performed by the people in these communities and obtained during workshops, Group Discussions and interviews (i.e. people use to call themselves 'labourers', 'informal workers' or 'formal employees').

These categories basically determine the nature of the occupation performed by the workers (formal, informal, self employee); the skills and training involved in the activity and its susceptibility to weather conditions.

Box 8.1 Livelihood, weather conditions and vulnerability
Ms S. (ID: Mz3-31) Ms S. (34 year old) is a street seller in Zone 3, Mabolo. Occasionally she gets some money from her husband in Manila to sustain their 12, 9 and 7 year old children. On a good day she can earn around 30 pesos from her activity (selling fried sweets). This is not enough to even cover her family's basic needs but she has no other alternatives for making a living. Selling in the zone where she lives means staying closer and taking care of the children; furthermore she does not have to pay for transportation, which she cannot afford. Her work depends on good weather conditions for customers: mostly school children and peasants. The wet season usually results in a loss of profit; on a rainy day she can expect to lose between 25-30% of her income. Furthermore as schools are closed when typhoon warnings are at level I, she has fewer customers even if it is dry. As she cannot afford to stop working she continues selling until the flood reaches *knee* depth; otherwise she would not be able to provide food for her children. Usually while working with floodwaters at ankle or knee depth she gets skin rashes and athletes foot which make her feet bleed. Even in this situation she does not stop working. If water depth continues to rise she cannot go out anymore and then the family rely on aid (mostly food and medicines) from neighbours or the Barangay calamity fund, until floodwaters recede. After this she looks for alternative sources of income such as hand washing clothes for wealthier families in other wards; this implies walking nearly one hour or even more to cover the distance. In these circumstances it may take Ms S. almost two months in order to regain the base capital for selling sweets again. If the thatched house the family occupies is damaged she repairs it little by little, partly with the materials given as relief by the municipality and partly with scrap or second hand material. After every flood episode she feels even poorer and in her perception her family never fully recover from these 'disastrous' situations. Mr J (ID: Mz5-18) Aside from being a Barangay officer Mr J. (52) is a merchant at medium scale. He owns several trucks to trade vegetables between Naga, the Bicol Region and Manila. Although this activity does not provide him with a fixed income, his monthly income may exceed 15000 pesos. His wife (38) works as secretary for the Municipality with a monthly salary of around 8000 pesos. Usually Mr J's business is not severely affected by the weather conditions. He trades vegetables from several regions; therefore when heavy rains or a typhoon hits one zone, he sends the retailers to another area with better climatic conditions. Widespread or severe flooding can lessen the profits of his business; however even in this situation he will make a profit: after a typhoon, groceries get scarce and prices higher thus he can recover the eventual losses. Although he is aware of living in one of the most prone to flood zones in Mabolo (5) he does not move as the land was inherited and besides he likes the area and the community. His two-storey concrete house provides his family with a safe shelter even if the flooding is severe. During typhoons his house has served as a refuge for some of his neighbours as it was the case with Typhoon Unding-Yoyong (2004). During and after flooding he uses to distribute vegetables and assistance from his own budget to those most affected in his Zone.

The 5 groups found were characterised as follows:

Group 1 **Labourers**: People engaged in work that requires bodily strength and manual labour rather than skill or training. This consists of marginal or subordinate activities performed mostly outdoors, sometimes on mobile units (including carts and bicycles) and usually takes places close to the place of residence as transportation is too expensive. These jobs report daily earnings in unstable and irregular amounts and are highly susceptible to weather conditions and flooding (see Figure 8.1). Activities found in the study area and classified in this group correspond to:

- Baggage and burden carrier (CBD and PNR terminal), dispatcher.
- Food (candies) manufacturers and packers.
- Laundress, housemaid.
- Vendors, itinerant sellers (vegetables, small scale food vendors).
- Scrap material collector (*scavenger*).
- Marginal farming (vegetables, rice harvesting and drying).

Group 2 **informal workers and small business:** Correspond to a group of non-formal workers with special skills or knowledge; they supply day to day services and labour, often as freelancers, without formal contracts and benefits. Services are performed door to door or in the worker's house and usually provide daily, unstable and irregular income. Activities performed by this group of workers are highly susceptible to weather conditions and flooding (see Figure 8.1). However it was found that some of them render higher profits after typhoons and floods during the rehabilitation processes.

Figure 8.1 Examples of workers from groups 1 and 2. Clockwise a laundress, a street vendor, a rickshaw driver and farmers deal with rains and flooding characteristic of the wet season.

Workers in this group use to combine their activities with those from group one in order to raise their daily income or when not enough work was available. Small scale, in-house shops, food stalls were included under this category for they belong to the non-formal sector too (no taxes). This group is formed by:

- Tinsmiths, carpenters, tailors, painters, construction workers, barbers, butchers, welders and midwifes.
- Informal security guards, voluntary fireman.
- Motorcycle (*tricycle*) and rickshaws (*pedicab*) drivers.
- Small business, small goods (*sari-sari*) stores, eateries, food stalls.

Group 3 **Formal workers:** Includes educated/skilled workers usually working under formal conditions for medium and big scale business, shops and industries. Permanent or temporarily contracts provide stable income, even during flood or typhoon episodes; though not always high wages. In the study area they are represented by:

- Salespeople.
- Electricians, technicians, machinery operators and secretaries.
- Waitresses, cooks, chef assistants etc.
- Truck, bus, jeep and company drivers etc.
- Employees (shop, industry, companies).
- Barangay officers.

Group 4 **Highly skilled and independent workers:** comprises University and highly skilled and specialised workers who most of the times run their own businesses or are absorbed by the governmental institutions and industry. Their income is stable, regular and not affected by weather conditions, flooding or typhoons. In the study area this group was found to be represented by:

- Dentists, teachers and sailors.
- Government employees.
- Medium scale retailers, traders, businessmen etc.

Group 5 **Transferred income:** This group is characterised by family units receiving their economic support from external sources or pensions. Relatives working abroad or in bigger cities (e.g. Manila) usually provide support by monthly sending money enough to sustain their families in Naga. Remittances from external workers tend to be regular and are usually increased in order to assist their families during flooding or typhoon episodes.

Figure 8.2 shows the frequency of surveyed families according to the nature of their primary and secondary livelihood sources. In this research primary sources are associated with activities that provide the higher income to the household. Secondary and tertiary livelihoods are those that provide lesser money but in any case complement the family income. From Figure 8.2 it can be seen how for significant proportions of households in Triangulo (39.3%) and Mabolo (42.1%) the main income is obtained by informal workers and small in-house business (Group 2). Families whose main livelihood come from workers in groups 1 and 2 represent 65% in Triangulo and 79.3% in Mabolo. These numbers imply that nearly two thirds of the family units in both areas derive their main income from informal labourers and workers.

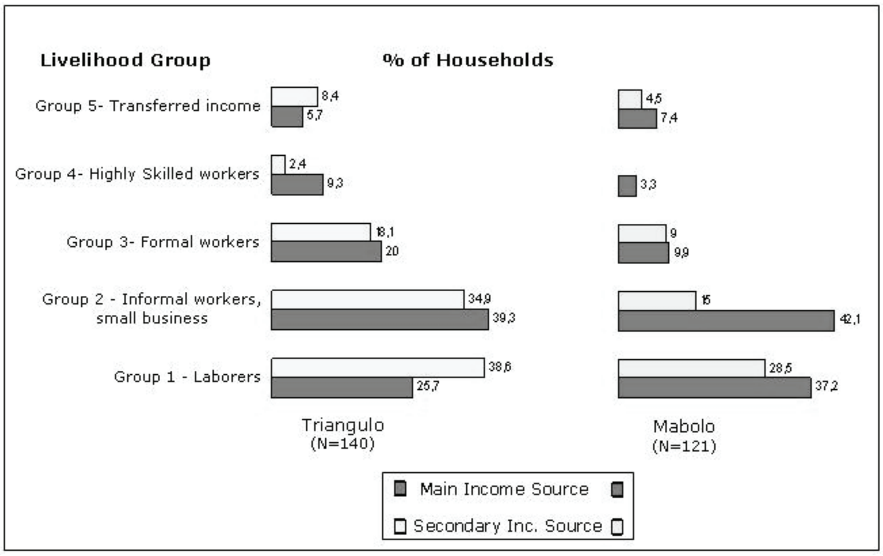


Figure 8.2 Percentage of households in the livelihood groups distributed according to their main and secondary sources of income

The analysis for secondary sources showed similar results with 79.3% of the householders in Triangulo and 43.5 % in Mabolo deriving their second livelihood from the informal sector (Groups 1 and 2). However, it should be noted that not all households reported secondary or tertiary sources of income. This was particularly noticeable in Mabolo as it was found that entire families rely on a single wage.

The distribution of income sources shown in Figure 8.2 has several implications regarding vulnerability to flood. As explained earlier, jobs from Groups 1 and 2 are particularly unstable and often provide very low wages. In addition they are highly susceptible to bad weather. During the survey it was found that workers belonging to these two groups often have their already low incomes reduced by between 20 to 30% on a rainy day. Note that work stops when floodwaters reach waist depth (around 90 cm or 3 feet). Besides having their basic needs hardly met during 'normal' times these families usually lack the economic resources and safeguard to face 'critical' periods. Irregular and low revenues generally drive these families more vulnerable and prone families to adopt risky coping mechanism such as payday and loans from conmen. They also entail long-term recovery and may push the household from poverty to marginality as some of them simply fail to recover after being severely or recurrently affected by floods or typhoons (see the narratives in Box 8.2).

Families whose main income is derived by workers from groups 3 and 4 constitute a smaller fraction in both areas with shares of 29.3% for Triangulo and just 13.2% in Mabolo. The stability offered by this type of jobs helps the families to create an economic buffer that enhances their resistance and coping capacity for 'critical' periods as can be deduced from the second narrative in Box 8.1.

Box 8.2 Negative effect of typhoons on livelihood groups

Family Q. (ID: Mz329)

Before November 2004 Family Q. used to get their livelihood from Mr. Q's Job (butcher) and a small shop attended by Ms. Q in a shed annexed to their house. During Typhoon Unding the shop was smashed by an uprooted Mango tree and part of their house's roof and walls were blown away. The flood also ruined some vegetables Ms. Q grew to sell in the shop. Savings and relief from the government were used to rebuild the house; yet their economic reserves were not enough to restore the shop. They could not afford a loan or use their father' income as this was just enough to meet their daily needs. From their point of view their current situation is *Disastrous* as after one year they have not managed to fully recover, they lost capital and a, much needed, second livelihood and now the entire family of five depends on the single income brought in by the father.

Mr M. (ID:Tz427)

Mr M. used to work as an ice cream vendor in Triangulo (zone 4 and 3) for which he uses a small wooden trolley. The daily income from this activity (around 200 pesos) was low but he managed to cover the basic needs of his family of three. During Typhoon Unding/Yoyong his house was destroyed and the trolley got shattered by the strong and sudden winds. To get some income he shifted his work to collect scrap material; from this activity he got half of the money (around 100 pesos/day), but most now he has to travel on foot across several other wards. One year later the family was still living with their in-laws and he had not managed to raise the capital for rebuilding their house and recovering his previous livelihood.

According to the participants in one of the Focus Group Discussions the gap between *informal* and *formal and highly skilled workers* is partly rooted in the economic difficulties to afford higher levels of education and partly in the lack of opportunities and few vacancies in the formal sector of Naga City.

Households in group 5 (Pensions and remittances) were found as getting adequate and regular income particularly if the family members work abroad. After being hit by floods or typhoons the transferences tend to be increased as the relatives try to help the family during the 'crises'. Families in this group comprised 6.9% in Triangulo and 7.4% in Mabolo.

The spatial distribution of the households in the survey according to their main source of income is presented in Figure 8.3. Families from the five groups are present in each ward, with groups 1 and 2 scattered through all zones as described in Table 8.1. In this figure, the flood scenario for heavy rains (or a 2-year return period) was used as background as evidence of how some households may face high levels of vulnerability even during small but recurrent flooding. From Figure 8.3 it can be established how families in groups 1 and 2 residing in Zones 3 to 6 in Triangulo and 4 to 6 in Mabolo are perhaps the most susceptible to all type of flood events.

Those households whose sources of income are located in areas where recurrent flooding (i.e. set by heavy rains) can reach *Highly Disturbing* and *Unmanageable* categories may find it particularly difficult to overcome or recover from these frequent 'critical' periods. During the interviews some households in these areas uttered that their working activities have to be interrupted even before flooding starts. This time has to be allocated to packing and getting ready for evacuating the family and belongings to a safer place. People also commented how during flooding they cannot work either because they have to remain in evacuation places or to take care of their relatives, plots and assets. After flooding a large share of the day time is used to clean and repair the damage usually without any assistance as neighbours and family are busy repairing its own. Depending on the magnitude of the flood these activities may take 4 to 7 days during which no income is earned. Small but repetitive episodes give families depending on labourers and informal workers few chances to recover in the short time. In addition the lack of opportunities for upgrading their sources of income keeps them in a state of nearly 'constant' disruption and high vulnerability.

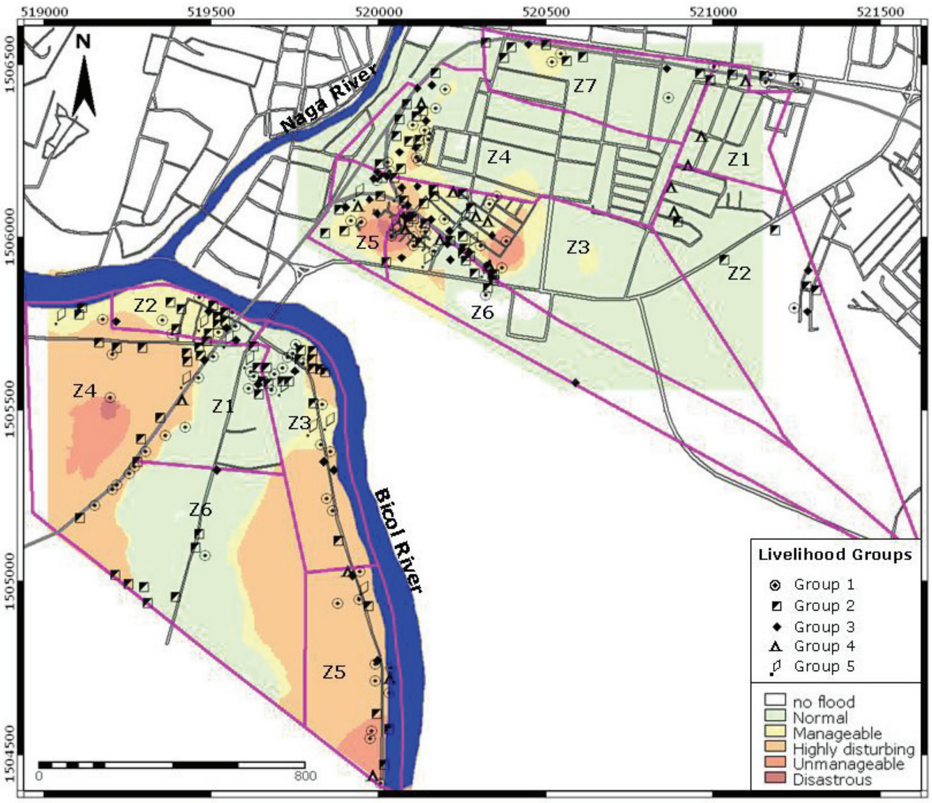


Figure 8.3 Spatial distribution of families by main source of income vs. community-based categories for a 2-year return period flood.

8.3.2 Family Income

Household income is referred herein as the total amount of formal and informal wages, remittances, pensions etc. from where the family satisfy their basic and non-basic, needs. In order to categorise the income level several aspects found during the survey were taken into account:

- In the Philippines, indicators such as the Annual Household Income, Poverty Threshold and Minimum Wages are calculated for families of five (5) members. In the study area the average family size was found to be

7.2 for Triangulo and 7.0 for Mabolo. This gap has significant implications as it implies that a 7-member family will need to earn 1.4 times the official minimum wage in order to subsist above the official Poverty Level.

- Most of the official poverty indicators are based on monthly or annual wages. As mentioned in the previous section, a big share of the households in the study area depends on informal sources of income and therefore do not have fixed weekly or monthly salaries. In these circumstances a vulnerability analysis based on monthly or even annual income, rather than on day by day wages, may become irrelevant.
- The day-to-day income system has derived in a 'life style' in which most of the basic needs of the families are likewise fulfilled on a daily basis. Provisions, drinking water, fuel for cooking and other essentials are acquired each day in amounts that depend on the income earned. The ability to fulfil the basic needs of the family with the daily income available was found as providing useful insights on the everyday construction of vulnerability. As a consequence, the analysis uses the daily income as indicator of the susceptibility to flood in the study area.

After considering the previous aspects, the Income analysis in this section was based on the total daily income per household and per person in Philippine Pesos (denoted herein as PhP). The 2005 Official Poverty and Food Thresholds estimated by the National Statistical Coordination Board (NSCB, 2006) for a 5-member family was used as indicated in Table 8.2. Calculated values for a 7-member family, used in this research, are also presented in order to compare and validate the analysis based on the average family size found in the study area.

Table 8.2 Monthly and Daily Poverty and Food thresholds for a 5 and 7 member family (all areas, year 2005)

Income Indicator	**5 member-family**			**7 member-family**	
	Monthly (PhP)	Daily (PhP)	Daily per person	Monthly (PhP)	Daily (PhP)
Poverty threshold	5,916	195	39	8,280	273
Food threshold	3,896	129	26	5,455	182

Source: National Statistical coordination Board (NSCB)

The data in Table 8.2 indicates that in 2005, a family of seven members in the study area should earn a monthly income of PhP 8280 in order to meet their basic food and non-food needs. Workers may find difficulties bringing their household of five above the poverty level if they were not earning at least PhP 273 per day. The household should provide PhP 39 daily per person in order to stay above the poverty line and at least PhP 26 in order to meet the basic food needs of every family member (Food Threshold).

Based on the data in Table 8.2 the categories for the analysis were established as follows:

- Families with daily income **below the Food threshold** (< PhP 182).
- Families with daily income above the Food threshold but **below the Poverty line** (PhP 182 - 273).
- Families with daily income one or several times **above the Poverty threshold** (> PhP 274).

Figure 8.4 gives an insight into the income level distribution for both wards.

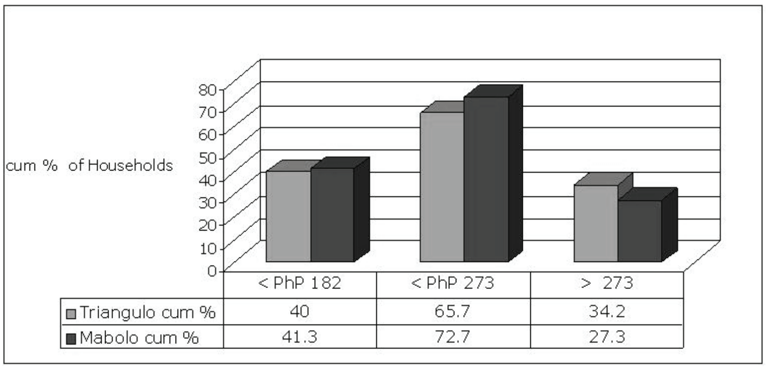


Figure 8.4 Cumulative distribution of households according to their daily income for Triangulo and Mabolo

It can be seen how only 34.2% of the households in Triangulo and 27.3% in Mabolo earn daily wages that are just enough to keep their families above the Poverty Line established for this analysis. Most families in both wards have incomes that do not allow them to fully satisfy their basic needs (Tr: 65.7% and Mb: 72.7%). On the other hand nearly 40% of the families in both wards have a daily income falling below the Food threshold (< PhP 182).

According to the data provided by the Naga City Social Welfare and Development Office in 2005 nearly 60% of the households in Triangulo and 50% in Mabolo were categorised as 'Indigent' families or those whose monthly wage was less than PhP 6,000 (See Table 8.3) (CSWDO, 2005). As mentioned earlier this official Poverty level is calculated for a family of five; at some point this difference can explain the observed gap between the official numbers and those found in this research.

Table 8.3 Percentage of families below the Poverty Threshold in the study area according to the CSWDO (2005)

Barangay	Households (2005)	Indigent families	Percentage
Triangulo	1,478	885	60 %
Mabolo	1,226	619	50.5 %

The daily income analysis was complemented with the available family income per person in order to determine if the basic and non-basic needs of each family member could be fulfilled. For this purpose the total income reported by the household was split among the total number of residents. In this case it was assumed that, regardless of their age, occupation, health status etc, every member has the same share of the family income (which may not be always the case). In this case the categories corresponded to:

1. Families with daily income per person below the Food threshold (< PhP 26) (see Table 8.2).
2. Families whose daily income per person is above the Food threshold but below the Poverty line (PhP 26 - 39).

3. Families whose daily income per person is one or several times above the Poverty threshold (> PhP 39).

The outcome of this analysis is shown in Figure 8.5.

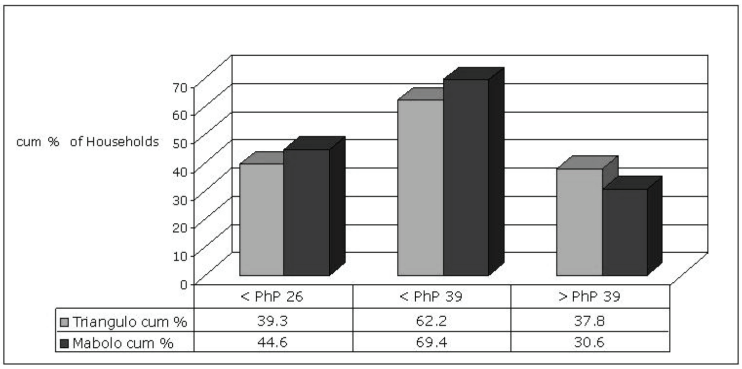


Figure 8.5 Cumulative distribution of households according to their daily income per person (Triangulo and Mabolo wards).

Comparatively, the output is similar to the one obtained from the Income Analysis shown above. Nearly 40% and 45% of the families in the study area are not able to fulfil the daily basic food needs of each one of their members with the income in hand. Also, more than two thirds of the households in both wards (62.2% in Triangulo and 69.4% in Mabolo) do not have income enough in order to achieve what the National Statistical Coordination Board calls as an 'economically-decent lifestyle' or one in which the basic and non-basic need of each members are accomplished (NSCB, 2006). In this respect the analysis indicates that just 37.8% and 30.6% of the households were able to achieve this goal.

Regarding the connections between everyday life and flood vulnerability it was known that during the wet season the daily wage of most of the households tended to decrease or even come to a halt if flooding took place. These families are often forced to adopt dangerous strategies to cope with this situation. Smaller and less frequent rations, poor quality food, begging and even starvation were some of the risky mechanism detected through the survey. Also inadequate and deficient food intake results in malnutrition and high susceptibility to diseases, affecting mostly children and elderly. The survey reported that this situation becomes further aggravated in areas where people are constantly exposed to bad weather conditions and face direct contact with stagnated and polluted floodwaters.

The lack of income to supply even the most basic needs implies that these households have no savings or financial reserves to be used during 'crisis' times (i.e. to buy medicines or take the ill to the doctor). In this respect people become almost reliant on medicines and attention provided by the Barangay healthcare services (if available) and public hospitals. On the other hand possibilities for adopting preventive measures to lessen the impact of flooding or strong winds are very low. Elevating the house from the ground, nailing wooden walls and roofs, stocking food and drinking water are coping mechanisms that families in the study know well; yet in absence of available money they are simply unaffordable. Low and irregular wages besides the informal status of many workers determine that very few times they may have access to insurances, loans and other risk deferring mechanisms.The interviewees expressed how in the absence of valuables or properties (to be used as collaterals) they do not dare to apply for low-rate loans.

Families whose daily income is not enough to fulfil even the most basic needs during 'normal' times will be the most vulnerable when rains and flooding arrive. Households with more adequate income are expected to be better equipped and perform better during both 'normal' and 'crisis' times. During the survey it was found how the life of those families that had sufficient and secure incomes, the capability for building financial reserves was less threatened by floods or typhoons even if they were settled in areas prone to severe flooding (see Mr J's case in Box 8.1). The spatial distribution of the daily income categories is shown in Figure 8.6 .

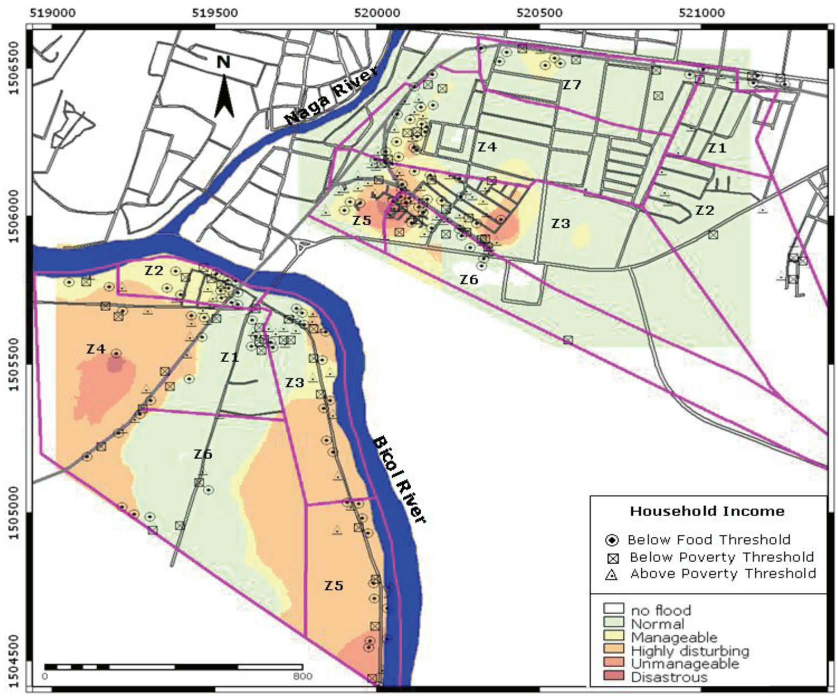


Figure 8.6 Spatial distribution of families by Daily income vs. community-based categories for 2-year return period flood.

The map shows how areas were flooding can reach *Highly Disturbing, Unmanageable* and moreover *Disastrous* categories during small inundations (such as the depicted 2-year return period) are mostly occupied by families with inadequate daily income. Particularly in Triangulo the wealthiest families tended to settle in flood-free areas where flooding is marginal (zones 1, 2, and part of Zones 3, 5 and 7). As explained in Chapter 7 many of these sectors correspond to areas that have been artificially elevated above the ground level either by the municipality or private developers. In Mabolo the well-off families are settled along the Pan Philippine Road that crosses Zones 1 and 6 and nearby sectors in zones 2, 3 and 4. Whereas families with low daily incomes are mostly to be found in zones 2, 4 and 6 along the National Railroad (PNR), and part of zones 3 and 5.

8.3.3 Factors conditioning the Family Income

The data collected throughout the survey allowed this study to expose several of the main reasons existing behind the differences in observed household income. Sources of livelihood, education and gender of the main worker were found as some of the factors conditioning the earnings. Table 8.4 illustrate the relationship between occupation and the average daily wage (by 2005) of workers in the income groups.

Table 8.4 Average Total daily income per household and per person according to the source of livelihood (income group) for 2005.

Income Group	**TRIANGULO**		**MABOLO**	
	Total Daily Inc (Ave)	Daily Inc pp (Ave)	Total Daily Inc (Ave)	Daily Inc pp (Ave)
Group 1- Labourers	149.2	23.7	192.1	27.9
Group 2- Informal workers and small business	253.3	37.8	222.9	37.0
Group 3 - Formal workers	289.3	45.3	272.5	46.8
Group 4 - Highly skilled workers	474.1	86.6	453.8	82.7
Group 5– Transferences, pensions	333.8	46.9	273.9	51.8

The figures in Table 8.4 show a positive correlation among occupation, or economic activity and daily earnings. Marginal activities and informal work characteristic of groups 1 and 2 provide very low wages even though they involve a lot of physical effort and extended working hours. The Formal sector corresponding to workers on Group 3 represent a secure, but not highly rewarding source of income; wages in this group are just enough to keep the average family of seven members above the Poverty line. Families relying on remittances, especially from abroad seemed to do better in satisfying their needs.

The influence of the educational attainment on the available income can be deduced from the data in Table 8.5.

Table 8.5 Average daily income per family and per person by educational attainment of the main income provider

Educational level	TRIANGULO		MABOLO	
	Total Daily Inc (Ave)	Daily Inc pp (Ave)	Total Daily Inc (Ave)	Daily Inc pp (Ave)
Elementary	245	32.1	182.9	24.7
Secondary	195.6	36.2	226.4	33.2
High School	229.8	32	228	42.4
Vocational	233.3	31.7	293	44.2
Technical	353.3	39.8	300	33.3
University	392	73.4	442.9	87.2

On average just the highly educated workers and those with technical and college level managed to stay above the Poverty line set for this analysis (PhP 273). The average Total Daily Income per household and per person clearly declines for workers with low to very low educational attainment.

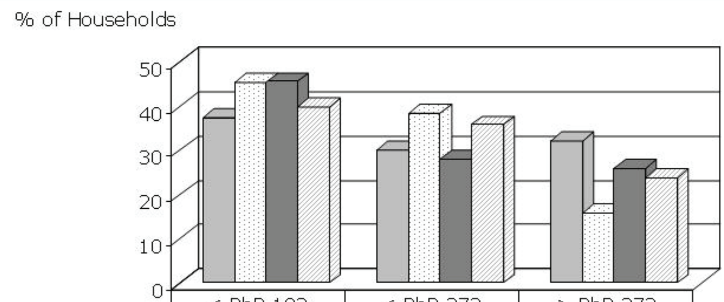
In both wards none of the main income providers was found as illiterate implying that, at some point, the working group has attained at least basic educational level. Yet is evident how in both areas an important proportion of the labour force with low educational qualifications (below secondary level) earns daily wages that fall below either the Food or the Poverty threshold.

Better wages were observed linked to high qualified workers, such as those with technical and university degrees although they constitute an extremely low proportion of the head of households, particularly in Barangay Mabolo (5.8%). In Triangulo a cluster of highly educated workers (6.1%) was found as perceiving wages below the Poverty level. The explanation obtained laid in the few opportunities for highly qualified work in Naga. Confronted with the need to raise some income *Highly Skilled* people are forced to take low-profile jobs or engage in activities beneath their qualifications, often in the informal sector.

In these communities, as in the whole Philippines, people have a deep regard for education, which they view as a primary avenue for upward social and economic mobility. Is a fact that families with incomes below the poverty line could not afford to educate their children beyond elementary school; however in these wards it was observed that many householders stretch their income and look for affordable tuition fees and governmental subsidies to grant their progeny at least medium education levels. Nevertheless, when it comes to highly specialised or technical studies, they cannot afford the cost of sending their children to universities or other institutions even if they want to. As discussed in a Focus Group, the few vacancies and opportunities available in Naga, and even in the Philippines, discourage the household of embarking in such economic effort.

Another reason for the low proportion of qualified workers found is related to gender issues. In the traditional Philippine society marrying younger is still a must for women; therefore after finishing college many women usually decide on marrying and starting a family rather than entering the labour market.

In the analysis the gender of the main worker was found to influence the daily income. The female workforce provides the primary income for 31.4% of the households in Triangulo and 20.6% in Mabolo. Yet, as the distribution of daily wages by gender in Figure 8.7 reveals, more than two thirds of these female workers received wages below the Poverty Line; what is more in Triangulo the earnings of the 45.5% of them fail to reach the Food Threshold.



	< PhP 182	< PhP 273	> PhP 273
Tr Male %	37.5	30.2	32.3
Tr Female %	45.5	38.6	15.9
Mb Male %	45.8	28.1	26
Mb Female %	40	36	24

Figure 8.7 Cumulative distribution of daily wages by gender in Triangulo (Tr) and Mabolo (Mb)

For Female-headed families the dislocation caused by the wet season tends to be higher. Earning a livelihood and having to protect their family from floods or strong winds present a double burden for the working women. Widows, particularly, may find extra difficulties as they were used to have their husband undertaking these duties for the whole family. The low wages represent an extra factor of vulnerability as not being able to fulfil the basic needs during 'normal' times implies lack of adequate nutritional and financial status during crisis times related to floods (see the narratives in Box 8.1).

8.3.4 A household's livelihood arrangements

Besides daily income several other factors were found as influencing a household's vulnerability to flood. Aspects such as family size, number of workers and the income dependency ratio may exacerbate the degree of disruption as well. A large family, in particular one with several children, relying on a solo worker will see their everyday life severely disrupted if less or no income is at hand. As Figure 8.8 indicates the predominant family size in both Barangays is still large consisting of six to ten members. As described by the participants in the workshops these extended households usually consist of father, mother, five to six children and in-laws. Occasionally the parental house is shared with the family of the progeny.

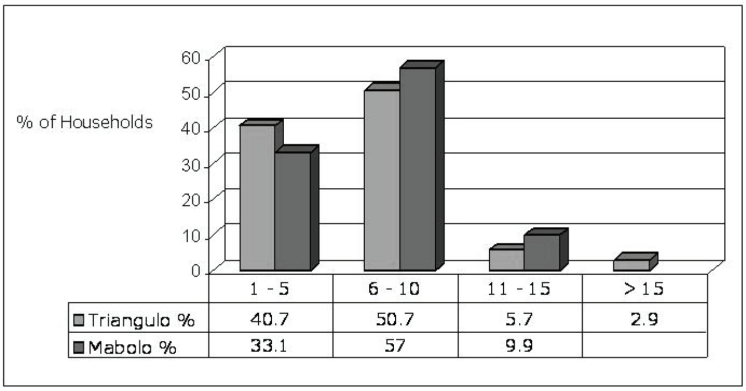


Figure 8.8 Distribution of households by number of residents (Triangulo and Mabolo wards).

The relationship between household size and vulnerability to flood is a direct one; during 'normal' times satisfying the food and non-basic demands of a large family will strain the available income to its maximum. Expenditures in health and education by member may tend to be less as well as their opportunities for building economic reserves. During 'critical' times large families are more susceptible to the adverse effects of income shortfalls; particularly if they depend on informal or solo workers. A large number of children may put also a lot of burden on the females preventing most women from taking up for work or contributing to the household income (see Figure 8.9).

Figure 8.9 Typical large families from the study area

The spatial distribution of families according to their size is presented in Figure 8.10. Most of the large size households are settled in areas highly prone to flooding, moreover in zones where small floods (i.e. the 2-year return period flood depicted here) can reach *Highly Disturbing* to *Disastrous* categories. This is the case in zones 4 and 6 in Triangulo and 2, 5 and 6 in Mabolo. The concentration of households with large number of members, particularly children, in these sectors implies more vulnerable individuals highly exposed to flooding.

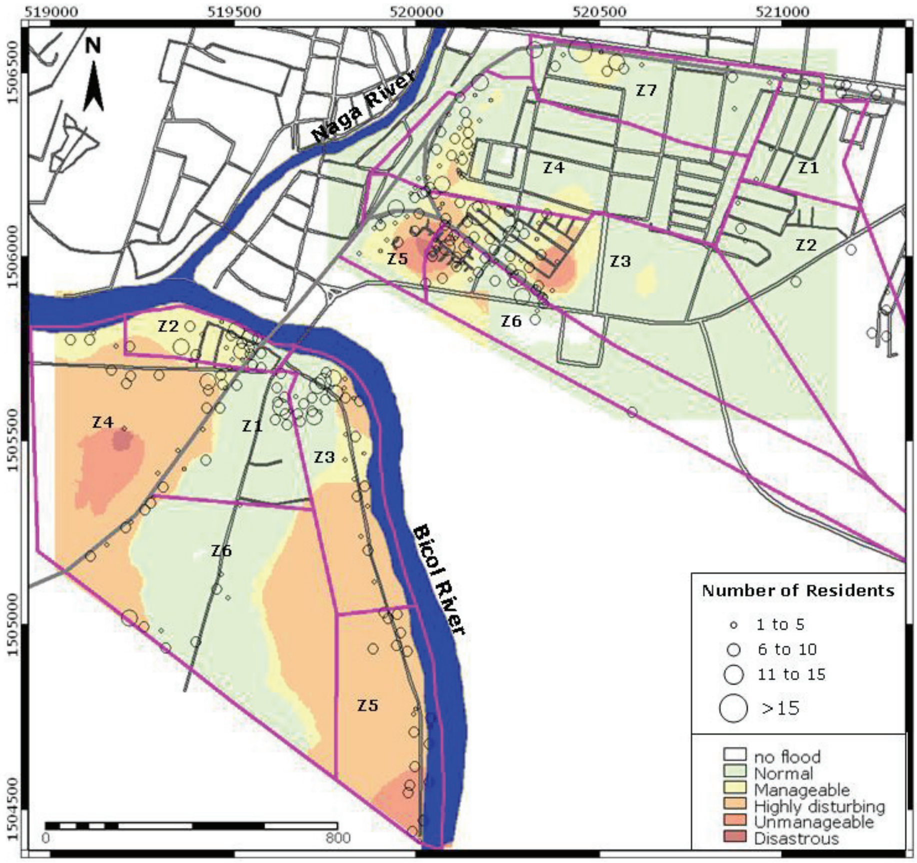


Figure 8.10 Spatial distribution of households by family size vs. community-based categories for a 2-year return period flood.

Finding adequate refuge and provisions for large families is by far more difficult not just for the families but for the local and municipal authorities too. Local and municipal authorities have to expend their revenues providing safe places and food supplies for increasing number of people even during small scale flooding. During inundations the usual coping mechanism of the large families is to temporarily split up. Children are sent to relatives in flood-free areas or kept with neighbours in safer houses. The parents usually stay at the house until the very last moment and then move to officially designated evacuation centres although these places are seen with apprehension because of congestion, diseases and generally uncomfortable conditions.

Finally the *number of people depending on* one worker was also found as affecting the income available. For the current analysis the *income dependency ratio* was obtained by identifying the number of residents relying on each worker, or source of income, per family. Figure 8.11 presents the distribution of households by dependency ratio in both wards.

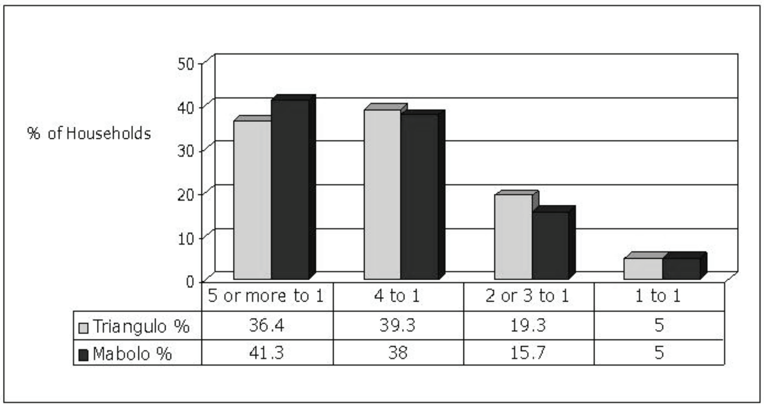


Figure 8.11 Distribution of households by income dependency ratio (Triangulo and Mabolo wards)

The graph shows how for Mabolo nearly 40% of families with five or more members rely on the income of a single worker. In Triangulo the proportion is a bit smaller although it still represent one third of the families surveyed. For both Barangays it was found that for nearly 40% of the families, four members depend on one source of income. As can be expected owing to the large size of the households and low number of workers per family the cluster where one worker is in charge of him/herself and other person is extremely small and corresponds to just 5% of the population in both areas.

The link between income dependency ration and flood vulnerability is straightforward. Several persons depending on the wage of a single worker will put a lot of stress on the income available just to meet their needs. On the other hand families relying on a unique source of revenue, particularly when the wage is low and unstable, do not require a large inundation to experience high disruption. These families are highly vulnerable even to heavy downpours and small scale but recurrent flooding as long as they cause a shortage in the income on which they rely. Another source of vulnerability during floods was found in a coping strategy largely practised in both wards. Once kids, women and elders are moved to safety the head of the household, often the husband or the eldest son is left behind to take care of the dwelling and belongings. By adopting this mechanism the whole family is in danger as the main worker is highly exposed to drowning, illness or injuries while waiting or wading amidst floodwaters.

8.3.5 Housing types and household safety

The type and quality of the dwelling occupied highly determines the outcome or level of disruption that a family can experience during and after floods and typhoons. The interviews revealed that severe damage, and even destruction, of their dwelling may leave them highly expose and even homeless.

Precarious location, frail materials and inappropriate construction methods are critical when a typhoon or flood take place. One of the main concerns for the people in these communities is how to face every year the difficulties associated with the wet season given the weak and unsafe conditions of their houses. Fragments of the Focus Group Discussions with local officers' -in Box 8.3, evidence to some extent the general perception of fragility and lack of safety arising from the inadequate housing conditions in these wards.

Box 8.3 Excerpt from the Focus Group Discussion on housing safety and vulnerability to flood with Barangay officers (B.O)
June – 2005 **Triangulo B.O**: My dream is to build a real house for my family. **Researcher**: I thought your family had already a house, I was there. **Tr B.O**: Of course not, you cannot call that a 'real house'. **R**: Then…What do you mean by a 'real house'? **Tr B.O**: A 'real house' for me is one made of concrete, where I know my family is safe and I would not be worried on what to do or what is going to happen whenever a typhoon is announced. September – 2005 **Mabolo B.O**: Do you know the difference between a *house* and *home*? **R**: Well... I guess a house is the one made from bricks or wood and a home is formed by the people, the family... **Mb B.O**: That's ok; so you will see how in this Barangay everyone has a *home* but very few people have a *house*.

The analysis in this section is based on the characterisation of the main housing types found in both Barangays. Materials, construction systems but moreover the level of protection provided to families during events such heavy rains, flooding, strong winds were used for this classification based on Focus Group Discussions and transects with local officers and community leaders. The classification of housing is summarised below:

Houses in Reinforced Brick- concrete (B-CR): Houses with foundations and main structure made of a concrete frame with reinforced columns at the corners and around main structural elements. Walls are often made of concrete (hollow) bricks; doors and windows in glass or metal and roofed with corrugated galvanised iron (CI) sheets or concrete slabs. Most of these residences are built on pillars or elevated around 0.5 m from the ground level to avoid flooding (see Figure 8.12). According to the participants in the FGD these houses, particularly those with two storeys, provide the safest shelter against flooding. Nevertheless they may become moderately unsafe for the family and their belongings if the roof is blown away by strong winds as those brought by Typhoon Unding (November 19, 2004).

Semi-Concrete (Semi-Cr) houses: Name given in these communities to houses with the first storey made of (hollow) bricks and concrete and the second one in light (wooden) materials (see Figure 8.12). The foundations of these residences consist of a brick and concrete perimeter wall with earth infill; metallic or wooden doors and windows and roof in corrugated iron (CI) sheets. They are typically built by middle-low income households as refuge against flooding. Depending on the water depth they can constitute a safe shelter from floods but the family and their properties may become highly vulnerable if strong winds swept away or damage the flimsier structures and walling on the second floor.

Figure 8.12 Brick and Concrete (top) and Semi-concrete (bottom) houses from Triangulo and Mabolo.

Houses in Light materials (LM): Wooden and other organic materials constitute the most widespread construction system in both wards. The average house is made of a wooden or bamboo frame, elevated from the ground level around 0.5 to 1 metre; their pillars or foundations are made of earthen plinth or stilts in wood, stones or concrete. Walls and divisions are built up from a single material i.e. wooden boards and lumber to an assortment of materials such as, plywood, hardboards (*lawanit*), metallic sheets or corrugated iron; native materials such as timber, bamboo, palm leaves (*nippa*) and mats (*sawali*), split bamboo and even sacs, plastic and cardboard. Roofing is generally made with palm (*nippa*) leaves, sometimes mixed with CI sheets. Based on the materials, construction system used and overall conditions the houses in light materials were further divided into:

<u>*Well preserved wooden-board houses* (LM C1):</u> roofed with corrugated iron sheets; these traditional one storey houses are built nearly one metre above ground level on thick wooden stilts. They seem to date from the times when the Philippine National Railroads (PNR) settled their workers along the railway (around 1940-50). If properly maintained they seem to be adequate for standing at least 1 m depth floods and strong winds (see Figure 8.13).

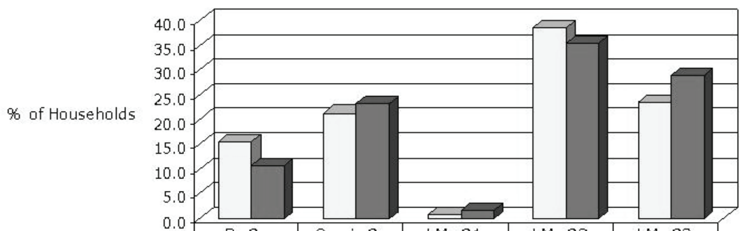
Figure 8.13 Houses in light materials found across the Barangays (type LM_C1 on top, LM_C2 in the centre and LM_C3 at the bottom)

Shanty houses (LM_C2): usually a mix of two or more of the aforementioned materials used for walls and roofing in conditions that range from fair to bad (see Figure 8.13). These houses are built around 0.5 m above ground level on thick wooden stilts or trunks. Scattered all over both Barangays they constitute the predominant housing type found.

The weak structure and materials used besides poor maintenance determine that floodwaters and strong wind gusts may cause heavy to total damage on them; however, it was found that during flooding most families stay in these elevated houses at least until the water reaches the floor. Two-storey houses or the ones in high stilts become very unsafe during strong gales or typhoon winds as the whole structure can be easily blown away.
Dampas or huts (LM_C3): extremely feeble makeshift houses; usually built by the poorest households. Second hand or scavenged materials (kept in

very bad conditions) are used for their construction. The structure consists of a single room elevated on thin wooden or bamboo stilts and trunks between 0.5 to 1 m above ground level. Almost every type of materials is mixed for walls, divisions and roofs (see Figure 8.13). The organic nature and poor quality of the materials employed in these houses determine that elements such as roofs, walls and floors may leak and crumble even during heavy rains or after two or three days contact with floodwaters. Families living in these houses are extremely exposed to all events from heavy downpours to flooding and strong winds. After every wet season the unsafe conditions may remain for long time and even become permanent as most of the households are too poor to repair the damage. During fieldwork this situation was clearly evident by the fact that nearly one year after the event, most of the houses damaged or destroyed by Typhoon Unding-Yoyong had not been repaired, and remained in very bad condition (see Figure 5.12).

The proportion of the housing types in the survey is presented in Figure 8.14.



	B_Cr	Semi_Cr	LM_C1	LM_C2	LM_C3
Triangulo_%	15.7	21.4	0.7	38.6	23.6
Mabolo_%	10.7	23.1	1.7	35.5	28.9

Figure 8.14 Distribution of households by housing type in wards Triangulo and Mabolo.

Figure 8.14 shows that at least 62.2% of the families in Triangulo and 64.4% in Mabolo inhabit poorly built and extremely frail houses where they remain highly exposed to rainstorms, floods and strong winds. Families living in safe dwellings built with strong materials or adequate construction systems represent 38% and 35% of the households in Triangulo and Mabolo respectively.

The spatial distribution of the families according to their housing conditions is shown in Figure 8.15.

Households occupying makeshift dwellings and additionally settled in areas where recurrent floods can reach *Highly Disturbing, unmanageable* and even *Disastrous* categories are the most vulnerable. Having their houses badly damaged or destroyed almost every year by flooding or typhoons can lead these families to a state of Marginality. Families living in unsafe housing can be found particularly in Zones 4, 5 and 6 in Triangulo and 4, 5 and 6 in Mabolo. Regardless of their location, the exposure of all families living in this type of houses strong winds is very high. In this respect it was also found how those families in areas where vegetation is still abundant are also jeopardised by falling trees and trunks (see Ms Q's narrative in Box 8.1).

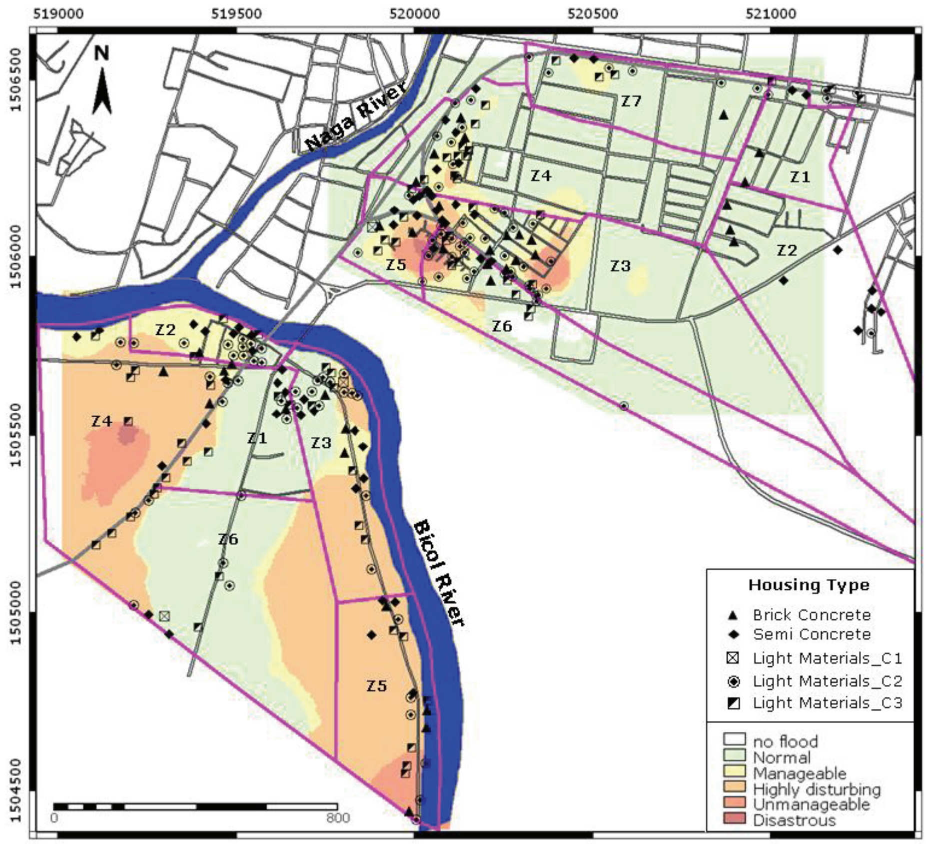
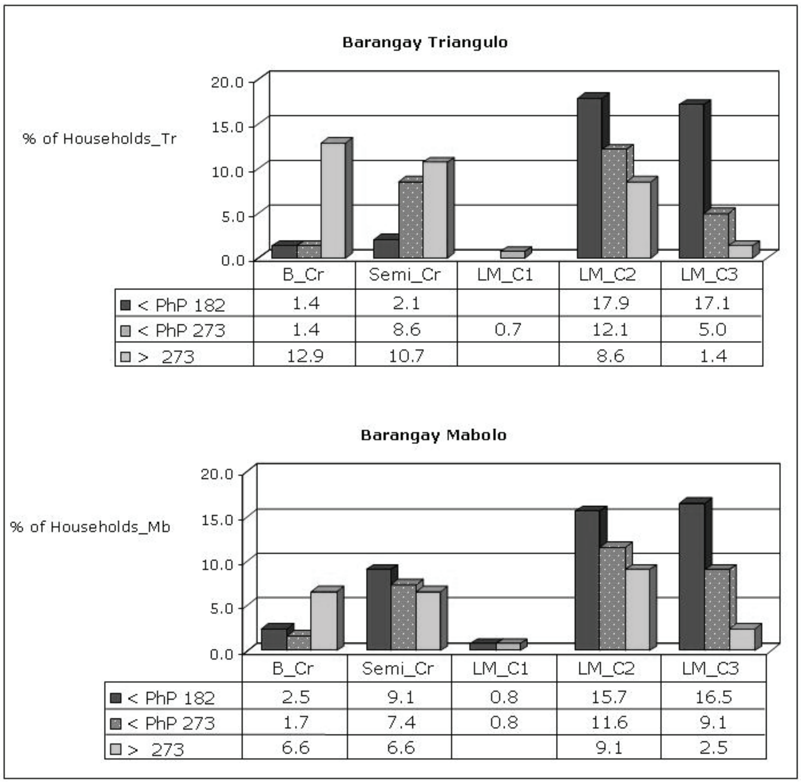


Figure 8.15 Spatial Distribution of households by housing type vs. community-based categories for 2-year return period flood.

The predominance of inadequate and unsafe houses in these wards is related to several aspects. Low income, poor access to low rate loans and subsidies and conflicting land ownership were some of the main factors identified by the households for their precarious dwellings.

The bivariate analysis in Figure 8.16 shows the correlation among the housing types previously identified and the daily income available by family unit.

From the figure it can be seen how especially for Barangay Triangulo most of the families with higher income inhabit concrete and semi-concrete houses. There are also a large proportion of families with wages below the poverty line living in light material units inboth wards (52.1% in Triangulo and 52.9% in Mabolo). The graph additionally showed that 17.1% of the poorest households in Triangulo (those below the PhP 182 Food Threshold) and 16.5% in Mabolo reside in the weakest and more unsafe houses as it is the LM_C3 type.



Barangay Triangulo

	B_Cr	Semi_Cr	LM_C1	LM_C2	LM_C3
< PhP 182	1.4	2.1		17.9	17.1
< PhP 273	1.4	8.6	0.7	12.1	5.0
> 273	12.9	10.7		8.6	1.4

Barangay Mabolo

	B_Cr	Semi_Cr	LM_C1	LM_C2	LM_C3
< PhP 182	2.5	9.1	0.8	15.7	16.5
< PhP 273	1.7	7.4	0.8	11.6	9.1
> 273	6.6	6.6		9.1	2.5

Figure 8.16 Distribution of housing type by family daily income in Triangulo (top) and Mabolo (bottom) wards.

Evidently a family with not enough income to meet their most vital needs will hardly invest in adequate construction systems and materials; even if they are fully aware of the risk. The link between unsafe housing and low income implies that besides their high susceptibility to become homeless these families also lack adequate financial, nutritional and sanitary status to cope with the 'critical' times usually triggered by typhoons.

In this respect it should be mentioned how during the survey most of the households involved in the municipal on-site and resettlement programmes for the Urban Poor in zones 5 and 3 in Triangulo and 2 and 5 in Mabolo fall into this highly vulnerable group. Once the terrain is provided by the city government these families are not able to fulfil their basic needs and at the same time pay for the land, raise the level of the terrain and build adequate and safe houses with their low income.

Regarding the relationship between housing and land ownership it was found that (particularly in Triangulo) a large share of the residents settled in low-lying areas do not own the land where their houses have been constructed. The lack of land entitlements creates a general sense of uncertainty, increases the perception of potential eviction and finally discourages the household to invest in adequate housing or stronger materials.

In order to establish the correlation among housing and land tenure the participants of each of the households in the survey were asked to provide details about their type of ownership (see Appendix 3.A). In essence three modalities of land tenure were found:

1. The land is owned by the family or being paid to the City as part of the on-site or resettlement programmes of the Urban Poor Office (UPAO).
2. Neither the land nor the house is owned but the household take care of them as a tenant or pay a small amount to the real owner - usually a close relative or friend (*compadre*).
3. the household is illegally settled on privately or state-owned land for instance the right of way strip of the National Railroad (PNR) (a buffer of 15 to 30 meters at each side of the rail track).

Table 8.6 shows the distribution of families by land tenure.

Table 8.6 Distribution of Households by land tenure in the study area

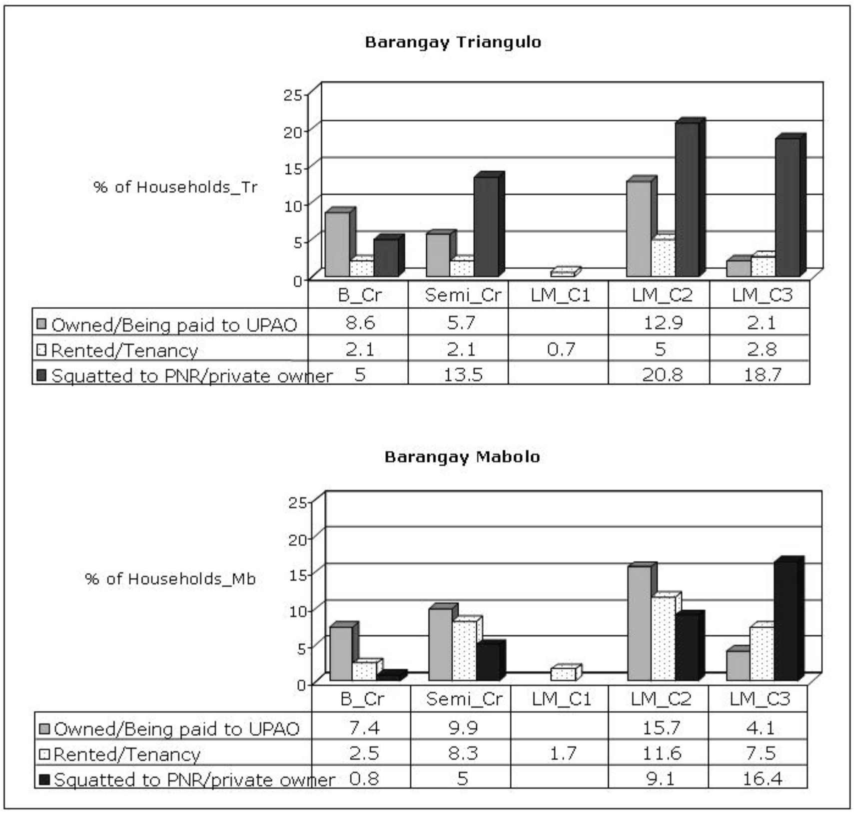
Land Tenure	**TRIANGULO**	**MABOLO**
	Households (%)	Households (%)
Owned	17.1	16.5
Being paid to Urban Poor (UPAO)	12.1	20.7
Rented	5.0	14.9
Tenancy	7.9	16.5
Squatter on PNR right of way strip	41.4	13.2
Squatter on privately owned lots	16.4	18.2

The data presented in Table 8.6 indicates that at least 57.8% of households in Triangulo and 31.3% in Mabolo do not own the land they currently occupy. Therefore, even if having the means for building or reinforcing their houses, this investment will be at risk if the private owner or the state exercises their (land) rights.

The influence of land tenure in the distribution of housing types found in the study area is indicated by the bivariate analysis in Figure 8.17.

In Triangulo, insecure land tenure is highly associated to unsafe types of housing; nearly 40% of the householders with no entitlements reside in light material dwellings (type LC-2 and LC-3). In Mabolo this association has less influence, which is probably because of the higher number of people owning their land through the Naga City official programmes for the Urban Poor.

From the analysis in Figure 8.17 is also noticeable the percentage of houses in concrete and particularly semi-concrete (Semi-Cr) materials built on private or state-owned lands. In Triangulo, for instance, they represent nearly one fifth (18.5%) of the surveyed families. Despite the threat of eviction these cases show evidence of the households' response to their fear of typhoons. In Mabolo, for instance, one of the respondents illegally settled in the PNR right of way strip explained that '*He decided to rebuild their house* *in semi-concrete materials after the previous one in light materials (LC_2) was swept away by Typhoon Unding in 2004. He was indeed concerned by the chances of losing their investment; however he prefers to be sure that their offspring have a safe roof over their heads during the next typhoon'*.



Barangay Triangulo

	B_Cr	Semi_Cr	LM_C1	LM_C2	LM_C3
Owned/Being paid to UPAO	8.6	5.7		12.9	2.1
Rented/Tenancy	2.1	2.1	0.7	5	2.8
Squatted to PNR/private owner	5	13.5		20.8	18.7

Barangay Mabolo

	B_Cr	Semi_Cr	LM_C1	LM_C2	LM_C3
Owned/Being paid to UPAO	7.4	9.9		15.7	4.1
Rented/Tenancy	2.5	8.3	1.7	11.6	7.5
Squatted to PNR/private owner	0.8	5		9.1	16.4

Figure 8.17 Distribution of housing type by land tenure in Barangays Triangulo (top) and Mabolo (bottom)

8.3.6 Sanitary and environmental conditions and household wellbeing

Regarding flooding, the availability and quality of basic services such as drinking water and sanitation become crucial in determining the level of disruption experienced by the households.

During 'normal' times some families may become more vulnerable if they cannot afford to pay for bottled water or if the water they consume is not safe. Particularly children may be more susceptible to diseases and infections if the surface or groundwater they use for their daily activities is contaminated with human waste or other pollutants.

On the other hand the inadequacy or lack of sanitary units and sewage and waste disposal systems may lead the household to adopt perilous practices that constitute a serious threat to their health and life and deteriorate the environmental conditions of their surroundings. The presence of stagnated waters and minor but perennial flooding constitute one of the most problematic situations found in the study area as both adults and children are continuously exposed to water-borne diseases, pollution and other unhealthy conditions.

The data in Table 8.7 shows how, at least in Triangulo, the incidence of respiratory, gastrointestinal and waterborne diseases and infections constituted the most frequent causes of morbidity for the period 2001 to 2004 (TBHC, 2005). According to the data from the health care centre each year, from 2001 to 2004, nearly one in four people in this ward was ill or asked for assistance.

Table 8.7 Morbidity profile for Barangay Triangulo (2001 – 2004)

Diagnosis	**Average Number of patients**	**Average % of consultation**
Cough and colds	523	28.4
Fever	398	21.6
Head ache	280	15.2
Hypertension	145	7.9
Diarrhoea	138	7.5
Pneumonia	92	5.0
Asthma	85	4.6
Abdominal pain	72	3.9
Skin rashes	68	3.7
Infected wound	40	2.2
Total	1841	100%

From the total number of registered patients 57.3% were youngsters (under 18 years old) and 42.7% adults. The average age was found to be 4.5 years old for children and 36 for grown-ups. These figures in some way indicate that throughout the year a significant proportion of parents, or head of household, may get ill or need to take care of ail children.

This situation is more frequent during the peak of the wet season (October to December) when the prevalence of diseases and the proportion of people seeking attention at the health centre increases (see Figure 8.18). In Triangulo, the incidence of illnesses is more prevalent in residents from the flood-prone zones 3, 4 and 6. From the survey it was found that almost every rainy season, or after small flooding, all type of respiratory and gastrointestinal infections affect one or several members of 80% of the families in Triangulo and 87% in Mabolo.

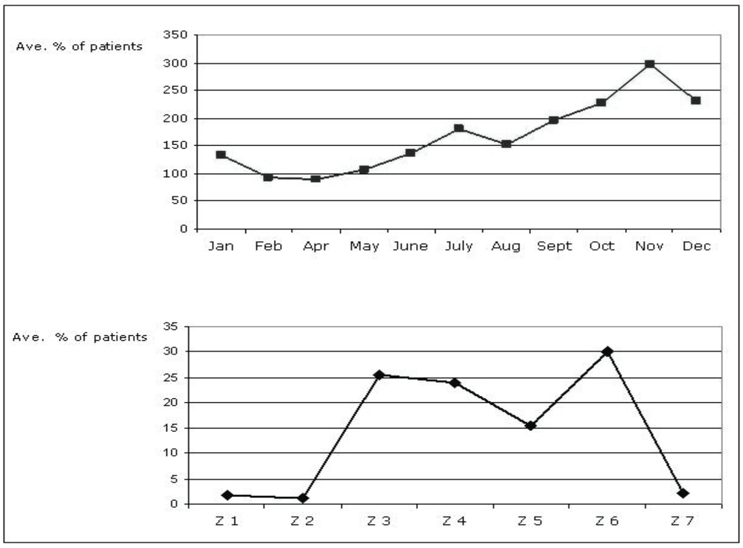


Figure 8.18 Average distribution by month (top) and Zone of consultations (bottom) at the Health Center in Triangulo (2001-2004).

According to the interviewees the most widespread ailments are waterborne diseases such as diarrhoea and dengue, skin infections and allergies (dermatitis, athlete's foot, itchiness) which are strongly related to unsafe water supply, areas with poor sanitation and hygiene and people in direct contact with polluted waters.

In both wards, most of the households that reported not experiencing any health disorders from flooding or typhoons corresponded to families in flood-free areas or wealthy sectors with adequate services and hygienic conditions. This aspect coincides with the bottom graph in Figure 8.18, where the low incidence of diseases, or at least a lower consultation rates are observed for zones 1, 2 and 7.

In the wealthy subdivisions (zones 1 and 2), households can afford other type of health services provided by the social security and private medical services. For the poorest families the Barangay Health Centre (BHC) represents the primary health facility for consultation, health care and medicines. Aso nearly 55% of the households in Triangulo and 54.5% in Mabolo reported to have no affiliation to any of the state or private-run Health and Social security services available in Naga.

The vulnerability to flood of these families is evident as illnesses of young or adult members decline their productivity and income, and keep them exclusively relying on the availability and adequacy of governmental facilities for covering their vital health needs.

8.3.7 Access to basic services and families wellbeing

Some of the factors that may threat the health and wellbeing status of the families both during flooding and 'normal' times were found to be related to unsafe water supply and poor sanitation and hygienic conditions; likewise the presence of stagnated and polluted waters.

In order to determine the type and quality of some basic services and the overall sanitary conditions across the wards the household survey was complemented by several transects carried out in the company of local officers and community leaders across their respective jurisdiction zones. These joint activities helped to identify, but moreover, to discuss and map aspects concerning the family wellbeing such as sources of drinking water, toilet facilities and waste disposal practices among others (see Sections 3.6.5 and 3.6.6).

Sources and access to Drinking Water: In Barangay Triangulo and Mabolo the drinking and domestic water demand is mostly supplied by the National Water Sewerage Authority (NAWASA) and the Task Force Tubig (TFT) using the groundwater from the deep well pumping station in Zone 4 in Mabolo.

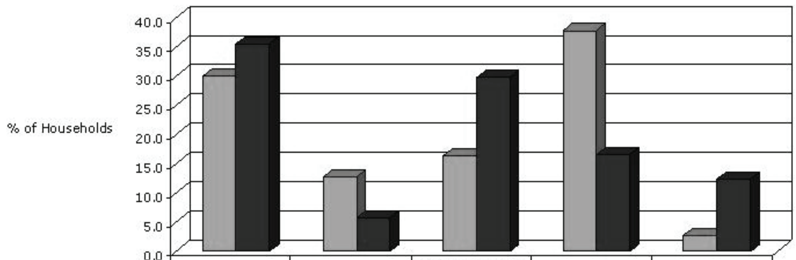
The survey showed that even if most of the households make use of the installed system not all families can afford direct access to piped water in their residences. As a consequence the communities and sometimes the municipality have implemented several other modes to fulfil the people's need for drinking and domestic water. The additional systems found in operation were:

Shared or community faucet: based on an informal agreement among several households. The system is installed on sidewalks with a counter that measures the amount of water dispensed on a monthly basis; the total bill is divided up among the users who on average should pay PhP 200-250 per household (see Figure 8.19).
Buying from private users: in this case the household buys minimal amounts of water from those who own the private faucets, usually the well-off. The water is bought on a daily basis and is used mainly for cooking.
Public faucets: installed by the City Government, they provide drinking water to poor or 'indigent' families that cannot afford private access to the system. The water is provided for free and in some sectors restricted to schedules i.e in Mabolo, where the pumping station in Zone 4 distributes water for two hours in the morning and late afternoon.
Public pumps: Tubed intermediate-deep wells (<30 m) distributed all across the Barangays and installed either by the City or by politicians under request from the community. The water from these pumps is not treated and therefore is mostly used for domestic activities such as bathing, washing clothes and the like. Nevertheless, it was found that in areas with no public faucets some of the poorest families have no choice but to use this water for consumption.

Figure 8.19 Sources of drinking and domestic water in the study area

The distribution of households by the source of their drinking water is presented in Figure 8.20. This analysis shows that in Triangulo, nearly 40% of the families can benefit from public facilities. In Mabolo the access to potable free water sources is lower and therefore mostly poor households have to look for other alternatives as buying form private faucets (29.8%) which may imply an added expenditure to their low income or hazardous consumption of water pumped from public wells (12.4%).

In terms of quality, affordability and physical access to this service during flooding the households that make use of shared and public faucets and pumps, have to face several challenges. During transects it was seen how most of the taps and pumps raise less than 0.5 m above ground level.



	Private Faucet	Shared Faucet	Buy from Private Faucet	Public Faucet	Pump
Triangulo %	30.0	12.9	16.4	37.9	2.9
Mabolo %	35.5	5.8	29.8	16.5	12.4

Figure 8.20 Distribution of households by source of drinking water in Barangays Triangulo and Mabolo

These facilities are installed with no sink to isolate them and lack adequate drainage for directing wastes towards the sewerage system (see Figure 8.19). These inadequate settings often cause stagnated grey-water zones, particularly when domestic activities such as the washing of clothes and bathing take place around them; becoming spots for mosquito breeding and water-borne diseases. Regarding location, most of the pumps and faucets are installed along the main access roads; many families residing in the remote sectors should cover around 200 metres several times a day to be able to fetch drinking water; sometimes amidst ankle to knee-deep flooding.

During and after floods households making use of these facilities have restricted, or no access, to water for consumption and domestic use as the pumps and faucets get partial or totally covered by floodwaters. According to the local officers after flooding people are not supposed to use the pumps and water from the wells for about two weeks. This measure would seem to be in place for minimising the risk of diseases after consuming or making contact with potentially contaminated groundwater. However, in order to meet their fresh water needs some families have to strain their scarce income by purchasing pricey bottled water or have to walk longer distances to get it from flood-free areas; while some others continue fetching water from hosed taps and water wells - despite of the warnings - as, in their words, '*they have no other choice'*. This situation was witnessed during fieldwork amidst the knee-waist depth flood produced by Tropical Depression Labuyo.

Public pumps and faucets mapped while transecting together with the spatial distribution of households by the sources of drinking water is shown in Figure 8.21. In terms of flood vulnerability families fetching their drinking water from pumps in zones 4 and 6 in Triangulo and 3, 5 and 6 in Mabolo are the most susceptible. Households depending on shared and public faucets living mostly in zones 4 and 6 in both Barangays will be highly affected during flooding as these facilities may get easily covered by knee-deep floodwaters.

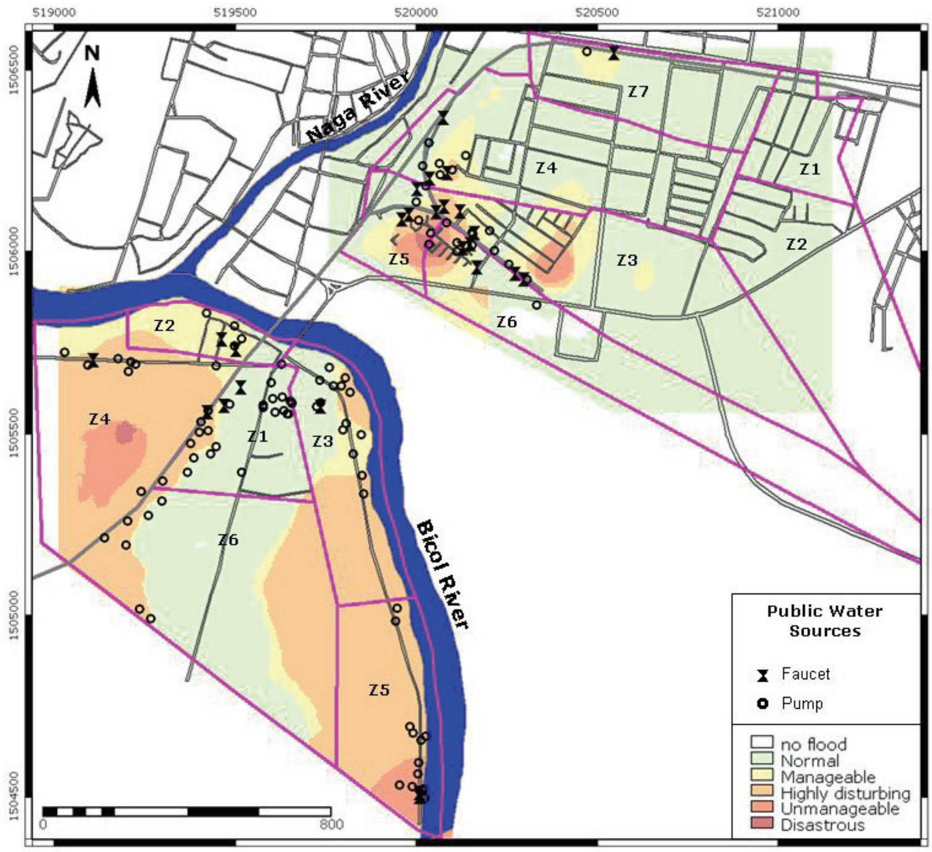
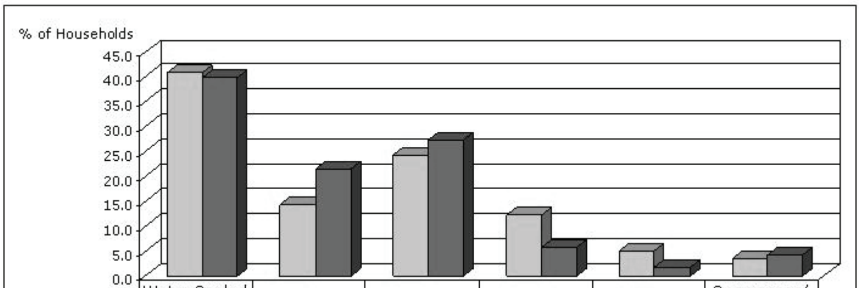


Figure 8.21 Spatial distribution of Public water sources (Triangulo and Mabolo wards).

Sanitation toilet facilities: Quality, location and moreover performance of facilities during flooding are basic for the daily life of the families and highly determine their differentiated vulnerability to floods. During the rainy season the lack of sewage management system creates unhealthy sanitary conditions for families in the low lying zones. Runoff and floodwaters get contaminated increasing the incidence of gastrointestinal and other waterborne diseases.

During the survey it was found how the predominance of informal housing and the small space available per household (in some cases not even enough to build toilets) determined that many families have no access to adequate water sealed units. Sanitary needs are therefore fulfilled by other, sometimes risky, means such as installing open pits, shared use of private and public toilets and the use of open spaces or polythene bags commonly known as '*flying toilets*' to dispose of human waste.

Figure 8.22 shows the proportion of families per sanitary system used.



	Water Sealed Unit	Open Pit	Shared Unit	Public Toilet	Plastic Bag	Open space/ River
Triangulo %	40.7	14.3	24.3	12.1	5.0	3.6
Mabolo %	39.7	21.5	27.3	5.8	1.7	4.1

Figure 8.22 Distribution of households by their access to sanitary facilities in both wards

The water sealed units (40% and 39.7%) correspond mostly to concrete and semi-concrete houses which incorporate the space and infrastructure required for these units in their design. Some of these units are shared with relatives or neighbours by charging a small fee for the water bill.

Households with no space or infrastructure make use of handier open pit private units (14.3% and 21.5%) and some others use communal toilets installed by the municipality or the community. Some of these public facilities correspond to water sealed units (3 in Triangulo and 1 in Mabolo) often mounted in concrete rooms and some others to open pits installed in makeshift sheds (see Figure 8.23). These units serve a considerable proportion of families particularly in Triangulo (12%); regrettably it was found that some of them are deteriorated or poorly maintained and thus become a threat to both the users and the surroundings (see Figure 8.23).

A reduced number of households in both Barangays (8.6% in Triangulo and 5.8% in Mabolo) reported some particularly hazardous practices as it is using open spaces, the river and plastics bags for disposing of their waste. This extremely dangerous strategy, limited to a handful of families in the 'normal' times, becomes widespread practice during flooding as the water sealed units and open pits are rendered useless. The pollution so caused embodies health risk to all the community, plants or animals that make direct contact with contaminated floodwaters and can even pervade shallow aquifers and neighbouring areas spreading the threat to even flood-free areas.

Waste disposal practices: The expansion of the road network for Bus and jeep Terminals and other commercial activities at the Central Business District Teo (CBD-II) in Triangulo and the expansion of industrial and commercial activities in Mabolo have improved the routes and access for the City's Waste pick-up plan. According to the households and local officers before the implementation of the waste disposal programme practices such as dumping waste on street corners and lots or throwing it to waterways and the rivers were rampant; as to contamination and unhealthy conditions particularly during floods.

Figure 8.23 Sanitation facilities in the study area: Private water sealed units (top), public toilets (bottom left) and shared open pits (bottom right)

The launching of the waste management scheme has decidedly reduced these harmful practices, lessened the pollution of floodwaters when inundation takes place and therefore greatly improved the overall sanitary conditions in both wards (see Figure 8.24).

Figure 8.24 Waste collection programme in action at Triangulo

The plan is mainly based on the free of charge collection of waste along the main roads. However not all zones are accessible for the trucks, therefore the programme has been complemented with strategies such as pick-up points along the main access roads. In this case the households should bring the bags on a certain schedule, in order to be collected by the trucks. Other mechanism is based on the house to house plan with collectors subscribed to the Environmental and Natural Resources Management Office (ENRO) who gather the waste in carts and charge the household a small fee. Nearly 85% of the families in Triangulo and 78% in Mabolo dispose their waste by using the facilities implemented by the City. There are still a considerable number of families (15 to 20%), mostly living in the most remote areas, which have not yet adopted any of the programme schemes and still follow methods such as burning, burying or composting the waste.

As presented in Section 3.6 and Figure 3.7 the activity of transecting with the local officers helped to identify, map and discuss the presence of these harmful practices, as follows:
Transitory spots: The household accumulate the rubbish until the collection day. Organic and non-organic material are kept in open bags or lying directly on the ground attracting rodents and domestic animals who scavenge the contents (See Figure 8.25 A).
Burning: mostly vegetative material plastic bags and paper wraps are pilled-up and incinerated. However it was observed that not all of the 'material' gets completely burnt or destroyed and can be easily spread by winds, rainwater or scavenging animals. This practice embodies a secondary hazard as unattended fires are often set amidst a highly flammable built environment (houses in wooden and light-materials) (See Figure 8.25 B).
Filling-up: waste mixed with dirt is used to elevate the ground level as a coping strategy against floods, particularly by residents in low-lying areas (See Figure 8.25 C).
Waste Dumping: Located behind, among or below houses they are the focus for rodents, mosquitoes and other pest. In addition most dumping grounds are close to heavily occupied areas, swampy or stagnated water zones, natural waterways and drainage channels (See Figure 8.25 D and E).
Zones for debris dumping: Open areas and empty spaces availed by the city for earth debris and Waste disposal they are intended for elevating the level of low-lying zones for urban expansion. Some poor families were know to have scavenged these dumping sites for wood and other recyclable materials (see Figure 8.25 F).

The images in Figure 8.25 indicate the threats embodied by these inadequate practices to the health and overall wellbeing of the people, particularly children. The presence of waste deteriorates the sanitary conditions in the wards, increases the likelihood and magnitude of flood by clogging the drainage network and pollutes the floodwaters with all type of materials and effluents.

The prevalence of these harmful practices was discussed during workshops, where it became clear that people in these communities are fully aware of the risk these inadequate practices represent for their daily life, mainly during flooding. Some of the points examined during several workshops on the difficulties that local people identify as arising from these practices and the threat they pose to their everyday life as well as some of the root causes for them are presented in Box 8.4.

Figure 8.25 Harmful waste disposal practices in the study area.

The topics addressed in Box 8.4 show the need to determine the relation among the education and commitment of the household and the presence of authority (represented by the local officers) in certain areas.

In order to further discuss these points a direct mapping activity was programmed with local officers. The result of this joint activity is presented in Figure 8.26. Some of the conclusions derived from the participatory mapping were that the inadequate disposal of waste are not exclusive of zones with inadequate access for the collection trucks, which at some point may excuse the existence of alternative methods for disposing of the rubbish.

Box 8.4 Threat to daily life and 'root' causes for harmful waste management practices addressed by locals (workshop, August 2005)
Daily life threats • Pollution • Poor environmental quality • Unpleasant image of the Barangay • Induce the presence of rats, mosquitoes, cockroaches • skin diseases • Water-borne diseases Root causes • Households are not aware of the relationship between harmful waste management practices and proliferation of diseases. • Poor hygienic education. • Lack of discipline from the community: parents do not segregate the waste and children who throw sweet wrapers and litter on the streets. • Poor access of some areas. • Dependence on household time and commitment for segregating the waste and take it to the pick-up points • Paternalistic attitude and lack of power from Barangay officers and authorities. • People do not obey ordinances about waste dumping. • Ordinances are not strictly implemented (not mandatory). • Cleaning activities are sometimes seen as a beautification practice and not fully addressed as flood mitigation process.

In wealthy and highly developed areas, such as those in Zones 1 and 2 in Triangulo (also know as Naga city subdivision) dumping waste in open areas is still a prevalent method for disposal. During fieldwork it was seen how many times the bags and litter reach and clog the drainage system along the streets. On the other hand it was also found that dumping and filling-up practices are more common in areas where flooding can reach knee-depth during heavy rains (i.e. the 2-year flood depicted in Figure 8.26). Households in Zones 4 and 6 in both wards still use waste to elevate the ground level in the area surrounding their residences. Burning is a common practice in remote areas whit inadequate access for trucks or where people find the frequency for waste collection low as in Zones 3, 4 and 7 in Triangulo and zones 1 and 6 in Mabolo.

8.4 Main findings and discussion

The vulnerability analysis carried out in this chapter verified how the difference of experiencing a *Normal, Manageable, Highly Disturbing* or *Disastrous* situation largely depends on the resources and circumstances under which a family covers its daily basic and non-basic needs. Type, nature and number of livelihood sources greatly differentiate the vulnerability to floods between the families. The narratives, workshops and open interviews with the households made clear how the susceptibility of the livelihood to weather conditions plays an important role. It was found how the revenues of workers may decrease and even come to a halt, because of 'normal' rainstorms. The meagre income available for some families is not enough even to meet their basic needs during 'normal' dry times.

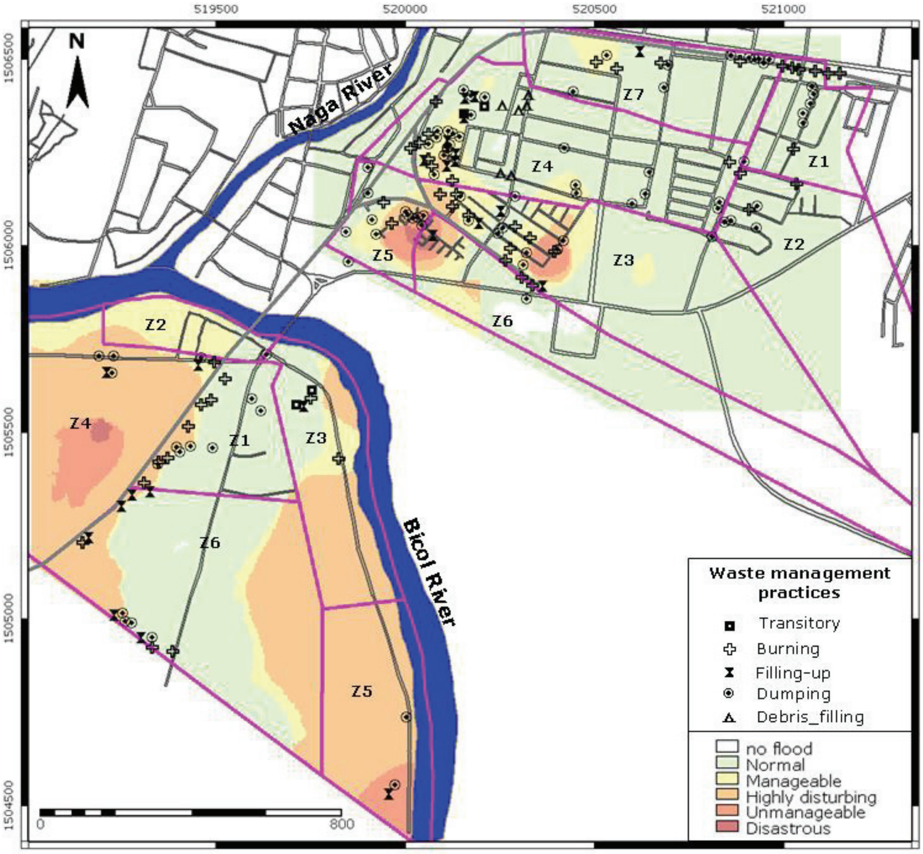


Figure 8.26 Distribution of harmful waste management practices in the study area.

This circumstance determine their high vulnerability, specially if they live in areas where small but cyclic flooding may reach *Highly Disturbing* to *Disastrous* stages and their nutritional, financial and overall conditions will not be adequate to face the recurrent threats.

The analysis also showed that typical household arrangements in terms of family members, gender of the main worker and dependency ratio greatly differentiates the disruption triggered by floods. Extended families relying on solo workers strain the income at hand to the point that the basic needs of every member could not be met. In addition these large families also put a burden on women who cannot access the labour market and if so their income level was found smaller when compared with the male.

The type and safety of their houses also plays a significant role in differentiating the vulnerability to flood for the families in both wards. Houses built with adequate materials and construction systems offer a safer refuge to the occupants while families occupying makeshift houses constructed with weak materials were found vulnerable even to heavy downpours. Scarce daily income available but also insecure land tenure and limited access to governmental programmes and low interest loans were found as some of the root causes for the predominance of unsafe housing types in these wards. Even though highly aware of their vulnerability to floods and typhoons the households were even more scared of being evicted or losing their investments in stronger materials and construction systems.

Finally it was found how the characteristics, access and performance of basic facilities such as drinking water, toilets and the waste disposal system may have negative implications for the family's health and wellbeing during 'normal' and 'crisis' times. Unhealthy sources of water for consumption and domestic activities, inadequate and poor maintained sanitary units and harmful ways of disposing human and other waste (despite the existence of a waste management programme), were found to be causes for the high incidence of ailments - mostly during the wet season. The poor hygienic conditions found in some sectors made several members of the household, particularly children, sick nearly all the year round. These constant ailments strain the household and municipal economic resources, as most of the families in these areas depend on the Barangay and City facilities to cover their basic health needs.

The high reliance on the Municipality to provide some of the basic needs of the families in these wards such as education, public water sources, sanitary units, waste management programmes, medical assistance, evacuation centres and relief assistance after flooding and typhoons, also contribute to their potential vulnerability. Although Naga has a significantly growing economy the burden of providing free of charge services to a growing population may exceed the City's resources when the threat of climatic events becomes larger and more frequent.

The conceptual analysis carried out in this chapter highlighted some of the main economic, social, physical and environmental conditions of the households' everyday life to elucidate the different levels of vulnerability to flood found among the communities in the study area. To achieve this the use of participatory and GIS tools was crucial. They fostered the analysis and discussion with local officers, leaders and households and disclosed the vast knowledge that people in these communities have on their own susceptibility to floods. The experiences and tacit information existing among these communities is one of the resources that the municipality has to start incorporating as part of its flood risk management strategies. Similar surveys are carried out at household level by the City Social Welfare and Development Office (CSWDO). GPS and GIS are available in the Electronic Data Processing Unit. Geo-referencing the most vulnerable households is just a one-time process after which the periodic monitoring of their situation during and after floods can help the municipality to improve or adjust its risk management programmes and policies. The outputs of the vulnerability analysis carried out by these means are of interest for most of the offices in the Local Government Unit but especially to those that are supposed to deal with the social, economic and safety aspects of the citizens of Naga.

Chapter 9: Spatial assessment of Flood Vulnerability at Barangay Level

This chapter builds on the analysis of household vulnerability presented in chapter 8, by up-scaling the vulnerability analysis from household level into a spatial vulnerability assessment at ward level. The factors contributing to flood vulnerability, identified by the communities, were integrated using Spatial Multi-Criteria Evaluation, and the weights derived from the criteria of the local people. By these means it was possible to determine, in spatial terms, the distribution of the elements contributing to the flood vulnerability of the households as well as the overall distribution of vulnerability across the communities in the two wards studied.

9.1 Introduction

The vulnerability analysis performed in the previous chapter helped to determine the diverse economic, social, physical and environmental circumstances faced by households in their daily life. It also analysed how the interaction of these factors determine different levels of vulnerability to flooding. In addition, the GIS-based survey used as basis for the analysis assisted in the characterisation and spatially location of a number of individual households that exemplify the diversity of vulnerability levels found among the two studied communities. Nevertheless, Local and Municipal authorities, including Disaster Management Units, are not only interested in the location of individual vulnerable households. Understanding the overall patterns of vulnerability and the reasons why unmanageable and even disastrous circumstances are experienced by certain groups of families every time flooding takes place is also their concern.

Vulnerability assessment is intended to provide communities and local authorities with this type of data. Thus, when this assessment is carried out in a spatial way these actors will also be able to know the geographical distribution of people and elements which can be damaged, in one way or another, by the occurrence of floods.

The estimation of how susceptible to flooding are the social, economic, physical and environmental aspects in which the households perform their everyday life is an important step in the assessment of vulnerability. Knowing how the susceptibility of these elements contributes to make the families in these Barangays more or less vulnerable is the assessments core step.

The approach performed in this chapter recognises that people, particularly households, and the elements of their daily life are vulnerable in different ways. Achieving this understanding required getting close to the experiences and concerns of vulnerable communities. During fieldwork it was observed that local people fully understand the incidence that aspects such as socioeconomic level and geographical location have in their own susceptibility to flooding. Including these perceptions and priorities along the steps comprising the current vulnerability assessment was deemed important. Among others, it increases the possibilities that the outputs will resemble people's concerns and the vulnerable situation at hand. On the other hand, the aim is that the contextualised and spatial data produced may help the communities and local authorities to look at alternative and innovative ways to improve the manageability of floods of several magnitudes.

9.2 Assessing Vulnerability to floods at ward level

As aforementioned the present assessment discriminates between the vulnerability of the households in the studied communities and the susceptibility of their socioeconomic context. The estimation of vulnerability presented herein was then performed as a 'twofold' procedure. Firstly, by making use of a spatial multi-criteria scheme the propensity of certain families to be affected by floods was evaluated as well as their distribution across the ward. Secondly, the susceptibility to flood of the physical, social and economic activities present in each ward was also determined. In this case the topographical situation was used for their vulnerability evaluation as well as their incidence in the overall vulnerability of the households.

The twofold evaluation took the land use map (prepared for each ward during fieldwork and presented in Figures 4.14 and 4.17) as starting point. *Residential* and *Mixed Commercial-Residential* areas were used to evaluate the spatial distribution of the factors identified by the communities as contributing to their own vulnerability to flood. Other land uses related with socioeconomic activities such as *Commercial, Education, Religious* and the like were set aside for the second part of the vulnerability assessment related to socioeconomic activities (see Figure 9.1).

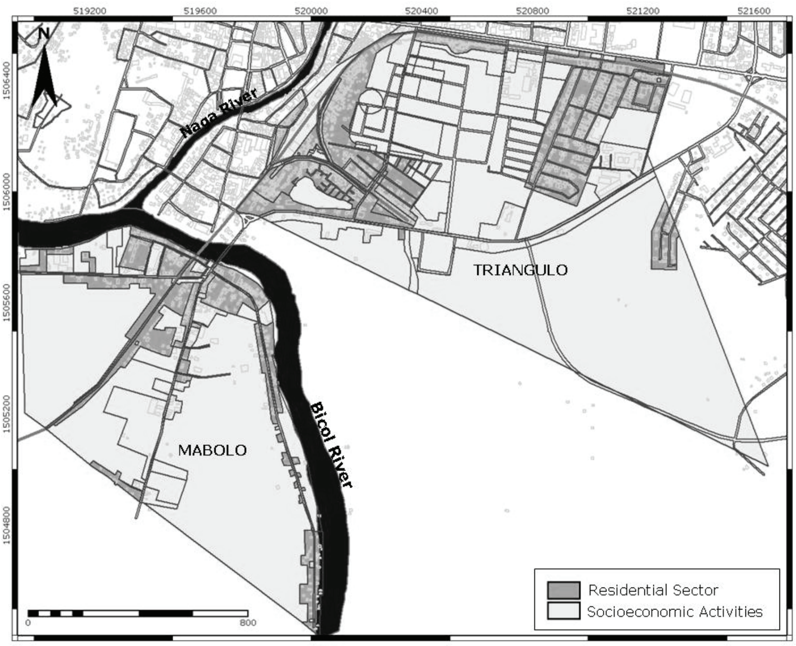


Figure 9.1 Reclassified Land use map used for the vulnerability assessment of household and socioeconomic activities.

9.2.1 Estimating flood vulnerability of the households

This research considers the community as the vulnerable element. Therefore, the spatial assessment of vulnerability to floods implies, in this case, indentifying where, why and to what extent the diverse groups of households or family units in the study area may become susceptible to be affected, and experience some degree of the disruption triggered by floods.

Identifying those aspects that the households consider as important for carrying out their everyday life in a proper way was therefore relevant for this assessment; for their availability and quality contribute to the intrinsic vulnerability to flood of the families. The ranking exercise in Table 9.1 present the elements found in both barangays, which were derived by means of a Focus Group Discussion (FGD) with Barangay officers and leaders.

The ranking exercise presented in Table 9.1 showed in first place that, in comparative terms, the importance given to the presence or disruption of flood management infrastructure (such as a drainage system) is relatively low in both areas (rank 7 and 6). At this respect it was found that compared with everyday, more pressing, problems flooding becomes a ‘minor’ and ‘seasonal’ difficulty. The people perceived that flood is a problematic issue that ought to be managed but once aspects such as lack of income, unsafe housing, lack of opportunities and overall poverty had been solved.

Table 9.1 Ranking of aspects considered important for the everyday life of the households which disruption may contribute to their flood vulnerability.

Aspect	Triangulo rank	Mabolo rank
Employment- Livelihood means	1	2
Housing (type and ownership)	2	3
Education	3	4
Health status	4	1
Environmental quality (sanitation, garbage collection, presence of stagnating waters)	5	7
Access to drinking water	6	5
Access to services and development-related infrastructure (drainage system, public transport, roads, street light)	7	6
Availability of assistance during crisis times (warnings, relief, evacuation centre)	8	8

From the table it can be seen also how aspects such as those related with livelihood, housing, access to land, education, health and drinking water, and environmental quality seemed to be perceived and ranked with a different level of importance in both areas. At the same time inside both wards there are sectors where the occurrence and quality of some of these aspects greatly differ from each other. For instance, the zones 1, 2 and part of zone 3 in Triangulo and parts of zone 1, 2 and 3 in Mabolo have high levels of development in terms of physical infrastructure, facilities and other services. Other sectors are much less developed and often occupied by the poorest families; with no access even to basic needs, community facilities and support services. In other areas households with different characteristics were found to be mixed i.e. extremely poor families that have constructed their makeshift houses wall to wall to houses belonging to the wealthiest families. All these disparities in the presence, distribution and importance of the socioeconomic factors listed in Table 9.1 somehow determine that, when compared with each other, certain groups of households become more vulnerable than others even if they are exposed to the same flood water depth and duration.

The results of the vulnerability assessment presented herein were meant to address the differences in the existence and spatial distribution of these aspects at ward level. This goal was then achieved by developing a procedure in which the factors identified by the participants in the workshop were firstly organised into a three-level criteria index. Shortly after performing the aforementioned procedure, the households in both communities were grouped into *homogenous units* of families with similar socioeconomic conditions. Finally the distribution of the socioeconomic aspects (listed in Table 9.1) for these groups were determined by means of *indicators* and *categories* and then integrated into the spatial multi-criteria module for the final vulnerability assessment.

9.2.1.1 Creating the Multi-criteria Index

The aspects listed in Table 9.1 were rearranged in a composite index shaped as a 3-level nested model (refer to Figure 3.11). Each aspect was categorised as a main *factor* consisting of *indicators* which in turn are comprised of *categories,* as follows:

- ***Factors*:** identified as economic, social, physical and sanitary circumstances contributing to the intrinsic households' vulnerability. Under this category two aspects that could be considered as external to the family unit (but that in one way or another influence their susceptibility) were included, being them: Reduction of *economic opportunities* (owing to the inundation of areas that are normally used by the households for economic and productive activities such as commercial buildings, business districts, agricultural areas and the road network). The second additional factor was the interruption of *societal and institutional services* related to health, institutional, educational and other facilities considered essential for the community (see Table 9.2).
- ***Indicators:*** series of quantifiable features identified through the analysis in Chapter 8. Indicators were assumed to be constituents of the main factors and as such determine the degree of influence of the factor for the overall flood vulnerability.
- ***Categories:*** the classes in which the indicators were categorised and that specifically belong to the study area. They were identified through the survey and ultimately determine the vulnerability.

Table 9.2 presents a list of the main factors and Indicators constituting the vulnerability Index. A more complete table including categories and values assessed during the spatial multi-criteria analysis is provided as Table 9.4 in sub-section 9.2.1.3.

Table 9.2 Factors and Indicators involved in the spatial assessment of flood Vulnerability

Factor	Indicator
Socioeconomic status	Livelihood
	Income level
	Income Dependency Ratio
	Family Size
Housing	House type
	Land ownership
Facilities	Access to Drinking Water
	Sanitation facilities
Environmental quality of surroundings	Waste disposal
	Presence of stagnated and polluted surface water
Economic opportunities	Topographic elevation of Facilities with economic importance for the community
	Topographic elevation of Road Network
Community Capacities	Topographic elevation of Facilities with social importance for the community

9.2.1.2 Dividing the ward in homogenous units

In order to determine the distribution of the factors, indicators and categories and then be able to assess the flood vulnerability for the community, it was deemed necessary to up-scale the vulnerability analysis from household to ward level. For this purpose it was then assumed that groups of households sharing (to some extent) similar socioeconomic conditions will be equally affected by flooding and will (more or less) carry out similar coping mechanisms against it. Based on this reasoning both wards were then divided into so-called *homogenous units* of households.

Mapping and spatially representing socioeconomic groups and their respective parameters was carried out by means of several participatory tools. As the participatory activities performed though the research evidenced Barangay officers, zone and local leaders have a deep acquaintance about the social and economic circumstances of the people in their wards. Therefore the analysis took advantage of this knowledge and made use of the interpretation of conventional photographs and GIS-based transects in order to carry out the division of homogenous units for every Barangay.

The household-level statistical analysis for socioeconomic and housing conditions performed in this study as well as two of the MSc researches carried out in Naga City (Monroy, 2005 and Reganit, 2005) determined that at household level there is a significant correlation between housing and socioeconomic aspects (refer to Section 8.3.5). As the interviews, workshops and personal contact made clear at family level there is a strong relationship between income level and construction system (see Figure 8.16). Households with better income often built houses in stronger materials. When the source of income increases or improves (for instance by remittances) one of the first investments is on strengthening (upgrading, retrofitting) the house, even if the land is not owned. On the other hand it was also observed that the distribution of these systems within the Barangays is strongly related to development levels. Highly developed elevated areas are inhabited by the well-off while lowest-lying or isolated areas are occupied by the poorest ones.

Figure 9.2 illustrates the results obtained after grouping up households with similar socioeconomic conditions in this case for Triangulo.

Figure 9.2 Homogenous units of households delineated according to their socioeconomic conditions. The photographs illustrate typical examples for Triangulo ward.

A total of thirty-eight units were identified in Barangay Triangulo and fifty-five in Mabolo. Once delineated, each homogeneous unit was coded with a unique identifier. For every polygon the number of families was estimated as well as the percentage of a given attribute according to the indicators and categories was assessed (i.e. the percentage of *labourers, informal workers* in that unit etc.) based on the tacit information managed by the local officers and zone leaders, the survey and the statistical analyses are presented in Chapter 8.

This information was stored in a digital database linked to the household unit that contains a table for each attribute in which the distribution of criteria in percentages-per-polygon can be found (see Table 9.3 for some examples).

Table 9.3 Some examples of the database tables for vulnerability assessment showing the distribution, in percentages-per-category, of the Indicators Income Source, Housing and Facilities for several homogenous units in Barangay Mabolo.

Table (Indicator): Socioeconomic Status

Categories: Occupation and Income level

Name	Perc_Labourers	Perc_Informal	Perc_Formal	Perc_Skil	Perc_Transfer	Perc_Below_Food_	Perc_Below_Pov	Perc_Above_Pove
pol 1	47.1	38.2	5.9	2.9	5.9	58.8	23.5	17.6
pol 2	60.0	40.0	0.0	0.0	0.0	60.0	40.0	0.0
pol 3	66.7	33.3	0.0	0.0	0.0	100.0	0.0	0.0
pol 4	100.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
pol 5	40.0	60.0	0.0	0.0	0.0	40.0	60.0	0.0
pol 6	60.0	40.0	0.0	0.0	0.0	60.0	40.0	0.0
pol 7	37.5	62.5	0.0	0.0	0.0	37.5	62.5	0.0
pol 8	28.6	42.9	14.3	0.0	14.3	14.3	71.4	14.3

Table (Indicator): Housing

Categories: House type and Land Ownership

Name	Perc_H_BCr	Perc_H_SemiCr	Perc_H_LMC1	Perc_H_LMC2	Perc_H_LMC3	Perc_L_Owned	Perc_L_Rented_	Perc_L_Squatted
pol 1	4.1	14.7	1.8	47.1	32.4	70.6	17.6	11.8
pol 2	0.0	0.0	0.0	0.0	100.0	0.0	40.0	60.0
pol 3	0.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0
pol 4	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0
pol 5	0.0	0.0	0.0	100.0	0.0	0.0	60.0	40.0
pol 6	0.0	0.0	0.0	100.0	0.0	0.0	40.0	60.0
pol 7	0.0	62.5	0.0	25.0	12.5	0.0	62.5	37.5
pol 8	57.1	28.6	0.0	14.3	0.0	14.3	71.4	14.3

Table (Indicator): Facilities

Categories: Access to Drinking Water and Sanitary Facilities

Name	Perc_Pr_Faucet	Perc_Shared	Perc_Buy_P	Perc_Public	Perc_Public_pump	Perc_H_WSealed	Perc_H_OpenPit	Perc_H_Shared_	Perc_H_Public_
pol 1	17.6	5.9	26.5	29.4	20.6	40.0	29.4	23.5	0.0
pol 2	0.0	0.0	40.0	0.0	60.0	0.0	60.0	40.0	0.0
pol 3	0.0	0.0	0.0	0.0	100.0	0.0	33.3	66.7	0.0
pol 4	100.0	0.0	0.0	0.0	0.0	0.0	50.0	50.0	0.0
pol 5	0.0	0.0	0.0	100.0	0.0	40.0	20.0	40.0	0.0
pol 6	0.0	0.0	0.0	100.0	0.0	0.0	40.0	60.0	0.0
pol 7	62.5	0.0	37.5	0.0	0.0	0.0	37.5	50.0	0.0
pol 8	71.4	0.0	28.6	0.0	0.0	57.1	0.0	42.9	0.0

This way to collect and store data per homogenous units presents a simple way of visualising the spatial distribution of the categories, indicators and factors derived from Table 9.2. From the sample maps in Figure 9.3 it can be seen how the map on top indicates how for instance in Triangulo *units 22, 9* and *14* more than 80% of the households lack legal deeds necessary for the land that they are occupying. The map on the bottom shows that in Mabolo more than 80 % of the families in those units identified as 39 and 56 have a daily income falling below the threshold for daily food supply.

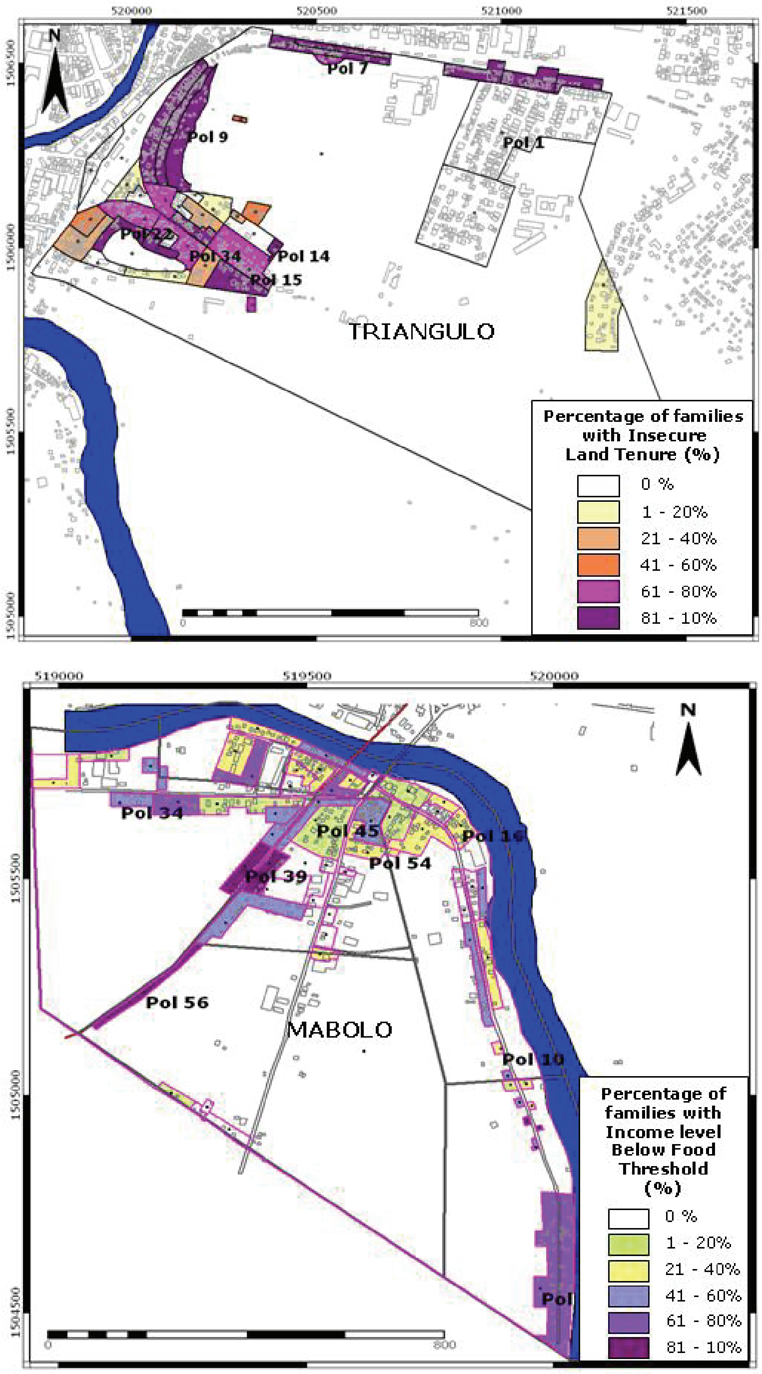


Figure 9.3 Maps of income level below food threshold (top) and insecure land tenure (bottom) illustrate the process of representing vulnerability criteria by homogenous units.

9.2.1.3 Creating the Spatial Multi-Criteria models

The need for implementing a spatial multi-criteria model lies in the need to determine how and in which proportion every category, indicator and factor contributes to the overall flood vulnerability of the households in a given unit. After preparing the data for all the homogenous units the next step was to introduce the data in the form of raster maps and tables so that the criteria could be compared with each other.

According to the procedure for the SMCE, as explained in Section 3.7.4, the 'Goal' of the current analysis was to firstly identify how vulnerable to flood the households in the homogenous units are and secondly to know the spatial distribution of the vulnerable units across the wards. The criteria tree was created by following the structure of factors, indicators and categories listed before, and are fully presented in Table 9.4.

The procedure for characterising, standardising and weighing criteria was performed according to the three levels proposed for this analysis. The first step, determining the negative or positive contribution of the criteria for the goal proposed, was carried out at the <u>Category</u> level. In this case a given class was considered as a 'benefit' when higher values contribute to make the unit more vulnerable to flooding. However, if the criterion decreases the flood vulnerability was considered as a 'cost'. An adequate illustration of this procedure is provided by the analysis of some of the classes in which the *livelihood* and *house type* indicators were separated. In the first case, the categories *'labourers'* and *'informal workers'* were considered as a benefit. As this type of livelihood actually contribute to increase the vulnerability of their families. *Formal, highly skilled workers* and *transferences* categories were then considered as a 'cost' because they decrease the flood vulnerability of the household. Regarding house type, the categories of reinforced brick-concrete (B-Cr) and semi-concrete (Semi-CR) houses were considered as a '*Cost'* as they do not contribute to the household vulnerability. The presence of houses in light materials (LMC1, LMC2 and LMC3) highly contributes to make the households vulnerable and therefore were categorised as '*Benefits'*.

Once the Cost/Benefit character for the categories in the Criteria Tree was established the standardisation process took place. As can be deduced from Table 9.2, the criteria used in this analysis greatly differ in their nature and the way in which they contribute to the flood vulnerability of the household. Therefore the standardisation procedure is necessary if different aspects are going to be compared against each other. The standardisation process in the current vulnerability assessment was carried out at the **Category** level as well, which implied that each individual category was standardised by setting the threshold criteria to 0 (for the units classed as 'not vulnerable') and 1 for the units classed as 'vulnerable'. After this the intermediate values were assigned by means of linear interpolation between the maximum and minimum values. Figure 9.4 shows examples of different 'rules' for standardising the categories 'labourers' and 'reinforced brick-concrete houses'. In the first example, (Graph A) the higher the percentage of 'labourers' in a *homogenous unit* the higher the vulnerability of the unit will be. Owing to the large importance of type of livelihood for the households' standardisation was made using the so-called 'goal' option which allows setting a maximum percentage above which the vulnerability will remain at its maximum.

Table 9.4 Factors, indicators and categories involved in the spatial assessment of flood Vulnerability in Triangulo, with the Weights used at each level and the indication of cost or benefit for each category.

Factor	Indicator	Category	Ch	W
Socioeconomic status (0.37)	Livelihood (0.396)	Labourers (% of unit)	B+	0.48
		Informal workers (% of unit)	B+	0.29
		Formal workers	C-	0.11
		Skilled & highly educated workers	C-	0.04
		Transferences from outside areas	C-	0.07
	Income level (0.396)	Families Below Food Threshold (% unit)	B+	0.61
		Families Below Poverty Threshold	B+	0.28
		Families Above Poverty Threshold	C-	0.11
	Income Dependency Ratio (0.117)	1 to 1 (% of unit)	C-	0.06
		2 or 3 to 1	C-	0.12
		4 to 1	B+	0.26
		5 or more to 1	B+	0.56
	Family size (0.07)	Less than 5 residents (% of unit)	C-	0.06
		6 to 10	B+	0.12
		11 to 15	B+	0.26
		More than 15	B+	0.56
Housing (0.31)	House type (0.55)	Reinforced Brick-Concrete (% of unit)	C-	0.03
		Semi-Concrete	C-	0.06
		Light materials class 1	B+	0.13
		Light materials class 2	B+	0.26
		Light Materials class 3	B+	0.53
	Land ownership (0.45)	Owned (% of unit)	C-	0.06
		Rented-tenancy	B+	0.27
		Squatted, illegal occupation	B+	0.67
Facilities (0.06)	Access to drinking water (0.60)	Private faucet (% of unit)	C-	0.04
		Shared faucet	B+	0.09
		Buy to Private Faucet	B+	0.15
		Public faucet and Pump	B+	0.30
		Public Pump	B+	0.42
	Sanitary facilities (0.40)	Water sealed unit (% of unit)	C-	0.02
		Shared unit	B+	0.17
		Open pit	B+	0.11
		Public toilet	B+	0.12
		Other	B+	0.57
Environmental quality (0.08)	Waste disposal (0.40)	Number of garbage accumulation spots	B+	0.40
	stagnated waters (0.60)	Percentage of the unit perennially occupied by stagnated waters	B+	0.60
Economic opportunities (0.03)	Topographic elevation of facilities with economic importance (0.67)	Commercial activities		0.29
		Transport-related activities		0.21
		Mixed residential-small businesses		0.21
		Agriculture		0.10
				0.05
	Topographic elevation of Road Network (0.33)	Main road		0.62
		Secondary road		0.30
		Pathways		0.09
Community Capacities (0.015)	Topographic elevation of Facilities with social importance for the community	Health services		0.41
		Institutional services		0.20
		Educational services		0.20
		Religious services		0.10
		Areas for recreation		0.04
		Open spaces for institute services		0.04

Ch= Character of Cost (C-) or Benefit (B+); W= Weight

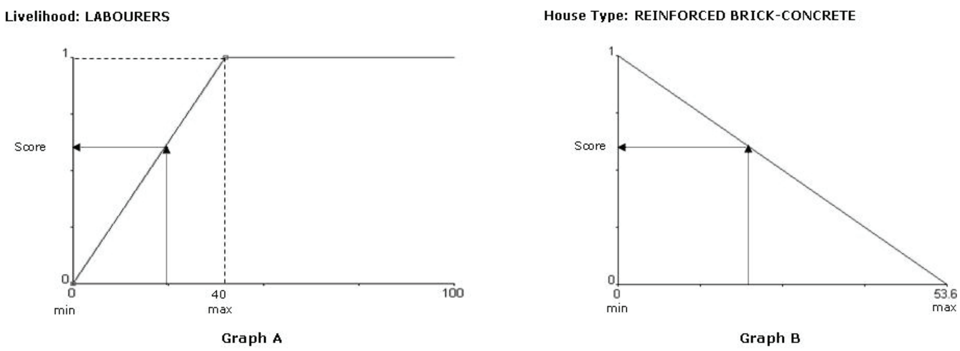


Figure 9.4 Examples of SMCE standardisation functions: 'goal' value rule applied to the 'labourers' category (left) and 'maximum value' for 'brick-concrete houses' (right).

One of the advantages of using the standardisation methods available in the SMCE module of ILWIS is that it allows for the inclusion of expert and local knowledge, for instance when defining the maximum and minimum values for each parameter. In the example of Figure 9.4, the considerations of the participants were that any unit with more than 40% of '*Labourers'* will be considered as highly vulnerable and therefore evaluated as 1. In the second example the application of the 'maximum value' rule was based on the assumptions that more houses in '*Reinforced Brick-Concrete*' will make the polygon less vulnerable. However, as previously explained, this *Category* was considered as a 'cost' for the vulnerability goal and therefore an inverse straight line defines the values between 1 (no presence of Brick-concrete houses and thus vulnerability 1) and the maximum percentage found or vulnerability 0 (see Graph B in Figure 9.4).

After standardising all the Categories the next and final step was the Weighting process which was meant to assign the relative importance for flood vulnerability of the whole set of criteria. This analysis was performed from the minor to the maximum levels of criteria in the model. The starting point was the definition of weights between the categories contained in a given indicator. Afterwards weighting has to be performed between the indicators forming a factor and finally the weighing of the factors themselves. In the SMCE module the process of weighing criteria, within the same group or among groups, is facilitated by several tools such as 'Pairwise Comparison', 'Direct Weight' and 'Rank Ordering' derived from the Analytical Hierarchical Processing (AHP) (ITC, 2005). Regardless of the method being used the sum of weights should always render 1 as the result. It should be highlighted that for most of these tools the comparison among criteria has to be consistently performed as the result should exhibit a consistency ratio below 0.1, otherwise the coherency of the process is considered poor.

Table 9.5 shows one example of the rules used to compare and weigh the categories within the *Livelihood* indicator. The pairwise method was used to determine the relative importance of each occupation type in qualitative terms, in order to establish to what extent a factor is more important than others.

Table 9.5 Example of pairwise comparison method for evaluating the categories of the Livelihood indicator

	Labourers	Informal workers	Formal workers	Highly Skilled	Transferred
Labourers	0	+	++	+++	++
Informal workers	–	0	++	++	++
Formal workers	– –	– –	0	+	+
Highly skilled	– – –	– –	–	0	–
Transferred	– –	– –	–	+	0
Weights	0.477	0.294	0.113	0.043	0.072

++++ = extremely more important
+++ = very strongly more important
++ = strongly more important
+ = moderately more important
0 = equally important
---- = extremely less important
--- = very strongly less important
-- = strongly less important
- = moderately less important

At the end, the comparisons of all pairs of factors were converted by the module into quantitative weights for all factors, with a consistency ratio of 0.09 - which was considered adequate.

Once the weights were assigned at *Category* level the process had to be repeated at an 'upper level', which involved comparing and assigning weights to each of the *Indicators* that comprises a given *Factor*. Once again the method to be applied was selected depending on the relative importance of the different indicators to contribute to the overall flood vulnerability. Table 9.4 already provided the weights assessed to the indicators; yet as an illustration the comparison between the indicators of the Socioeconomic Factors are listed as follows:

- Livelihood is Equally important as Income Level (0)
- Livelihood is moderately more important than Dependency Ratio (+)
- Livelihood is strongly more important than Family Size (++)
- Income Level is moderately more important than Income Dependency Ratio(+)
- Income Level is strongly more important than Family Size (++)
- Income Dependency Ratio is moderately more important than Family Size (+)

The results of these set of comparisons resulted in similar weights assessed to the Livelhood and Income level indicators; as such a comparatively lower value was given to Income Dependency Ratio and the lowest one to Family Size (refer to Table 9.4 for he weights assessed to the whole criteria). The inconsistency ratio was considered as very small (0.01) which indicated that the relationships established were highly coherent.

Figure 9.5 provides an illustration of the results of the entire weighting process for the vulnerability assessment of Triangulo. The criteria tree for Mabolo is provided in Appendix 9.A.

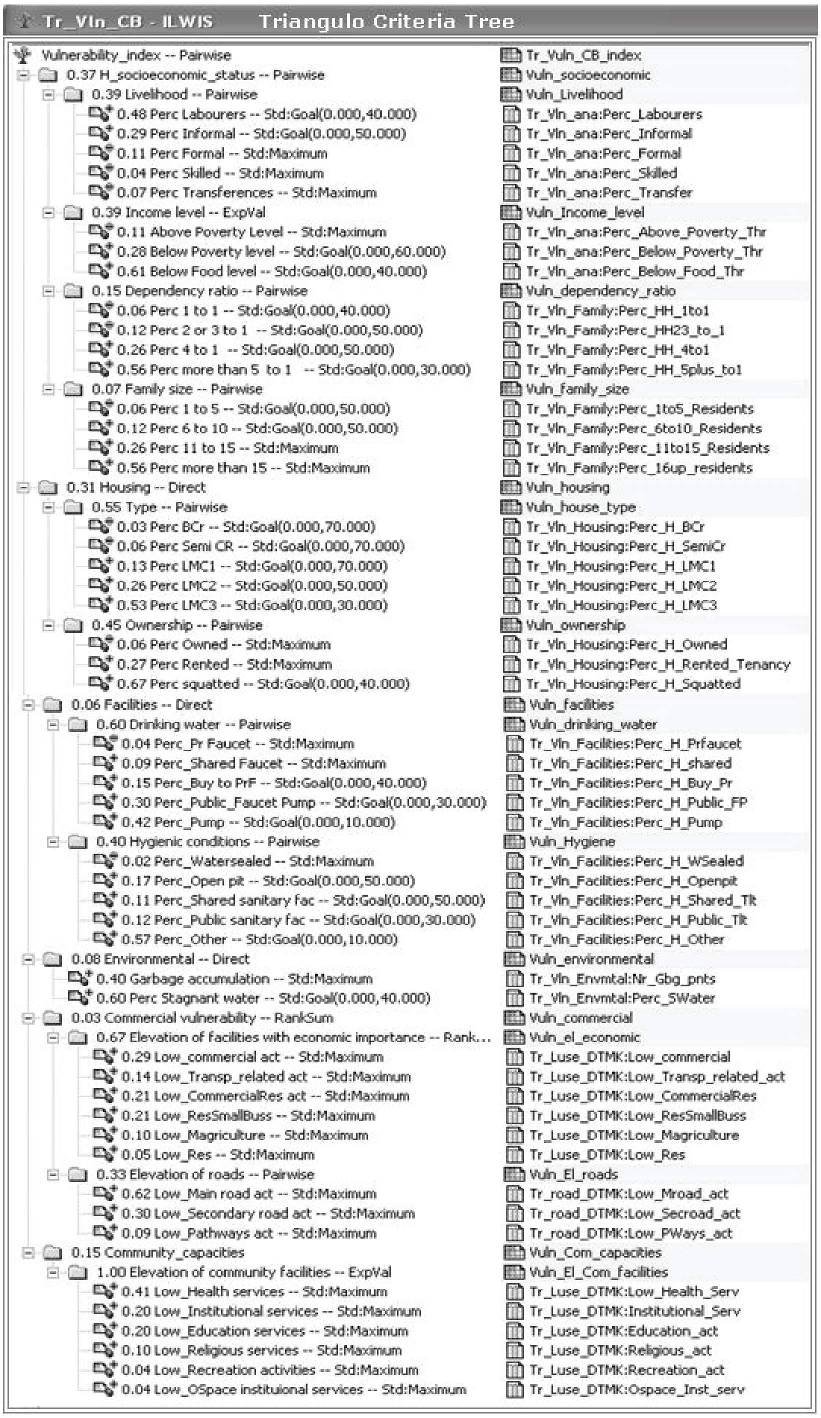


Figure 9.5 Resulting values of the weighing process for Indicators of flood vulnerability in Triangulo

9.2.1.4 Interpreting the results for the Household flood vulnerability

The final step in the Multi-criteria assessment process is related to the categorisation of vulnerability according to the resulting Index Values. Five categories were used to classify the families in the homogenous units ranging from Low to Extremely High Vulnerable as shown in Table 9.6. The boundaries were established based on a weighing up processes between units where the presence of low or high vulnerable households was known through fieldwork. These boundaries were applied to the final composite index map in order to obtain the spatial distribution of vulnerability categories for the households in both Barangays. The result is presented in Figure 9.6.

Table 9.6 Flood vulnerability categories and limits applied to Community and Researcher-based vulnerability indexes

Vulnerability Class	Index Value
Low Vulnerability	0 - 0.3
Moderate Vulnerability	0.31 -0.50
High Vulnerability	0.51 - 0.65
Very High Vulnerability	0.66 - 0.80
Extremely High Vulnerability	0.80 - 1

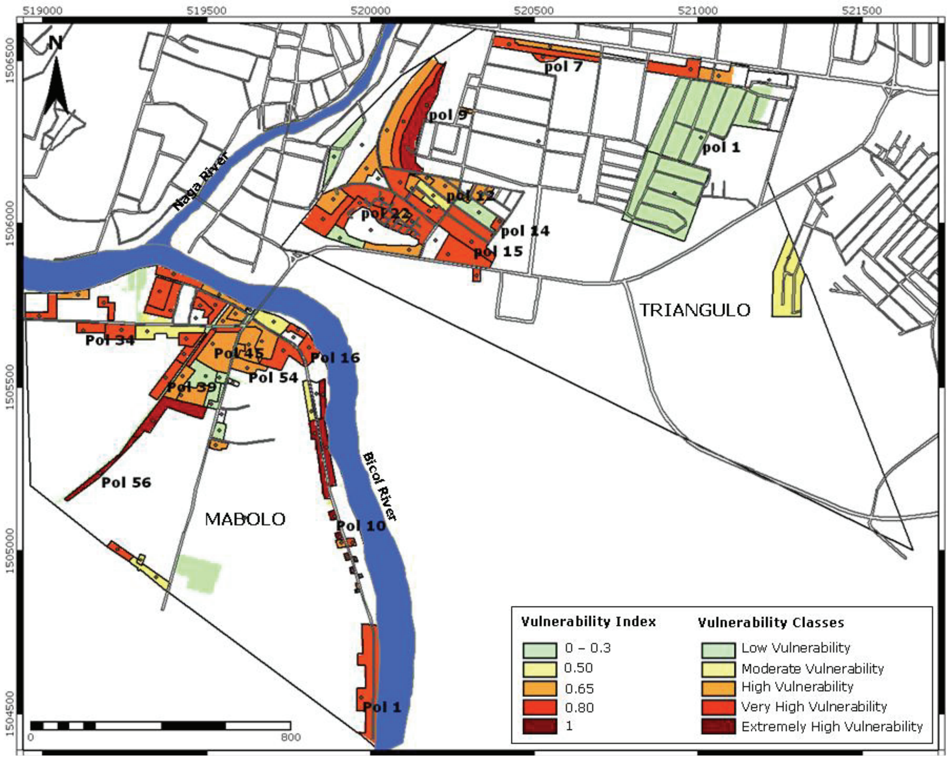


Figure 9.6 Flood Vulnerability assessment for households in residential areas using Community-Based parameters and Spatial Multi-Criteria Evaluation

Units characterised as **Extremely Highly Vulnerable** are populated by extremely poor families with a large family size (minimum of 5 to 6 members), where nearly 50% of them belong to the most vulnerable age groups (infants and elders). Regarding livelihood more than 60% of the households in these units earn daily wages falling below the food threshold. This income is most likely derived from informal jobs that are highly sensitive to bad weather. Housing consists for more than 50% of shanty-like residences in light, friable materials and the family has no access to adequate basic facilities. Finally, these units are located in areas with very poor environmental quality, where the residents are constantly exposed to stagnating waters, waterborne illnesses and overall unhealthy conditions. In Triangulo these High and Extremely High Vulnerable units were found particularly in zones 3, 4, 5 and 6 and some small areas along the train track in zone 7 (see Figure 9.6). The most vulnerable households were those occupying the homogenous unit number 9, located at the back of zone 4. It was found that this assessment highly matches the vulnerability profile drawn by the participants in the second workshop and early presented in Table 8.1 (see Section 8.2).

In Mabolo the homogenous units categorised as Very High and Extremely High Vulnerability represent nearly 75% of the units distributed between zones 2 to 6. In these units more than 80% of the households illegally occupied the railroad (PNR) right of way strip of land or the margins of the Bicol River (see Figure 9.6). The high vulnerability assigned to these units is attributable to similar socioeconomic characteristics of the families in Triangulo. A noticeable difference from the same category units between both Barangays is that in Mabolo the most vulnerable families are those whose livelihood is related to farming activities and agriculture which, as will be explained in the next Section 9.2.2, are highly vulnerable to flooding.

Low and **moderate vulnerable** units are constituted for more than 70% of households living in reinforced Brick-concrete houses with adequate access to basic services and infrastructure. The family size is smaller than in the previous categories (3 to 5 members). In these units the households have adequate income derived from at least two formal and highly-skilled jobs, which provide enough earnings to keep them above the poverty level. Although most of the low vulnerability units are located in the elevated areas, some of them occupy portions of the low-lying areas as well. In these cases it is expected that because of their location these families may have to face some disruption during inundations, yet their socioeconomic conditions made possible to decrease their exposure, prevent losses and therefore decrease their vulnerability to flood (i.e. Polygon 15 and 17 in Triangulo and 36 and 57 in Mabolo).

9.2.2 Assessing vulnerability to non-residential areas

As mentioned herein the map in Figure 9.6 constitutes the spatial output of the vulnerability assessment for the households in residential areas. However, as explained at the beginning of this chapter, the assessment also aims to analyse to what extent the socioeconomic activities taken place in both areas, are susceptible to flooding. The analysis in Section 4.6 and the land use maps for each Barangay presented in Figures 4.14 and 4.17 makes it evident that the two studied areas differ in both the type and presence of economic-oriented activities. Triangulo is more a service-oriented area; there commercial, business and transport-related activities provide opportunities for most of the working power, especially through informal and secondary activities linked to these economic sectors. In Mabolo instead agriculture and their related deeds are still the main source of income for a big share of the families, especially those living in the lowest-lying or more remote areas of the ward (i.e. zone 4 and 5).

For this research the vulnerability to flood of the diverse socioeconomic activities was determined based on their topographic elevation (above the mean sea level) and therefore in their potential disruption as a consequence of floods. In this case the vulnerability index was set ranging from value 0 or 'not vulnerable' (when no disruption of activities or potential damages can be undergone) and 1 or 'totally vulnerable' for instance when the activity completely comes to a halt or total losses can be expected (e.g. crops). The elevation of the different land uses was obtained by crossing the aforementioned land use maps per ward with the digital terrain model for the present situation. Afterwards the vulnerability values were assessed depending on the observed range of altitude. The vulnerability index values (provided in Table 9.7) were derived from open interviews to shop owners and employees, small and medium business, stalls in the bus terminal, small farmers, school teacher, health care assistant, chief priests and Barangay officers.

Table 9.7 Flood Vulnerability values used for socioeconomic activities

	Topographic elevation (m.a.s.l.)				
Land use- activities	**< 1.5 m**	**< 2 m**	**< 2.5 m**	**< 3 m**	**>3 m**
	Vulnerability index				
Commercial-Business	1	0.75	0.6	0.4	0.05
Transport-related activities	1	0.7	0.4	0.25	0
Agriculture	1	1	0.7	0.4	0.1
Marginal Agriculture	1	1	0.7	0.4	0.05
Institutional	1	0.9	0.75	0.5	0.05
Education	1	0.9	0.75	0.5	0.05
Health	1	0.9	0.75	0.5	0.05
Religious	1	1	0.8	0.4	0.1
Recreation	1	0.75	0.6	0.4	0
Open space-Institutional	1	0.75	0.5	0.3	0
Open space-Expansion	0.6	0.5	0.3	0.1	0
Road Network					
Main	0.9	0.75	0.6	0.4	0.1
Secondary	0.9	0.7	0.5	0.2	0
Pathways	0.8	0.6	0.4	0.2	0
Railroad	1	0.7	0.4	0.2	0

In the case of commercial and industrial establishments the vulnerability values are related to the disruption of commercial activities and the losses derived from power failure and stop of commerce because of bad weather conditions. In these cases the direct harm to the structures and buildings was not included because the structures associated to new commercial and industrial developments are raised in elevated areas (up to 3 metres above the sea level). This protective measure determines that during flooding these physical structures do not experience significant damage. In the case of the remaining agricultural activities still observed in Mabolo, they occupy mostly the lowest-lying portions of the area and therefore become easily flooded even by inundations with less than a 2-year return period. These agricultural fields are mostly held by small farmers in a subsistence-type of production. For them flooding represents a double threat: firstly, in the form of direct damage to the crops themselves and secondly, by menacing the economy and staple food provision of the farmers- many of which usually do not have any insurance and access to subsidies from the government.

The vulnerability of activities related to the social wellbeing of these communities such as education, health, religious activities and the like was assessed based on the interruption of these services to the community. Even if the physical structure as such is no damaged these activities are highly susceptible to flooding and therefore suspended when official alerts are issued. On the other hand, the fact those public schools, churches and health care centres may get easily flooded increase people's vulnerability as these places cannot provide physical, social or spiritual refuge to the community.

Regarding the road network, in the study areas the national and regional motorways and train tracks have an elevated construction. Nevertheless it was observed that the flooding of the road network causes the interruption of many small and informal economic activities taking place alongside them (from which a big share of the households derived their livelihood). In these cases the susceptibility was assessed as a result of the interruption of these informal activities as well as the transportation of goods and people rather than direct damage to the structure itself.

9.2.3 Summary of the vulnerability assessment

The map in Figure 9.7 constitutes the spatial output of the vulnerability assessment process for the study area. On it the flood vulnerability of the Homogenous Units of households is presented all together with the vulnerability assessment for other socioeconomic activities and features in both wards.

Data on Tables 9.8 and 9.9 complement the total spatial assessment by providing percentages of each element according to the vulnerability classes established above.

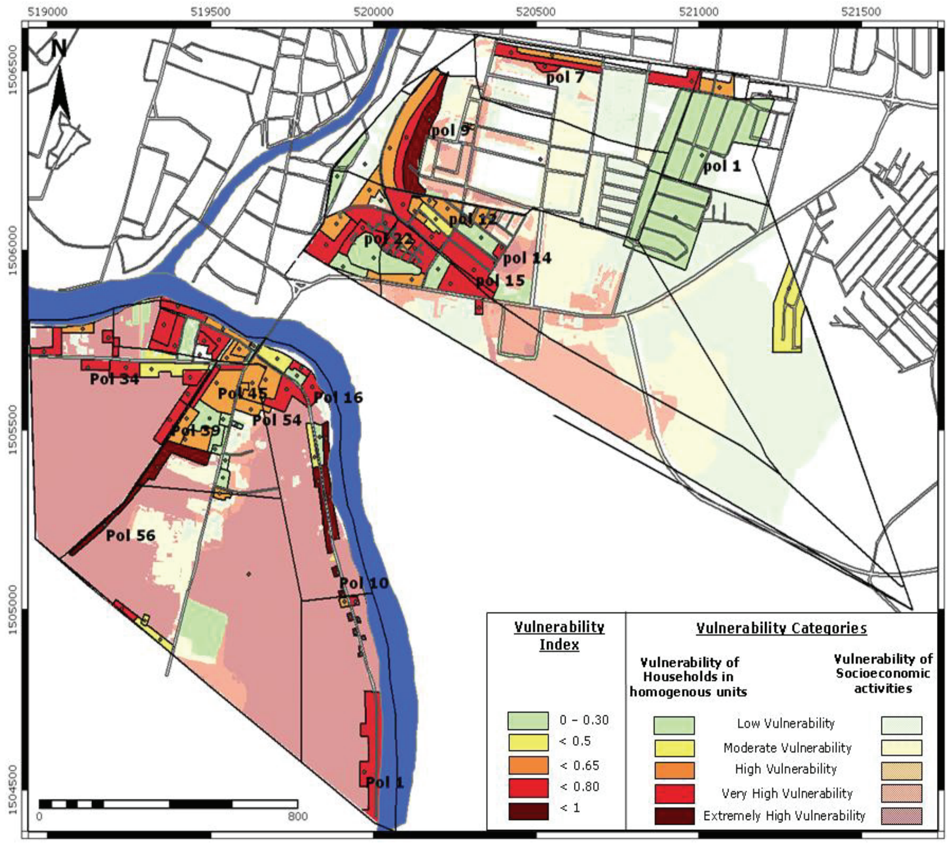


Figure 9.7 Flood Vulnerability assessment for the study area using Community-Based parameters and Spatial Multi-Criteria Evaluation

Regarding the vulnerability to flood assessed to socioeconomic activities and land uses in Triangulo, on one hand it can be observed how nearly 70% of the commercial activities and business sectors (CBD-II) present *None to Very Low Vulnerability*. The same was observed for 80% of the activities related to transport and mobilisation of passengers and cargo. All these trade and commerce establishments have been built on elevated terrain raised up above the level of the 20-year return period flood (2.5 to 3 meters above sea level).

On the other hand, it is noticeable how activities deemed crucial for the community such as education, health and religious services were mostly categorised with *Low to Moderate Vulnerability*, with just small portions classified as *Extremely Vulnerable* (<10% in each case). Yet, in this respect it is important to mention how those tiny areas, located in the low-lying sectors of the wards, correspond to installations where these services are provided to the poorer sectors of the community.

Table 9.8 Total Flood Vulnerability assessment for Triangulo ward

		TRIANGULO					
Feature	**Unit/ Total**	**Vulnerability Category (percentage)**					
		No Vln	**Low Vln**	**Moderate Vln**	**High Vln**	**Very High Vln**	**Extremely High vln**
Households	**No.**						
Family units	1511		20.2	5.6	22	48.2	4
Land use-activities	**Area (ha)**						
Commercial-Business	10.5	30.8	17	20	28.7	3.6	
Transport-related activities	6.3	64.5	25.6	5.6		1.8	2.4
Marginal Agriculture	2.9		34.7	22.5		24.3	18.5
Institutional	0.1		14.7	4.8			80.5
Education	3.4		80.7	5.3		1.9	12.1
Health	2.2		99				1
Religious	0.3		95.2	2.1			2.7
Recreation	0.6		34.1	1.8	3.1	45.3	15.7
Open space-Institutional	1.4		0.6	5		50.9	43.5
Open space-Expansion	85.7	21.6	40.7	24.8	12.9		
Road Network	**Length (km)**						
Main	5.9		30.9	23.5	19.4	17.2	8.9
Secondary	7.4	51.4	16.4	13.1		10.2	8.8
Pathways	1		22.8	18.7	9.7	27.1	21.7
Railroad	0.8		50.5	36.2	13.4		

The percentage of institutional activities classified as *Extremely High Vulnerable* corresponds to the town hall which, as mentioned before, is also settled in one of the sectors highly prone to inundations. Regarding the road network; most of the main and secondary roads categorised as *None, Low* and *Moderate Vulnerable* are found in elevated areas. The percentage corresponding to *High* and *Highly Vulnerable* categories and nearly 60% of the pathways are found in the poorer low-lying sectors of this Barangay.

The data on vulnerability assessment for Mabolo is provided in Table 9.9. Owing to their location in artificially raised areas, in this ward commercial zones and industrial activities display *Low* and *Moderate Vulnerability* to flood for more than 80% of the area occupied. The situation for social activities such as those related to Education, Health care and Religion is similar to the other Barangay, except for the town hall and the main health care centre which share a building located in the more elevated sector of the ward. According to the community the Barangay Hall building has never been flooded. In relation to the street network, some of the Main and Secondary roads were found as *Very High* and *Extremely High Vulnerable* (nearly 50%) corresponding to the lanes that cross the lowest lying areas of the Barangay.

Table 9.9 Total Flood Vulnerability assessment for Mabolo ward

		MABOLO					
Feature	**Unit/ Total**	**Vulnerability Category (percentage)**					
		No Vln	**Low Vln**	**Moderate Vln**	**High Vln**	**Very High Vln**	**Extremely High vln**
Households	**No.**						
Family units	1236		3.4	8.5	18.3	54.9	15
Land use-activities	**Area (ha)**						
Commercial-Industrial	7.9		20.9	60		13	5.7
Agriculture	59.6		0.6	0.8		4.4	94. 2
Marginal Agriculture	3.9		0.6	0.5	0.5	4. 2	94.2
Institutional	0.2		17.8	4.8	3.1	17.8	56.5
Education	1		11.2	3.7			85.1
Healthcare	0.02						100
Institutional-Healthcare	1		56.3	25.7		3.1	15
Religious	0.1		56.6	1.6			41.8
Recreation	0.3			0.7		21	78.4
Open space-Expansion	1.6			68.1		31.9	
Road Network	**Length (km)**						
Main	3		20.6	6.3	21.6	10.1	41.4
Secondary	1.2	9.6	4	17.7		26.8	41.9
Pathways	0.7	27.6	20.7	10.3	41.4		
Railroad	1.03	33.5	40.2	20.5	5.8		

According to the community these roads get easily flooded and damaged each year, hampering not just the transportation and economic activities performed along them but also the mobilisation and evacuation of people during inundations.

9.3 Main findings and discussion

One of the challenges of using community-based approaches for vulnerability analysis is to express this information in spatial terms. Moving beyond the analysis of individual cases to more representative scales, such as the ward level, is one of the difficulties faced by researchers, authorities and other actors, particularly when there are very few data at hand.

The approach proposed in this chapter combines conventional pictures, maps and the knowledge that local officers and leaders have with the spatial capacities of the Multi-Criteria module in GIS ILWIS. This method gave as a result the spatial grouping and characterisation of families in each study area - in what was proposed here as *homogenous units of households*. This method is promising for working at community level as it allowed displaying in spatial terms local information in the form of factors, indicators and categories of aspects that contribute to the households' vulnerability. In this way local and municipal authorities can, for instance, visualise those areas with higher percentages of families with insufficient income to cover their daily food needs and the like. This information exists in a tacit way at Barangay level, therefore being able to present this local knowledge into information that can be used in spatial planning and urban management at the Local Government Unit is one of the main advantages of the method proposed herein.

The Spatial Multi-Criteria Evaluation module for vulnerability assessment was selected because of its versatility in facilitating the introduction of this tacit knowledge as well as people's priorities and perceptions into the analysis. By using these types of tools available in GIS the municipality may allow actors, such as at-risk communities, Barangay authorities and other important actors at the local level to express their views during participatory activities. The methods used by the SMCE module such as Ranking, standardisation using Goal Values and Pairwise comparison are interactive and its logic easy to understand by lay people. Therefore; its use permits the translation of the local actors' perspectives into quantifiable spatial values for flood vulnerability and risk assessment. In addition the module is available in free-access software that is already available in the Electronic Data Processing unit (EDP) of the Municipality in Naga.

Nevertheless, some caution is appropriate at this stage of the research. First, as this has been mentioned earlier in this chapter (section 9.2.1) this method assumes homogeneity within the group of households. The more heterogeneous the group is, the more different ranking exercises are needed and the more complicated the application of the method will be. Moreover, the applied method of collaborative ranking brings besides its merits also the risk that priorities as felt by individuals are getting lost in the negotiation process. Because these issues are beyond the immediate scope of the research, they must be addressed in future research.

Regarding the results of the spatial vulnerability assessment performed, it became clear (a least in spatial terms) the high levels of flood vulnerability existing in the wards. According to the assessment the majority of households, their social and economic activities and many aspects considered important for the daily life of the communities are highly susceptible to the occurrence of flooding. In terms of vulnerability, the results of the multi-criteria assessment corroborate the analysis presented in Chapter 8. In Triangulo, for instance, the division of the ward into homogenous units of households made it possible to determine how, owing to the prevalent socioeconomic conditions, nearly 80% of the family units are susceptible (to some extent) to the negative effects of flooding. Moreover, according to this analysis half of them (52.2%) turn out to be *Highly* and *Extremely High vulnerable* to flooding and typhoons. In contrast, the units categorised as low or moderately vulnerable comprised of just 25% percent of the households in this ward. In Mabolo the situation is even more alarming as, owing to the socioeconomic conditions of the families, nearly 80% of them are *Highly* and *Extremely High vulnerable* to these events.

The study shows that some of the essential services provided to the poorer families by public schools, health care units and churches, are among the most vulnerable in their categories. This type of knowledge cannot be provided by merely spatial or statistical analysis – as being among the people, learning about their concerns and what makes them susceptible is what provided the background for the flood vulnerability assessment presented herein.

Chapter 10: Calculating risk at local level for diverse flood scenarios

The aim of Chapter 10 is to provide a methodology for quantifying and analysing the consequences of inundations at local level. Several flood risk scenarios are used to determine how the losses caused by floods impact the socioeconomic wellbeing of the communities in the two Barangays studied herein. Flood events with different return periods (2, 10 and 20-years) were analysed under varying hydrological, climatic and developmental conditions in order to assess their consequences. Moreover, the increased threats, in terms of losses that poor flood risk management and inadequate urban development models represent for the communities are assessed as well.

10.1 Introduction

Once the vulnerability to flooding and the coping mechanism of a given community have been assessed the following step is to estimate and analyse the potential losses that households can suffer and the implications to their everyday lives. As explained in Section 2.1.2, flood risk analysis looks for estimating the losses and consequences derived, in this case, from the occurrence of flooding and aims at providing the communities and authorities with information on the probabilities, magnitude and significance of the damage to be caused by these events.

The hazard and vulnerability analysis and assessment performed in the previous chapters made clear that the communities in the studied wards are vulnerable, in different degrees, to a diversity of flood types. It became also evident that, owing to the varying socioeconomic conditions, there are groups of poor households for which even small events may become a threat for the social, physical, economic and environmental aspects of their daily life.

The risk analysis carried out in this chapter aims to provide a detailed look, from both a qualitative and quantitative perspective, on the differential consequences that flooding and risk scenarios may have in the wellbeing of the households in the study area. The potential losses inflicted by floods are estimated and analysed on the basis of the 2, 10 and 20-year return period events previously modelled in Chapter 7. From that chapter, the analysis of present and future developmental scenarios are also used to determine how the urbanisation model adopted by the city of Naga is changing the outcome of flood events for the communities settled in these Barangays. The results of the risk analysis are also used to estimate the potential negative effect that more recurrent events may have on the families as result of climate change and global warming. The final aim of this approach for risk assessment is also to provide local and particularly municipal authorities, with contextualised information and tools that help them to anticipate the impact of flooding on their communities; and moreover to design adequate risk management policies and instruments aimed to strengthen the socioeconomic situation of the households in order to avoid disastrous situations in their normal life each time a flooding takes place.

10.2 Significance of flood magnitude and impact at local and household level

The risk assessment performed in this chapter has the household as the basic unit for risk analysis. The analysis takes into consideration some of the implications that inundations have at local ward level particularly in the socioeconomic conditions of certain groups of families.

The impact of extreme events is often adequately represented by the information collected at municipal and even regional level, yet in this research it is assumed that the impact of small, medium, recurrent and seasonal events become evident when this type of analysis is performed at local scale. Floods that may get unnoticed or considered as 'normal' events at higher administrative levels may have serious impact at household unit level with direct, secondary and even tertiary effects affecting the wellbeing of the most disadvantaged families. As result of the workshop on vulnerability and risk some of the repercussions from the occurrence of floods were derived in the form of progressive inquiries; this sequence evidences the evaluation that households perform once flooding or typhoons strike in order to assess the damage undergone and the resources they have to cope and recover. These questions are schematised in Figure 10.1.

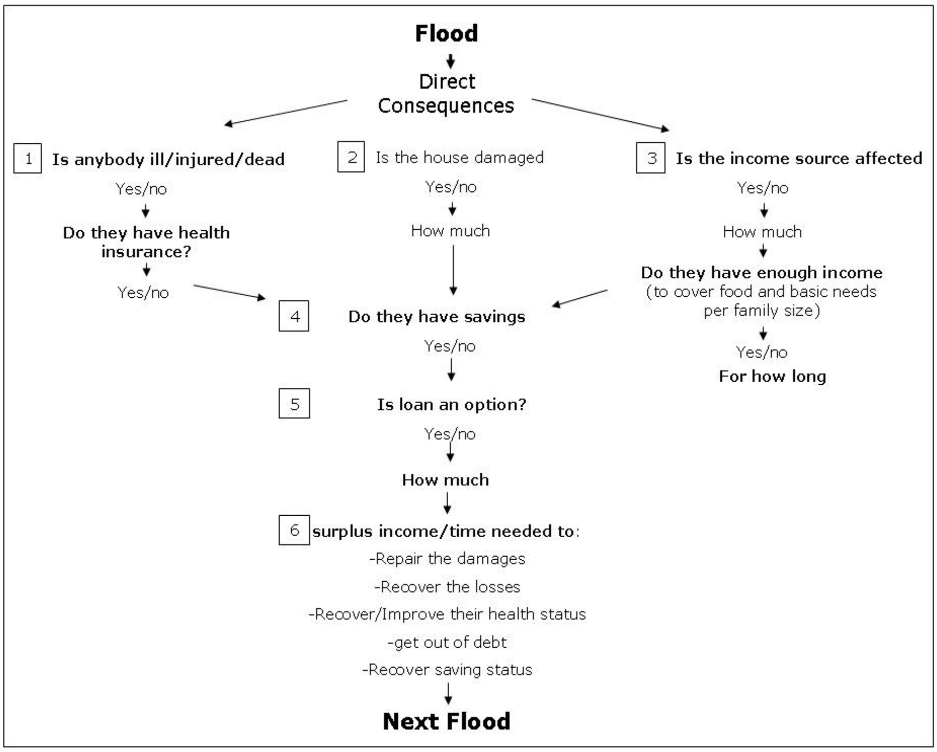


Figure 10.1 Schematic and sequential representation of direct and indirect flood impacts in the households' wellbeing

From the previous hazard and vulnerability analysis it is already evident that part or the overall situation depicted in Figure 10.1 may even take place as a result of non extreme events. Medium and small flooding also has the capacity to face the poorest groups of households with *unmanageable* circumstances. Generally, this is associated to the cumulative effect of by themselves modest incidents. For instance, if as result of flooding one or several family members get injured or sick they will have to spent part of their financial means for medicines or medical treatment (Question 1 from Figure 10.1). If, in addition, their fragile house undergoes minor but important damage (i.e. on the roof) they may need to repair it immediately in order to protect the family from severe weather (Question 2). Moreover, if there is no income of it is reduced for several days the few savings available will have to be spent in covering the basic food needs for each member, especially the children and the ill (Questions 3 and 4). If all these circumstances occur at the same time and the coping mechanism are not enough, the households that were already facing poverty will find themselves facing a *disastrous* situation (Questions 5 and 6); without the time to recover before a new flooding take place.

Nevertheless in the study area the decline in wellbeing is not merely associated to the poorest groups. During fieldwork it was observed that the high recurrence of events affects the well-off families too. The narrative in Box 10.1 shows how families whose income during normal times is enough to satisfy their basic needs and stay above the poverty threshold may be severely affected too. As a consequence these types of households face the risk of disaster. Families with intermediate income level and living in these flood-prone areas may get easily caught in a downward spiral to poverty just because they have to face recurrent events without a proper period to recover between one flood and the next. The association between floods and poverty 'trap' is even better illustrated by this example when it is known that one year later (while they were still recovering form the impact of the 2004 typhoon) Mr R's family had to face a 3-day inundation from Tropical Depression Labuyo (September, 2005) and was hit over again in 2006 by typhoon Mylenio (September, 2006) and a category 5 super-typhoon (Durian) in November.

In order to illustrate the risk derived from the relationship between probability of occurrence of flooding associated with typhoons and their rate of recurrence (return period), some of the storms (which were constantly recalled in the participatory activities) are depicted in Figure 10.2.

It can be observed how in a period of eleven years (from 1995 to 2006) the people in the studied Barangays were affected, at some degree, by at least 7 'noticeable' events; from which two had a return period of 20-years (5% probabilities per year to hit Naga); three events with 10-year return period (10% probabilities per year); one with 5 years return period (20% probabilities per year) and the one with 2-year return period (50-75% probabilities per year). As was already explained in Section 5.4.4, the high recurrence of these events, rather than their overall magnitude, often increases the risk for the people in these wards, particularly for those settled in areas where severe flooding may occur as a result of short return period events (1.5 to 2-years).

Box 10.1 Effect of floods and typhoons on household wellbeing

Ward: Triangulo	**Database identifier**: TZ5P108	**Date:** 23-06- 2005
Zone	5	
Name of interviewee:	Mr L. R.	
Household Members	4	> 65 : none
		13 – 65: 2
		< 13: 2
Livelihood:		
Sources of Income	2	
Main source of income	Train Driver (11000 P monthly)	Husband
Secondary income	Sari sari store (100 P daily)	Wife
Net daily income available	PhP 365 Approximately	Above poverty
Housing		
Materials walls/roof	Semi-Concrete/ Iron sheet	
No. Floors	2 (0 concrete/ 1 light materials)	
Elevation above ground level	0 cm	
Ownership status	Squatter on PNR right of way strip	
Facilities	Private faucet, Water sealed unit	
Hazard Inventory		
Water depth Heavy Rains	Ankle depth (< 20 cm)	Duration: 2 days
WD Unding/Yoyong	Waist Depth (90 cm)	4 days
WD Super-typhoon Rosing	Above chest depth (150 cm)	> 1 week

Narrative of damage after Typhoon Unding/Yoyong (November 2004):

The strong winds accompanying typhoon Yoyong blew away the whole roof of Mr R's house. As a consequence some of the appliances and belongings they had placed on the second floor were damaged by the rain. This was the first time they were so seriously affected by typhoons, in the past they have faced some minor flooding and losses but not as extensive as the one caused by Yoyong. I their words ' the typhoon strike was so sudden and strong we did not have time to evacuate to a safer place; it was dark and we were afraid of getting electrocuted while wading amidst floodwaters or being hit by flying GI sheets from the roofs of other houses ..'. They did not evacuate earlier as the warnings were not clear. Early in the morning PAGASA decreased the alarm level from Level three to Level two and declared the typhoon had left the country, however in the afternoon the typhoon made a loop and caught the community completely unaware and unprepared. Afterwards the family remain in their house, despite the adverse conditions (no roof and rain entering the house).

After the typhoon they recovered the few things that could be saved from the debris. In order to reconstruct the roof and repair the walls of the second floor they used their savings and had to ask for a loan from their relatives. Although it took them more than one month to repair all the damage; during that time they had no other choice than continue living in their house as it was. According to them when this ward is flooded at *knee* depth the water collection system did not operate and hygienic facilities are flooded; therefore the floodwaters get easily contaminated with rubbish and human waste. Because of the exposure to bad weather conditions and polluted waters Mr and Ms R as well as their children were ill (fever and skin diseases). By that time there was no money left so they asked for medicines to the Barangay Health Centre but they had no treatment or medicines for they are not considered as 'indigent households'. In these conditions they have no option but visit herbal healers (herbalist) to treat their ailments.

To be able to adjust to the new situation, pay for the loan and repair/replace the appliances they reduced the food consumption and stop stocking the shop. After one year their opinion is that they feel poorer than before. They cannot afford things that are necessary for their daily life and besides now they have a debt. In addition food and other basic needs become more expensive after floods or typhoons. The money spent on repairs could have been invested in school elements for their children; fulfilling their basic needs or stocking the shop so they can have more income and rapidly improve their current situation.

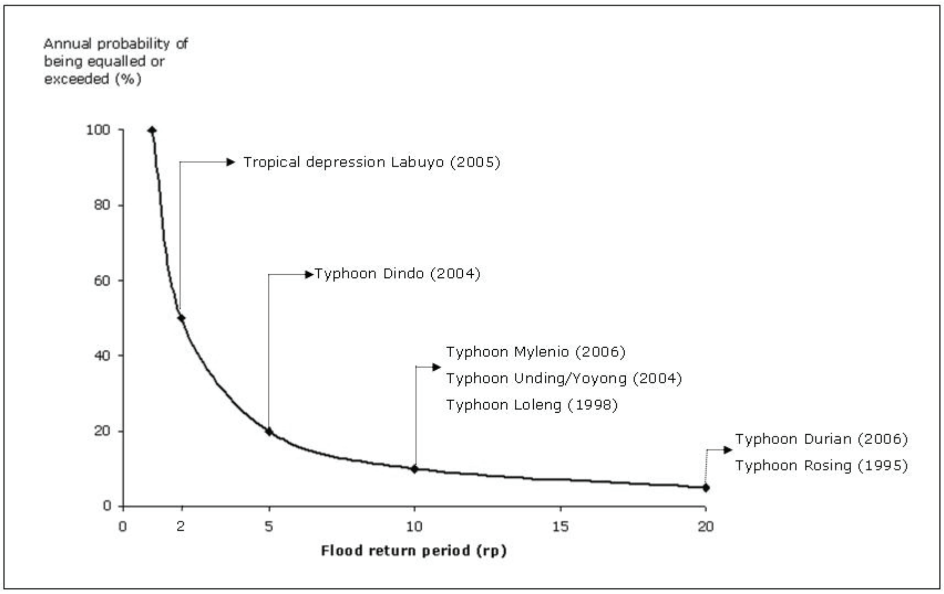


Figure 10.2 Annual probability of occurrence of flooding with different magnitude associated to the occurrence of typhoons

Incorporating some of these elements into risk assessment was deemed essential for this research. The idea behind the risk analysis at the household unit level therefore was to make visible the association between floods and the risk of increasing susceptibility and poverty for the communities in the study area.

The risk assessment proposed in this chapter is composed of two main parts:

- The first part deals with a qualitative approach to the overall risk derived from 3 flood scenarios. Flood hazard maps for a 2, 10 and 20-year return period floods for the *present* topographic and developmental situation are combined with the overall vulnerability assessment in order to determine the spatial distribution of flood risk for the groups of households and socioeconomic activities.
- In the second part elements and outputs from Chapters 5 to 9 are used to develop four risk scenarios. In this case a quantitative assessment of the losses and implications for these communities was derived from the occurrence of a 2, 10 and 20-year return period events for the *present* and *future* topographical, developmental and climatic circumstances.

10.3 Qualitative Flood risk assessment

Authorities, disaster management units and moreover communities in general are interested in knowing the location and circumstances of those families that may potentially face *unmanageable* or *disastrous* circumstances because of inundations.

As explained in Section 2.1.3 *Risk* is expressed by the notation:

Risk = **H** (Hazard) x **V** (Vulnerability)/**C** (Capacity)

If the value of the exposed elements is known, the risk can be expressed in monetary terms and the total damage can be estimated for particular return period flooding. If no information is available risk estimation can still be performed in quantitative terms. This type of assessments are useful in the sense that they can help to determine those areas where deep flooding can affect highly vulnerable communities which in consequence will face high levels of risk.

The initial qualitative risk estimation performed herein made use of the vulnerability assessment for households and other socioeconomic activities obtained as main output of the analysis in Chapter 9. The vulnerability index and maps presented in Table 9.6 and Figure 9.7 were combined with the hazard maps of a 2, 10 and 20-year flooding for the *present* situation presented in Figure 7.16.To be able to come with a final output where all the potential combinations between flood hazard and vulnerability categories are represented the following steps were taken:

1. A consecutive number (from 1 to 15) was assigned to each flood stage characterised by a given combination of water depth and duration as shown in Table 10. 1.

Table 10.1 Ordinal consecutive numbers assigned to each combination of flood depth and duration

Depth/Duration	< 3 days	3- 7 days	> 7 days
0-20	1	2	3
20 -40	**4**	**5**	**6**
40 – 90	7	8	9
90 -130	**10**	**11**	**12**
>130	13	14	15

2. The flood hazard maps were categorised accordingly and then crossed with the vulnerability index and maps. Afterwards the resulting maps were reclassified according to the matrix shown in Table 10.2 which was developed according to the community-based characterisation of flood threats presented before in Section 5.4.3.

Table 10.2 Matrix for Qualitative Flood Risk assessment

Vulnerability Index Value (Table 9.6)	**Flood hazard classes (from Table 10.1)**														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Risk Categories														
0 - 0.3	N	L	L	M	M	M	M	M	M	H	H	H	VH	VH	VH
0.31 -0.50	L	L	M	M	M	M	H	H	H	VH	VH	VH	EH	EH	EH
0.51 - 0.65	L	L	M	M	H	H	H	VH	VH	VH	EH	EH	EH	EH	EH
0.66 - 0.80	L	M	M	H	H	H	VH	VH	EH	EH	EH	EH	EH	EH	EH
0.80 - 1	M	M	M	H	H	VH	VH	EH	EH	EH	EH	EH	EH	EH	EH

N= No risk; L=Low; M=Moderate; H=High; VH=Very High; EH=Extremely High risk

3. Final maps representing the spatial distribution of risk for the households in the residential areas as a result of inundations with a 2, 10 and 20-year return period were obtained as shown in Figure 10.3.
4. Estimates in percentages of the area according to different risk categories (that may be present during every return period flood) were obtained for both areas and compiled in Table 10.3.

Table 10.3 Distribution of flood Risk categories for residential areas and other socioeconomic activities in Triangulo and Mabolo wards

	Triangulo				**Mabolo**			
return period/ Flood risk	**Residential area**		**Socioeconomic activities**		**Residential area**		**Socioeconomic activities**	
	Area (Ha)	Perc (%)	Area (Ha)	Perc (%)	Area (Ha)	Perc (%)	Area (Ha)	Perc (%)
2 year flood								
No risk	11.8	36	57.4	54.7	6.8	31	14.8	21.8
Low risk	4.4	13.4	5	4.9	1.6	7.4	0.1	0.2
Moderate risk	6.7	20.3	17.6	16.8	4.4	19.7	5.8	8.6
High risk	5	15.5	19	18	4.5	20.5	16.8	24.7
Very high risk	4.7	14.3	4.7	4.5	3.5	16.0	29	43
Extremely high risk	0.2	0.7	1.2	1.2	1.2	5.6	1.2	1.8
Total	*32.8*		*104.8*		*22.2*		*67.9*	
10 year flood								
No risk	10.7	32.5	39	37.2	3.2	14.3	1.3	2
Low risk	2.1	6.5	1.4	1.3	0.8	3.7	0.5	0.7
Moderate risk	5	15.4	27.2	26	3.9	17.7	0.6	1
High risk	4.2	13	7.3	7	2.6	11.7	4.4	6.4
Very high risk	4.7	14.3	18	17	4.8	21.7	8	12
Extremely high risk	6	18.4	12	11.5	7	31	53	78
20 year flood								
No risk	8	24.5	28.7	27.4	2	9.6	0.7	1.0
Low risk	1.6	5	0.5	0.5	0.5	2.3	0.1	0.1
Moderate risk	5.5	17	22	21	1.7	7.6	0.2	0.2
High risk	2.7	8.4	16.3	15.6	4	18.7	0.7	1
Very high risk	6	18.2	4	3.8	3.8	17.3	5	7.4
Extremely high risk	9	27.4	33.5	32	10	44.6	61.2	90.2

From the aforementioned procedure it can be proved how elements that were initially regarded as *'low vulnerable'* under certain conditions of hazard, for instance flood classes 6 and 8; may turn out to be at risk as a result of long-term exposure to flooding. Even if denoted in qualitative terms, the risk so expressed may help to determine those areas where certain groups of households would not be able to control the negative circumstances triggered by certain floods. This representation of risk may also facilitate the comparison among zones inside a given ward or even between *Barangays* in order to determine, for instance, in which of them risk management measures will beneficiate a bigger number of households at *very high* and *extremely high risk*.

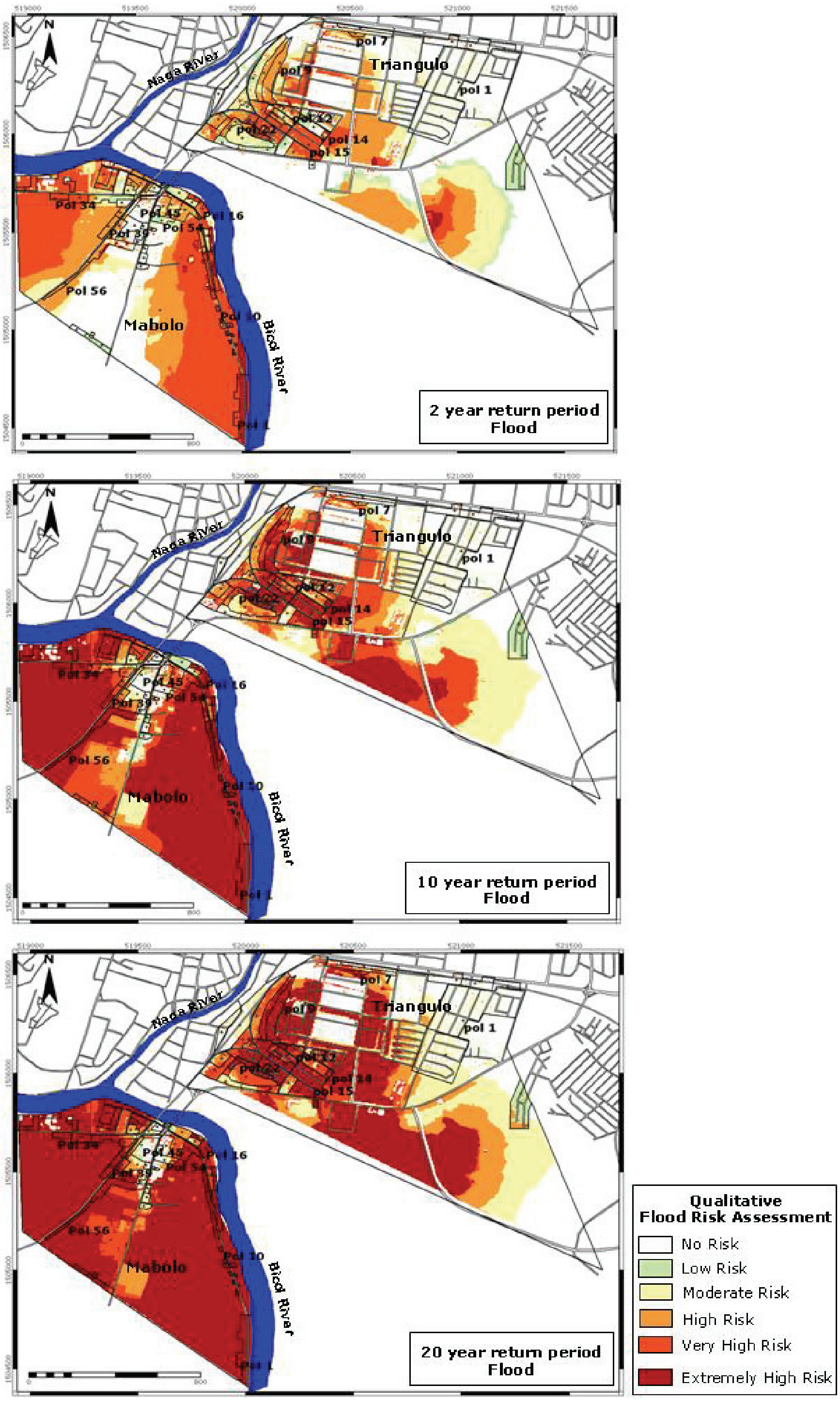


Figure 10.3 Spatial output for the qualitative flood Risk assessment in the study area

The graphs in Figure 10.4 help to illustrate this situation. By comparing the estimates of qualitative flood risk for the residential zones, it can be seen how for all three events (2, 10 and 20-yrp), the percentage of residential areas where the combination of flood threat and household vulnerability may create *high and extremely high risk* circumstances is bigger in Mabolo. It is evident that any risk management plan would need to address this difference between the two studied Barangays. Wards with higher percentages of families facing extremely high risk would require differentiated measures. On one hand they require more support from the municipality and flood-free areas in order to counteract the direct threat to their residents. However, in the long term these Barangays require developmental and risk plans that deal with both the flood hazard and the vulnerability of the households, in order to decrease their high exposure to disaster.

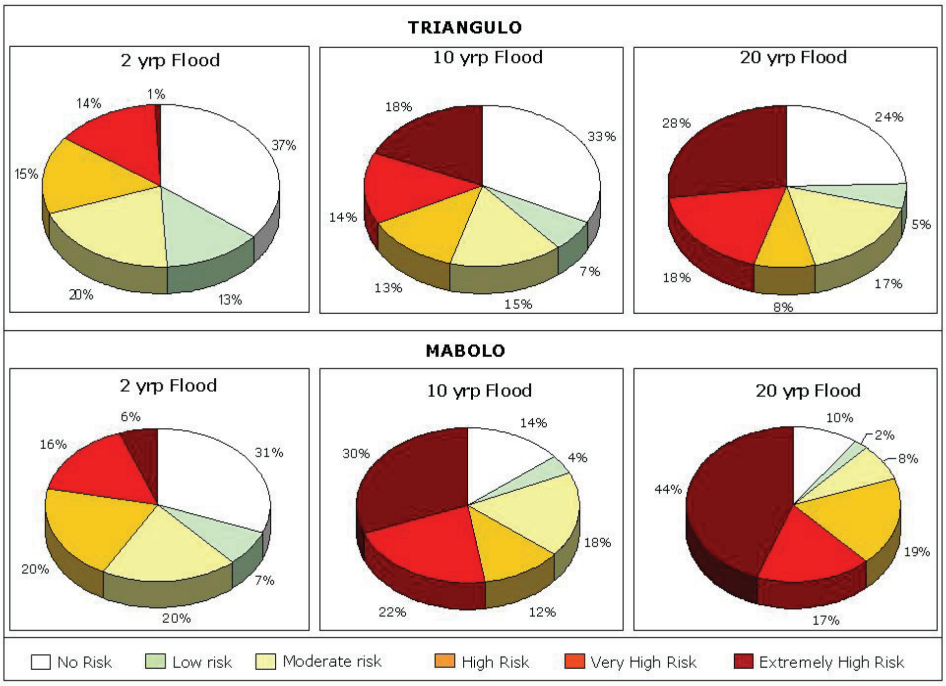


Figure 10.4 Estimates of flood risk for households in residential areas, according to community-based categories.

Nevertheless, it should be mentioned that this qualitative assessment involves a degree of subjectivity. For instance the categorisation of risk presented in Table 10.2 was developed by the researcher based on the knowledge acquired through participatory activities. The categories therefore could be assessed in a different way by another external actor if he/she is not acquainted of the socioeconomic context and the coping and manageability capacities of these communities.

It is evident that risk assessments would be more relevant if accompanied by quantitative information such as the number of families that would face different risk levels, the amount of income lost and their implications for households' wellbeing and the like. If these associations could be estimated and factored into flood risk modelling, and subsequently linked to a range of potential impacts, then planners and authorities would have a additional tool with which to calculate the contributions of risk mitigation programmes and policies such as land use changes, resettlement, retrofitting of houses and the like to specified levels of potential losses; and moreover to estimate the prevention dividends that would accrue from risk management. Being able to generate this type of data out of the elements available was deemed important for this research and became the subject of the quantitative flood risk assessment.

10.4 Quantitative Flood risk assessment approach

The purpose of the quantitative assessment in this chapter is to present several approaches to analyse the consequences of flooding (with particular return periods) at the household level; and express it in monetary or other measurable terms. In the study area aspects such as a fatalistic attitude towards flooding, the scarcity of financial mechanism for risk mitigation at household level (i.e. insurances) or the lack of information and means to access the existing risk management strategies were found. These characteristics determine that most of the damage and disruption derived from flooding has to be assumed by the individual or family affected. Hence, risk assessment needs to take into consideration the impact, in monetary terms that inundations will have on some of the socioeconomic aspects that make up the household's everyday life. This analysis should help to determine if (in the short-term) the family will be able to absorb, recover and even improve their pre-flood status, or on the contrary if it will become poorer, more susceptible and even unable to face subsequent events.

When dealing with quantitative assessments risk is expressed as:

Risk = **H** (Hazard) x **V** ((Vulnerability of the element at risk)*(cost in economic terms))

The risk assessment proposed herein firstly takes into consideration that increasing flood stages (water depth vs. duration) may have different impacts depending on the nature and characteristics of the element under evaluation. Secondly, the same flood stage may embody differential risk levels for the households owing to the socioeconomic diversity found in the studied wards. Thirdly, and finally it is considered that hazard; vulnerability and therefore risk are dynamic aspects in which variation is linked to some of the intrinsic conditions of the households but also to the changing physical, developmental and environmental (climatic) circumstances in the study area.

Regarding the last two aspects, the quantitative assessment evaluates the consequences of flooding in a '*future*' scenario where modifications in the topography for certain areas are included. By introducing these changes in landscape the aim is to simulate the potential risk that these communities will have to face once some of the projected commercial developments take place. Finally, the assessment also evaluates the potential effect that climate change may imply for the studied communities in terms of increased recurrence (more frequent) of floods.

The analysis made use of the approach presented in Table 10.2, but rather than using qualitative risk categories, a quantitative assessment for the expected damage was assessed per category that was comprised within the *livelihood*, *housing* and *facilities* **Indicators** (used in the vulnerability assessment presented in Chapter 9). An overview of the Indicators and categories involved in the assessment is given in Table 10.4.

Table 10.4 Overview of main groups, indicators and categories used for the quantitative risk assessment.

Main group	Indicator	Category
socioeconomic conditions	Number of working days interrupted according to livelihood categories	Labourers
		informal workers and small business
		Formal workers
		Highly skilled workers
		Transferred income
	Amount of daily income lost according to livelihood categories	Labourers
		informal workers and small business
		Formal workers
		Highly skilled & independent workers
		Transferred income
	No. of people having inadequate daily food intake	Income above poverty threshold Income below poverty threshold Income below food threshold
housing conditions	Number of buildings damaged per construction type	Bricks and reinforced concrete
		Semi-Concrete
		Light materials
	No. of people that may have to evacuate	Number of people occupying houses that undergo 50-70 % damage
	No of people that may become homeless	Number of people occupying houses that undergo >70 % damage
sanitary and environmental conditions	No. of people with inadequate access to drinking water	Type of drinking water source used: Private, shared or public faucet, public pumps.
	No. of people exposed to dangerous environmental conditions	Type of sanitary facilities used: Water sealed, shared or public, open pit units or open space disposal of waste.
socioeconomic activities	Percentage (%) of commercial activities affected	Commercial and business activities Marginal agriculture (vegetables) Marginal agriculture (rice)
	Percentage (%) of roads and transport-related activities affected	Main roads Secondary roads Pathways (alleys)
community capacities	Percentage (%) of community capacities and activities affected	Religious services Health services Institutional Educational
	No. of days that services are not available/accessible	

The figures on percentage of losses that a given flood stage may cause and the time (in days) that the activity, asset or service will be interrupted, damaged or out of service were acquired by means of the participatory approaches, particularly interviews, carried out during fieldwork. In this way flood risk could be expressed in monetary terms such as the amount of income that will be lost, the cost of replacement of damaged elements and the like. In several cases an additional period (in days) in which the households would not be able to perform the activity, access services or will endure the consequences of the losses was included (i.e. number of additional days that the main worker would have to stop working).

The consequence analysis performed for the three flood events in the *present* scenario was intended to calculate several risk indicators deemed of significance for the implementation of flood risk management at local and municipal level.

The assessment of flood risk under *future*, recurrent and climate change scenarios includes only the analysis based on the set of indicators related to socioeconomic conditions. The availability of sufficient income at household level guarantees that even during flooding times the basic needs of the family will be fulfilled, the damage that has taken place is going to be repaired and normal life will continue. Therefore this aspect was deemed as a strong indicative of the differential flood risk conditions faced by the households as result of dynamic flood scenarios.

10.5 Risk assessment for the present situation

In this section the consequences of flooding are analysed under the *present* situation referring firstly to the topographic and developmental state in 2005 of the two researched wards. Secondly this period is taken as the baseline for the socioeconomic circumstances of the households in the studied communities. The quantitative risk assessment for the *socioeconomic, housing and sanitary* and *environmental* indicators was carried through several steps, as follows:

1. A matrix that combines floodwater depth, duration and expected damage was developed for each category of the *livelihood*, *housing* and *facilities* indicators listed in
2. Table 10.4Table 10.4. In several cases an <u>additional factor</u> was included in the risk matrix in order to represent the extra time (in days) that the household will experience disruption for example in earning their livelihood or accessing a basic service. Some examples of the matrixes used are provided in and the rest can be seen in Appendix 10.A. The data for estimating the expected damage was derived mostly from the questionnaires used during the GIS-based survey, the open interviews to affected households and focus group discussions (FGD) with ward officers and leaders.
3. The figures obtained from the previous spatial operation were used for calculating the consequences of each flood. In this step the number of households affected was obtained from the percentage of homogenous unit (of households) affected per hazard category as shown in Table 10.6.

Table 10.5 Example of the risk matrixes developed for the 'labourers' (top), 'houses in light materials category 3' (middle) and 'Public faucets' (bottom) categories.

Indicator: **Livelihood**
Category: **LABOURERS**
Average Daily Income: PhP 149.2 (TR); PhP 192.1 (MB)
Expected Damage: decrease in daily income, loss of financial capacity

Depth \ **Duration**		**< 3 days**	**3- 7 days**	**> 7 days**
0 – 20	Expected damage (Percentage %)	10	10	10
	Additional factor*	2	2.5	3
20 -40	ED (%)	30	30	30
	Ad. F	3	3	5
40 – 90	ED (%)	50	50	50
	Ad. F	3	5	5
90 -130	ED (%)	100	100	100
	Ad. F	5	7	10
>130	ED (%)	100	100	100
	Ad. F	7	10	15

Indicator: **Housing Type**
Category: **Houses in Light Materials Category 3 - Dampas (LM-C3)**
Average replacement value: PhP 5000
Expected Damage (ED): Partial to total damage in wooden/organic materials

Depth \ **Duration**		**< 3 days**	**3- 7 days**	**> 7 days**
0 – 20	Expected damage (%)	0	0	0
20 -40	ED (%)	0	2	5
40 – 90	ED (%)	5	20	40
90 -130	ED (%)	50	70	100
>130	ED (%)	100	100	100

Indicator: **Facilities (Source of Drinking water)**
Category: **Public faucet** (piped water)
Expected Damage (ED): No provision of drinking water as Pump station in Mabolo stop functioning, public faucets along streets get flooded, obstruction of pipes

Depth \ **Duration**		**< 3 days**	**3- 7 days**	**> 7 days**
0 – 20	Expected damage (%)	0	0	0
20 -40	ED (%)	0	0	0
40 – 90	ED (%)	70	70	70
	Additional factor**	1	3	3
90 -130	ED (%)	100	100	100
	Ad. F	5	5	5
>130	ED (%)	100	100	100
	Ad. F	7	7	7

*Amount of extra time (in days) that the work is interrupted.
** Amount of extra time (in days) that the service is interrupted.

Table 10.6 Example of the calculations for the consequence analysis for labourers harmed by a 20-year return period flood

Flood Event:	20 years return period flood_*Present* scenario								
Indicator	Livelihood								
Category	Labourers								
Flood stage (Table 10.1)	Nr_Hhlds	Averaged income	Perc_dmg	Income lost per day	Flood duration	Ad.F	Total_days harmed	Total loss per Hhld	Total loss (PhP) Labourers
Hz1	3	149.2	0.1	14.9	2	2	4	60	179
Hz2	1	149.2	0.1	14.9	5	2.5	7.5	112	112
Hz4	8	149.2	0.3	44.8	2	3	5	224	1790
Hz5	1	149.2	0.3	44.8	5	3	8	358	358
Hz7	53	149.2	0.5	74.6	2	5	7	522	27677
Hz8	3	149.2	0.5	74.6	5	5	10	746	2238
Hz10	95	149.2	1	149.2	2	5	7	1044	99218
Hz13	193	149.2	1	149.2	2	7	9	1343	259160
Hz14	9	149.2	1	149.2	5	10	15	2238	20142
Total	366								410874

4. These types of calculations were carried out for each category of the *livelihood*, *housing* and *facilities* indicators as well as for *socioeconomic activities* and *community capacities* aspects for each flood return period. Finally, the data per return period was analysed and aggregated according to the risk indicators mentioned before in order to present consolidate figures per flood scenario.

10.5.1 Risk assessment for socioeconomic conditions

The data from Tables 10.7 and 10.8 help to illustrate the use of the proposed approach for analysing the risk derived from the interruption of livelihood and loss of income.

Table 10.7 Example of the risk analysis for the 'labourers' category of the livelihood indicator performed for three flood events

Flood Risk Analysis for Labourers in Triangulo			
Return Period	**2 years**	**10 years**	**20 years**
Total No Labourers affected	347	352	366
No. Families with daily income reduced up to 30%	116	39	14
No. Families with daily income reduced up to 50%	172	135	70
Families with (temporarily) no income (100%).	112	217	297
No Families (temporarily) below the food threshold	347	352	366
No People with (temporarily) inadequate daily food intake.	2,428	2,464	2,562
Total Income not received (PhP).	16,0712	350,290	410,870
Average Income loss per Labourer (PhP).	463	995	1,122
Equivalence of lost income in working days per labourer.	3	6	7.5

Table 10.8 Example of the risk analysis for the Highly Skilled workers category of the Livelihood Indicator performed for 3 flood events

Flood Risk Analysis for Highly Skilled workers in Triangulo			
	Return Period		
	2 years	**10 years**	**20 years**
Total No. of Skilled workers that are affected.	18	38	366
No Families with daily income reduced up to 10%	18	23	13
No Families with daily income reduced up to 30%	0	38	70
Families with (temporarily) no income (100%).	0	0	297
No Families (temporarily) below the food threshold	0	0	366
No People (temporarily) with inadequate daily food intake.	0	0	2562
Total Income not perceived (PhP).	4,594	10,705	19,851
Average Income loss per Skilled worker (PhP).	251	281	308
Equivalence of lost income in working days per Skilled worker.	0.53	0.6	0.65

These separate calculations 'per-category' allowed to substantiate the impact that flooding may cause on individual families. Furthermore they also helped to compare the different significance of these events on the households' wellbeing depending on their socioeconomic characteristics.

The graphs in Figure 10.5 were constructed based on the data for the risk of income loss in Triangulo. From them it can be seen how *labourers* and particularly *informal* workers are the ones which will have the highest average losses in terms of income not earned as a result of the occurrence of the three flood scenarios (Graph A). When those losses are expressed in terms of working days (Graph B) the '*Labourers'* are the category most at risk as the average losses for the 10-year return period flood are equivalent to one week salary (7 days). In the case of '*Formal'* and '*Skilled*' workers the losses are much less and represent less working time (hours) as well. The *Remittances* category was not included in this analysis as it was observed that they are not affected by flooding. Rather the money sent from abroad is increased in order to help the family to cope with the situation.

The data on income losses showed other implications, in terms of risk, for the households. It was found that because of these losses many families whose income during '*normal'* times is enough to keep them above the *food* and *poverty thresholds* may experience situations were it becomes insufficient to cover their basic needs. These households therefore may experience a temporal decrease in their socioeconomic status with the negative consequences derived of it. From the average income found for the livelihood categories and displayed in Table 8.4 (Section 8.3.3) it can be seen how labourers in Mabolo manage to keep their daily wages slightly above the food threshold. Nevertheless, these families will find themselves without the income required for supplying adequate food intake to all their members even if 'minimal' losses (i.e.10%) are experienced.

In the case of Triangulo it was observed that even during normal times the income of these workers is lower than the food threshold. Hence any additional reduction will put these households at risk of starvation. *Informal*

Workers in both wards face a similar situation. In the case of *Formal* or *Skilled* workers the risk is that even they may fall below the poverty threshold which means that some of their basic and non-basic needs may not get adequately covered.

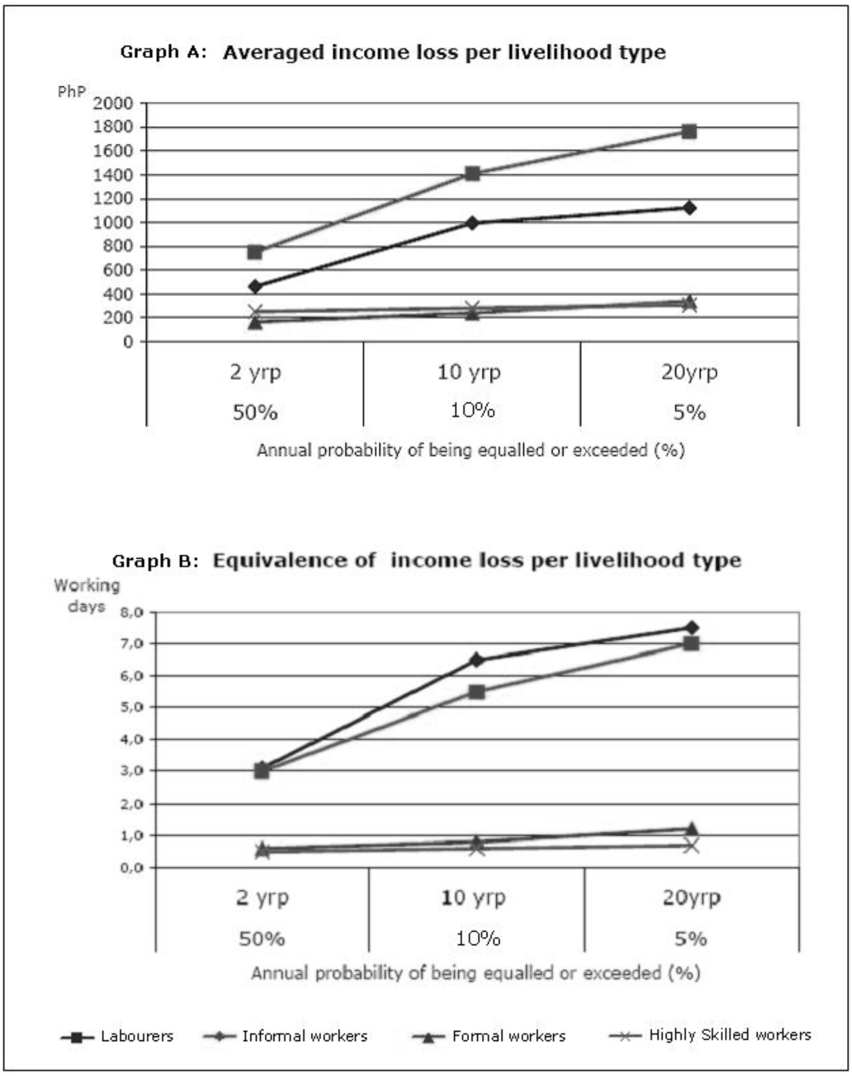


Figure 10.5 Income loss risk per livelihood for floods with 2, 10 and 20-year return period (Triangulo)

The series of maps in Figure 10.6 illustrate the risk of increasing poverty that households may face as a consequence of loss of income during floods of different magnitude and recurrence.

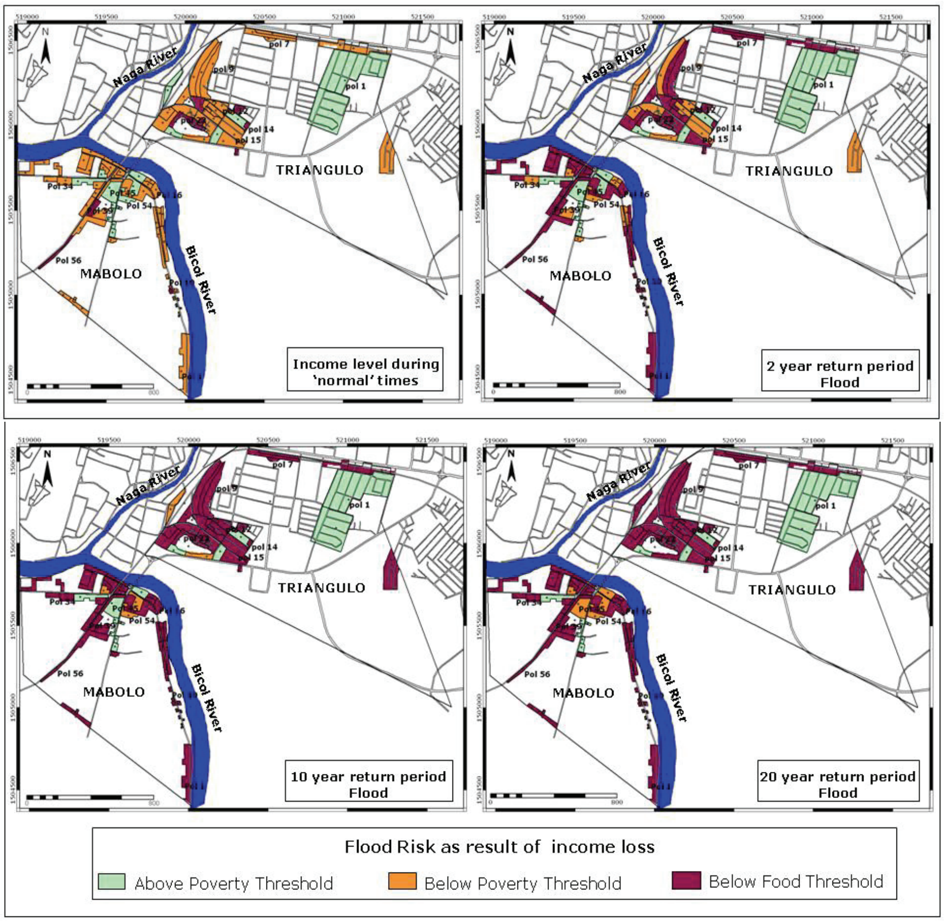


Figure 10.6 spatial representation of the flood risk for the households in the study area as a result of loss of income.

These maps were obtained after averaging the daily wages per homogenous unit of households (income level during '*normal*' times) in each ward and then calculating the percentage corresponding to the average income losses per livelihood type and flood scenario as shown in Table 10.9.

Table 10.9 Average income losses per livelihood type for 2, 10 and 20 yrp floods

Return Period	**Livelihood average income losses (percentage)**			
	Triangulo		**Mabolo**	
	Labourers and Informal workers	Formal and highly skilled workers	Labourers and Informal workers	Formal and highly skilled workers
2 years	20%	5%	25%	5%
10 years	30%	8%	35%	10%
20 years	51%	12%	55%	15%

The top left map (income available during '*normal*' times) shows that several groups of households may be driven from poverty to marginalisation as a consequence of the losses experienced even during a small event (i.e. a 2-yrp flood). Families with adequate income may also become poorer and temporarily fall below the *Poverty Threshold* as a result of 'extreme' events (see the bottom right map in Figure 10.6). A reduction of 10 to 20% in daily income may put the families of *labourers* and *informal workers* in harms way by making them face *unmanageable* and possibly *disastrous* circumstances. For formal workers the losses may represent a *highly disturbing* situation which requires financial coping strategies in order to avoid permanently falling below the *Poverty* line. Highly Skilled workers may find these levels as *manageable* or even *normal* depending on the situation at hand.

The data for the risk analysis for the socioeconomic conditions of the households in the studied wards is complied in Table 10.10.

Table 10.10 Risk analysis for the socioeconomic conditions of the households in the present scenario

Return period/Flood risk indicators	**TRIANGULO**		**MABOLO**	
	Households (No)	Perc (%)	Households (No)	Perc (%)
2 year flood				
Number of Households below the food threshold as a result of income losses.	554	37%	709	58%
Number of Households below the poverty threshold as a result of income losses.	168	11%	140	11
Total number of families with income affected	**722**	48%	**849**	69%
Total number of people with inadequate coverage of food needs.	3,878	37%	4,963	58%
Total number of people with inadequate coverage of basic needs.	5,054	48%	5,943	69%
Total amount of income loss in PhP.	**530,636**		**703,103**	
10 year flood				
Number of Households below the food threshold as a result of income losses.	797	53%	834	68%
Number of Households below the poverty threshold as a result of income losses.	179	12%	133	11%
Total number of families with income affected	**976**	65%	**967**	79%
Total number of people with inadequate coverage of food needs.	5,579	53%	5,838	68%
Total number of people with inadequate coverage of basic needs.	6,832	65%	6,769	79%
Total amount of income loss in PhP.	**1,022,147**		**1,296,857**	
20 year flood				
Number of Households below the food threshold as a result of income losses.	845	56%	856	70%
Number of Households below the poverty threshold as a result of income losses.	239	15%	171	14%
Total number of families with income affected	**1,084**	71%	**1,027**	84%
Total number of people with inadequate coverage of food needs.	5,915	56%	5,992	70%
Total number of people with inadequate coverage of basic needs.	7,588	71%	7,189	84%
Total amount of income loss in PhP.	**1,375,240**		**1,619,869**	

Analysing the data presented in the tables it is evident that in any case the number of families affected and the income losses under any flood scenario is greater for Mabolo where for more than half of the population the socioeconomic conditions are disrupted nearly every time that flooding takes place. This data also corroborates the panorama depicted in Figure 10.6 where the homogenous units of households helped to substantiate in spatial terms the risk of poverty and marginalisation derived from the occurrence of different flood scenarios.

10.5.2 Risk assessment for housing conditions

Regarding housing, the consequence analysis was focused on determining the damage derived from the occurrence of floods but moreover on assessing the risk that families in the study area may become temporary, and even permanently, homeless.

In order to calculate the amount of damage and economic losses for the *housing* indicator a procedure similar to the one used for the socioeconomic condition was followed. As aforementioned risk matrixes were derived for each of the construction types found in both wards (described in Section 8.3.5) which estimate the expected damage to be caused by the combination of water depth and duration during floods with the return periods used herein (see Table 10.11). The average value per housing type was obtained from a focus group discussion on this issue; data on replacement cost of buildings was collected during the GIS-based survey from the households that were affected by Typhoon Unding-Yoyong in 2004.

Table 10.11 Example of the consequence analysis for the 'houses in light materials - Category 3' harmed by a 10-year return period flood in Mabolo

Flood Event:	10 yrp flood_Present Scenario				
Indicator	Housing				
Category	Houses in Light materials Category 3 - LMC3				
Flood stage (Table 10.1)	Nr_LMC3	Perc_dmg	Replacement value	Total Value to replace per Hhld	Total loss_LMC3
Hz1	0	0	5000	0	0
Hz2	1	0	5000	0	0
Hz4	6	0	5000	0	0
Hz5	10	0.02	5000	100	1000
Hz7	70	0.1	5000	500	35000
Hz8	36	0.2	5000	1000	36000
Hz10	53	0.5	5000	2500	132500
Hz13	150	1	5000	5000	750000
Hz14	28	1	5000	5000	140000
Total	354.0				1094500

From these calculations the type of data presented in Table 10.12 was obtained for the five building categories outlined in the study area.

Table 10.12 Example of the housing risk analysis for houses in the 'light materials category 3 – LMC3' category for 3 flood events

Flood Risk Analysis for Hoses in Light Materials Category 3 in Mabolo			
	Return Period		
	2 years	**10 years**	**20 years**
Total Number of affected houses built with light materials category 3 (LMC3) affected.	230	345	357
Number of houses damaged up to 20%	182	116	23
Number of houses damaged up to 50%	193	169	63
Number of houses totally damaged (> 70%).	0	178	286
Total cost of replacement (PhP).	260,400	1,094,500	1,541,400
Average cost of replacement per household.	1,132	3,092	4,417
Equivalency in working days (minimum wage in PhP).	4	11	16
Number of families that may have to evacuate (above 50% damage).	48	231	326
Number of people that may have to evacuate (above 50% damage).	336	1617	2,282
Number of people totally homelessness (above 70% damage).	0	1246	2,002

The thresholds of the degree of damage at which houses are considered as unsafe and their residents start considering themselves as homelessness were derived from a focus group discussion. Local officers, volunteers of the disaster management brigade in the ward and heads of households agreed that, particularly for houses in light materials, around 50% of damage is the limit at which this type of residences are not considered a 'safe' refuge for the family anymore. With half of the house damaged the residents are almost completely exposed, susceptible to the adverse weather conditions and in need of protection provided by safer buildings and evacuation centres.

The data in Table 10.13 represents the consequence and risk analysis derived from damage to the housing components as result of the 2, 10 and 20-year inundations.

The separated per-category analysis revealed that houses in weak, light materials are the ones that under any flood scenario undergo severe damage and even total loss. Most of the times the whole house has to be replaced as the organic and wooden materials that constitute their structural components often get mouldy and start to crumble after prolonged contact with floodwaters. Houses built with stronger materials such as reinforced brick-concrete do not experience major structural damage as the velocity and strength of the floodwaters is not a significant feature of floods in the study area, particularly in Triangulo. Moulds, dirt and damage to the wooden components (i.e. doors, windows and floors) represent most of the damage for these types of buildings which on the other hand does not compromise the safety of the household. Furthermore, concrete houses are often used as refuge by other family members or neighbours living in unsafe houses. According to the people in the communities the circumstance where people cannot remain in concrete houses was just observed during typhoon Rosing

(1995) when the duration of the flooding (more than three weeks) put people at risk of disease and infections.

Table 10.13 Risk analysis for the housing and safety conditions of the households in the study area as result of the 2, 10 and 20 yrp floods

	TRIANGULO		**MABOLO**	
Return period/Flood risk indicators				
	Households (No)	Perc (%)	Households (No)	Perc (%)
2 year flood				
No. of affected houses built with light materials affected.	415	28%	419	34%
No. of affected houses built with concrete and semi-concrete.	92	6%	76	6%
Number of houses totally damaged.	0	0%	0	0%
No families that may have to evacuate (above 50% damage)	19	1.3%	87	7%
No people that may have to evacuate (above 50% damage).	133	1.3%	609	7%
No people totally homelessness (above 70% damage).	0	0%	0	0%
Total Number of people affected.	3,549	34%	3,465	40%
Total cost of replacement (PhP).	**706,110**		**1,037,100**	
10 year flood				
No. of affected houses built with light materials affected.	668	45%	625	51%
No. of affected houses built with concrete and semi-concrete.	185	12%	275	22%
Number of houses totally damaged.	143	10%	366	30%
No. families that may have to evacuate (above 50% damage).	434	30%	532	43%
No. people that may have to evacuate (above 50% damage)	3,038	30%	3,725	43%
No. people totally homelessness (above 70% damage)	1,000	10%	2,562	30%
Total Number of people affected	5,971	57%	6,300	73%
Total cost of replacement (PhP)	**3,107,160**		**4,136,000**	
20 year flood				
No. of affected houses built with light materials affected.	763	51%	732	60%
No. of affected houses built with concrete and semi-concrete.	244	16%	331	27%
Number of houses totally damaged.	393	26%	563	46%
No. families that may have to evacuate (above 50% damage).	620	41%	800	65%
No. people that may have to evacuate (above 50% damage)	4,340	41%	5,600	65%
No. people totally homelessness (above 70% damage).	2,751	26%	3,940	46%
Total Number of people affected.	7,049	67%	7,441	86%
Total cost of replacement (PhP).	**5,094,560**		**6,056,400**	

In general terms it can be seen how, owing to its proximity to the Bicol river, the figures obtained for Mabolo are higher for all scenarios even though the families in this ward (approximately 1,200) are less than those in Triangulo (around 1,500) as shown in Figure 10.7.

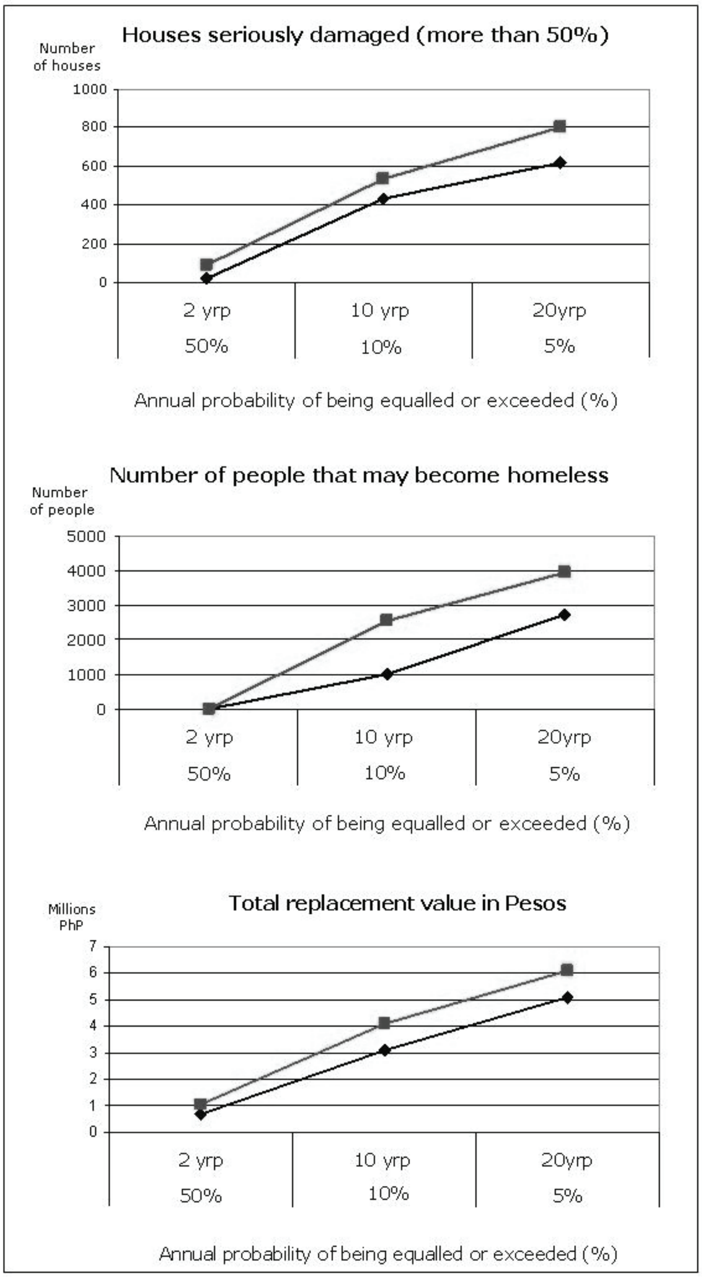


Figure 10.7 Housing risk for floods with 2, 10 and 20-year return period in the study area

Regarding the risk of becoming temporarily, or totally homeless, as result of housing damage it can be observed how for the 2-year flood event no houses are estimated as totally destroyed. Yet there is a possibility that in response to unsafe shelter conditions a fraction of families may have to evacuate, particularly in Mabolo (7%). During fieldwork, a preventive evacuation for a similar event was observed, however as most of the movement took place internally within the community (to neighbours or relatives living in stronger houses) it remained unnoticed at municipal level.

The havoc created by more severe inundations will probably be of concern at ward and the City level as in the 10-year event nearly one third of the population in Mabolo and 10% in Triangulo will have to seek refuge in safer buildings. In this scenario it was estimated that on average 20% of the houses will be totally damaged. Finally, the 20-year flood is estimated to wipe out 26% of houses in Triangulo and 45% in Mabolo. The risk of becoming homelessness will affect nearly 3000 people in Triangulo and 4000 in Mabolo from which at least 50% are expected to be children and elders.

10.5.3 Risk assessment for sanitary and environmental conditions

In this case, rather than expressing damage in economic terms, the health risk resulting from the lack or inadequate provision of drinking water was evaluated as well as the risk derived from the unhealthy conditions created by the lack of appropriate access to hygienic facilities.

The matrixes created were applied to the different sources of drinking water and sanitary facilities found in the studied areas and analysed in Section 8.3.7. Regarding the access to drinking water the percentage of damage is associated with a disruption in the service as shown in Table 10.5 (and Appendix 10 A).

A frequent occurrence during flooding is the obstruction of the pipes, flooding of faucets and pumps and suspension of the service as the main pumping station in Mabolo is flooded as well. Here, the additional factor was again incorporated, representing the days after the inundation that the service and facilities would remain unavailable. To be able to express this unavailability of the service in economic terms (so that the risk could be quantified) the daily value paid for the provision of the service by the household was multiplied by the number of days that it will remain disrupted as consequence of flooded infrastructure. These values were multiplied by the number of households and type of service used in the homogenous unit.

The risk assessment for this component is presented in Table 10.14.

According to the data in Table 10.14, a 10-year flood may expose 56% of the people in Triangulo and nearly 70% in Mabolo to this type of risk. A 20-year scenario will create such conditions for most of the population occupying the lowest lying sectors of the two areas which represent 65% and 75% in Triangulo and Mabolo respectively.

Table 10.14 Risk analysis for facilities and sanitary conditions of the households in the study area as result of the 2, 10 and 20 yrp floods

	TRIANGULO		**MABOLO**	
Return period/Flood risk indicators				
	Households (No.)	Perc (%)	Households (No.)	Perc (%)
2 year flood				
Number of households with access to private or shared facilities totally or partially disrupted.	134	9%	70	5%
Number of households with access to public facilities totally or partially disrupted.	315	21%	242	18%
Total number of people with access to drinking water totally or partially disrupted.	3,143	30%	2,184	24%
Total number of people at risk due to partial or total disruption of sanitation facilities.	4,781	46%	4,697	51%
Average number of days with services totally or partially disrupted.	5		7	
Total cost of services not provided (PhP).	**17,960**		**17,472**	
10 year flood				
Number of households with access to private or shared facilities totally or partially disrupted.	322	21%	250	19%
Number of households with access to public facilities totally or partially disrupted.	462	31%	314	24%
Total number of people with access to drinking water totally or partially disrupted.	5,488	52%	3,948	43%
Total number of people at risk due to partial or total disruption of sanitation facilities.	5,922	56%	6,350	69%
Average number of days with services totally or partially disrupted.	12		14	
Total cost of services not provided (PhP).	**141,840**		**54,144**	
20 year flood				
Number of households with access to private or shared facilities totally or partially disrupted.	422	28%	357	27%
Number of households with access to public facilities totally or partially disrupted.	500	33%	256	19%
Total number of people with access to drinking water totally or partially disrupted.	6,433	61%	4,291	46%
Total number of people at risk due to partial or total disruption of sanitation facilities.	6,430	61%	6,832	74%
Average number of days with services totally or partially disrupted.	25		28	
Total cost of services not provided (PhP).	**304,416**		**102,984**	

The inadequate functioning of these two critical facilities may put the health and physical wellbeing of the people in these communities at serious risk (see Figure 10.8).

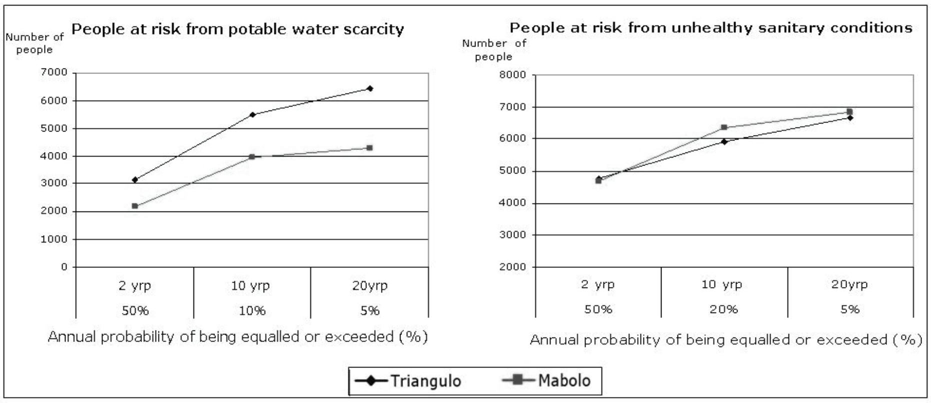


Figure 10.8 Risk derived from total or partial disruption of facilities by floods with 2, 10 and 20-year return period in the study area.

10.5.4 Combined risk evaluation

A combined analysis of the aforementioned three indicators: Income losses, housing and sanitary and environmental conditions help to understand the perception that people in these wards have on the risk that floods embody for their daily life. By complementing the community's perspective on flood threat (as explained in Section 5.4.3) with the damage assessment performed herein it becomes evident that the water depth, duration and the damage caused define the flood risk for these communities.

The graph in Figure 10.9 was developed as the risk component of the community's perception of flood threat.

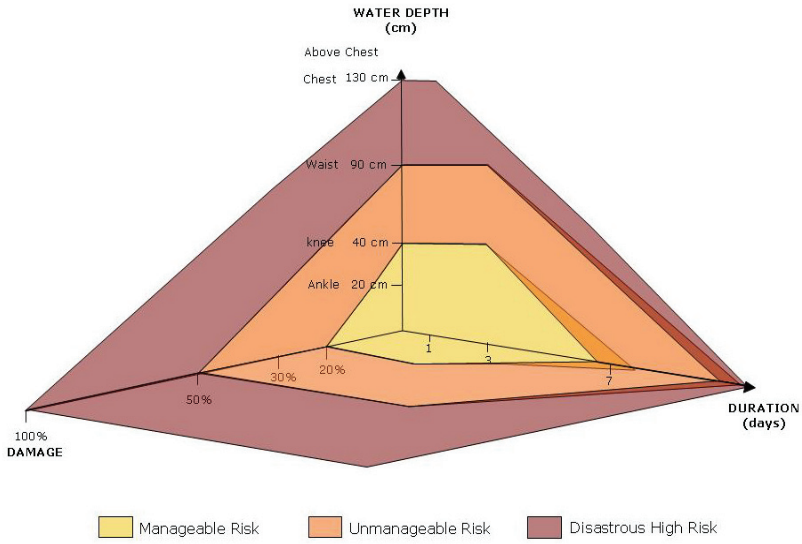


Figure 10.9 Elements of flood risk based on the community's perception of threat and damage assessment.

In this three dimensional graph risk is expressed as a function of water depth, duration and damage. Notice that it helps to illustrate some of the potential risk situations that can be derived from the combination of damage and losses.

Inundations that do not exceed more than *knee* depth and last less than three days can be considered as a *manageable* risk as long as the combined losses do not exceed the 20% of a family's resources, the social and governmental institutions still function and the commercial sector run. These flood stages can bring disruption mostly to the livelihood aspect and cause some minor damage to the residences although these losses remain between the manageability ranges for most of the households (see maps in the top of Figure 10.10).

Deeper and long-standing flood depths can cause combined losses higher than 30% and therefore may exceed the coping capacity of most of the poorer households in these wards (see middle and bottom maps in Figure 10.10). This type of flooding can bring vast damage to both the livelihood and the housing components of the families whose expenses (most of the times) have to be assumed at individual and family level. They also disrupt the functioning of community and institutional services, decrease the economic opportunities and cause widespread dislocation at city level. Hence, from the community point of view and regardless of the return period of the inundation, the combination of flood stages categorised as *highly disturbing*, *unmanageable* and *disastrous* and the damage they can inflict match the conditions for serious and even catastrophic risk.

10.5.5 Risk assessment for social and economic activities

Table 10.15 provides an insight into the calculations performed, in this case for the commercial and transportation sector in Triangulo. The consequence analysis for these components was evaluated firstly for the economic losses and damage caused by the occurrence of floods and secondly for the social services that are not going to be provided to the communities. For economic activities such as commerce and business the average annual gross sales per ward were used to determine the losses that the whole commercial area may experience.

The data was provided by the Bureau of Internal Revenue (BIR) and is also available through the website of the Local Government Unit. For the average agriculture production prices per hectare for vegetables and rice crops were collected from the Department of Agriculture (DA). The average price per kilometre for main and secondary roads was obtained from the Department of Public works and Highways (DPWH). The annual budget for health, education and general programmes carried out in each ward was provided by the Barangay Offices as part of their development programmes for 2005.

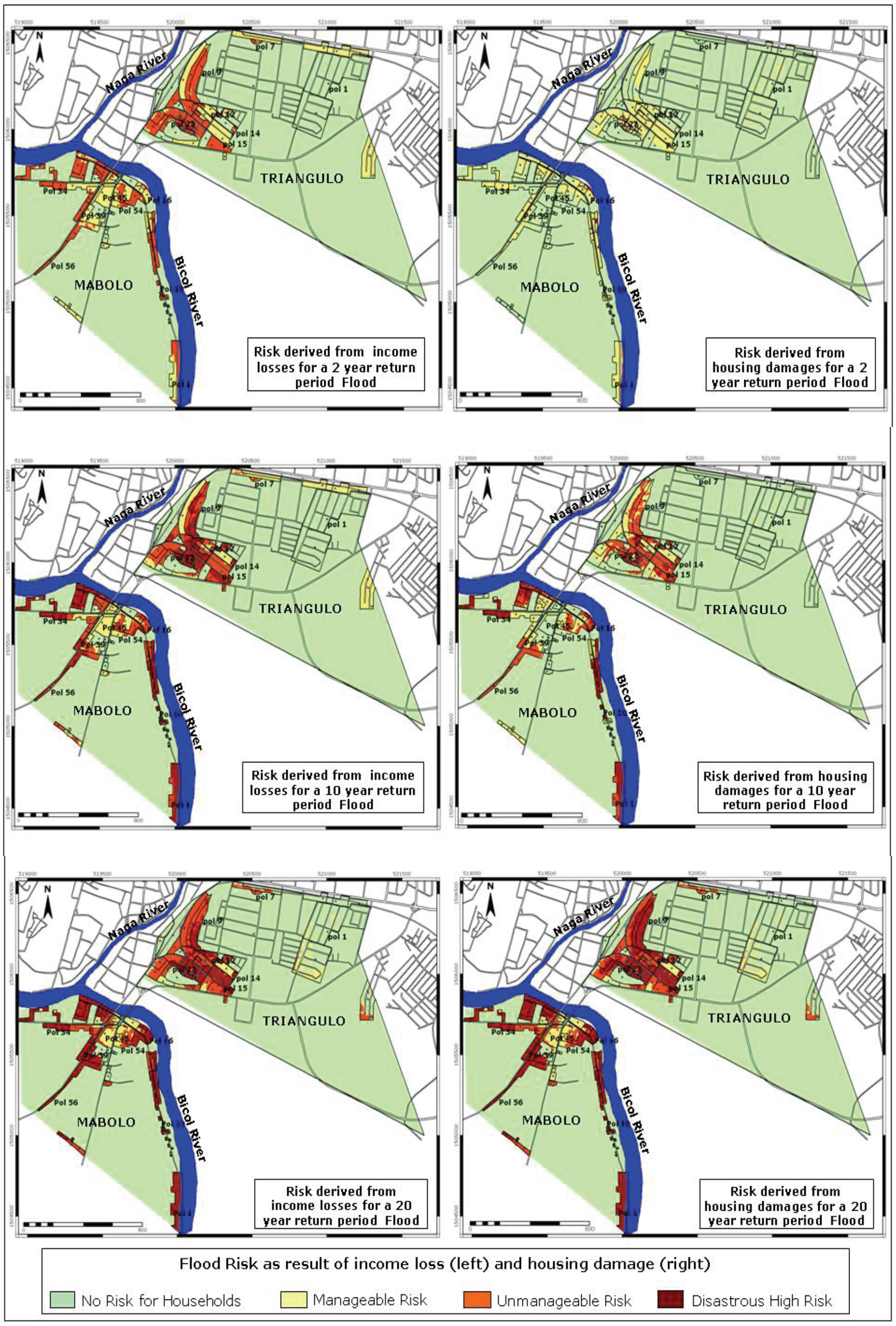


Figure 10.10 Spatial representation of flood risk derived from income loss (left) and housing damage (right) for the 3 flood scenarios: 2-year (top), 10-year (middle) and 20-year return period (bottom)

Table 10.15 Example of the consequence analysis for commercial activities harmed by a 20 year return period flood in Triangulo

Flood Event:	**20 years return period flood_*Present* scenario**					
Indicator	Economic activities					
Category	Commerce and transport related activities					
Flood stage (Table 10.1)	Area (ha)	Percentage (% ha)	Annual gross sales averaged	Annual gross sales percentage *area	Exp_ damage	Gross sales_loss
Hz0	4.2	25.5	4395000	1119130	0.01	11191
Hz1	1.5	9.2	4395000	404540	0.02	8091
Hz2	0.5	2.9	4395000	128133	0.02	2563
Hz4	0.9	5.1	4395000	225471	0.05	11274
Hz5	0.1	0.6	4395000	24783	0.2	4957
Hz7	3.6	21.9	4395000	961047	0.2	192209
Hz8	0.1	0.6	4395000	25837	0.5	12919
Hz10	2.3	13.8	4395000	605440	0.7	423808
Hz13	3.4	20.4	4395000	897455	1	897455
Hz14	0.0	0.1	4395000	4324	1	4324
Total	16.7	100.0				**1568790**

The total losses for these aspects are presented in Table 10.16. Once again it is evident how the figures for all the flood scenarios analysed are higher for Mabolo. In this case the main contributors are the losses in the commercial and industrial area, which renders higher annual gross sales, as well as the damage to the rice plantations.

Owing to the low-lying topography a 2-year return period flood, has the capacity to affect nearly 80% of the area cultivated in vegetables and rice. These two sectors represent the activity from which most labourers and informal workers derived their livelihood and a large share of their staple food supply.

Another important aspect to remark upon is the loss in terms of educational, health and institutional services that are not provided or which the budget has to be invested in repairing and restoring the installations and services. Even if small in comparative terms, the quantities per service type represent important shares of the budget allocated to each ward in order to assist the poorer sectors of the community. The small but repetitive losses as a result of minor inundations occurring almost every year determine that at least 5% of the budget allocated for development programmes will be lost on a biannual basis (see Figure 10.11).

Regarding the road system, from these figures it can also be concluded that even if the percentage in damage is relatively low for all flood scenarios, the significance of the losses derived from this aspect come from the disruption in transportation and services. The 10 and 20-year floods often inundate most of the whole network of secondary roads and alleys, particularly in the lowest-lying sectors of both wards and seriously disrupt the traffic along main roads, which are needed for evacuation and rescue activities.

Table 10.16 Risk analysis for socioeconomic activities and community capacities in the study area as result of the 2, 10 and 20-yrp floods

	TRIANGULO		**MABOLO**	
Return period/Flood risk indicator				
	Losses (PhP)	Perc (%)	Losses (PhP)	Perc (%)
2 year flood				
Religious services	10,500		12,000	
Health services	3,500	3.5%	14,800	4%
Institutional	74,30	3%		
Educational	24,000	9.5%	36,800	9%
Commercial and business activities	256,250	6%	575,020	3%
Marginal agriculture (vegetables) *	26,860	30%	173,780	90%
Marginal agriculture (rice) *			498,530	76%
Main roads **	93,000	0.5%	136,400	1.3%
Secondary roads**	251,700	0.4%	16,700	0.7%
Pathways (alleys) **	8,250	1.7%	2,800	0.8%
Total cost of damage and services not provided (PhP)	**493,781**		**1,466,760**	
10 year flood				
Religious services	16,500		17,000	
Health services	5,400	6%	37,700	10%
Institutional Services	38,750	16%		
Educational Services	55,500	22%	92,000	23%
Commercial and business activities	715,988	16%	4,261,372	22%
Marginal agriculture (vegetables)	70,000	57%	239,150	100%
Marginal agriculture (rice)			1,258,570	99%
Main Roads	380,000	2.1%	538,000	5.1%
Secondary roads	251,700	1.7%	134,200	5.6%
Pathways (alleys)	22,700	5%	8,700	2.5%
Total cost of damage and services not provided (PhP)	**1,556,526**		**6,586,100**	
20 year flood				
Religious services	36,000		18,000	
Health services	14,000	14%	50,000	15%
Institutional Services	50,000	20%		
Educational Services	72,000	29%	103,500	26%
Commercial and business activities	1,568,790	35%	5,507,500	30%
Marginal agriculture (vegetables)	112,557	100%	244,730	100%
Marginal agriculture (rice)			1,447,800	100%
Main Roads	767,200	4.2%	706,700	7%
Secondary roads	447,675	3%	197,500	8.2%
Pathways (alleys)	38,884	8.6%	19,400	5.5%
Total cost of damage and services not provided (PhP)	**3,107,106**		**8,295,200**	

* Percentage of the whole area cultivated that is affected by floods
** Percentage of the type of road affected by floods

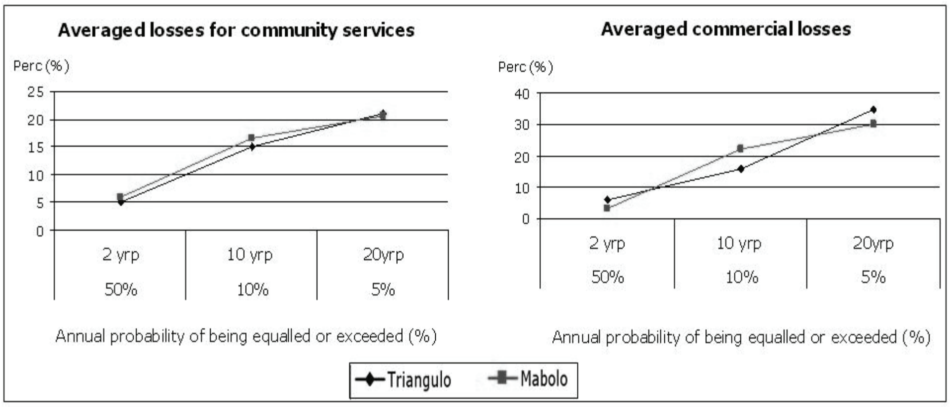


Figure 10.11 Risk derived from total or partial disruption of community services and commercial activities by floods with 2, 10 and 20 yrp.

10.5.6 Total risk assessment

Finally Table 10.17 presents a general overview of the damage and economic losses per flood scenario that includes all aspects analysed for the present situation. Once the total losses estimated are plotted against their annual probability of occurrence the differential risk that each of these events represent for the communities becomes evident (see Figure 10.12).

In a normal year, for instance, there is a 5% probability that the total losses exceed (PhP) 10 and 16 million for Barangay Triangulo and Mabolo respectively as result of an extreme event. The annual probabilities of an average loss of 2 million pesos as result of a smaller 2-year flood are approximately 50%. These figures imply that in an interval of time of 10 to 15 years five successive 'small' floods in Triangulo and eight in Mabolo may cause losses that are equivalent to a bigger 20-year event.

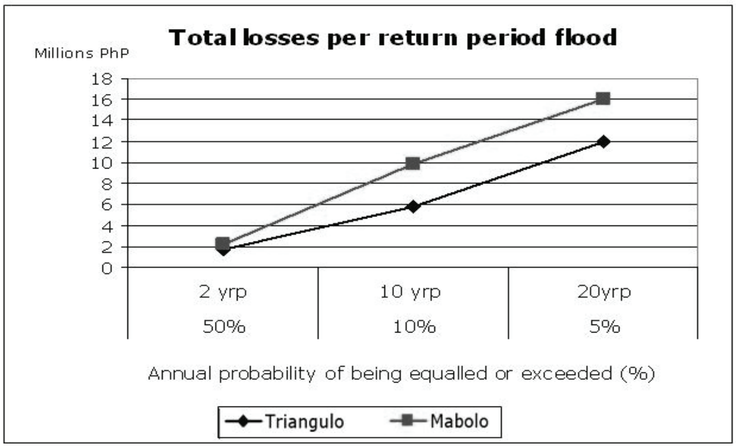


Figure 10.12 Risk curve of losses in million pesos against probability of occurrence for floods with 2, 10 and 20 yrp in the study area.

Table 10.17 Total risk analysis for the study area as result of the 2, 10 and 20 yr floods

	TRIANGULO		MABOLO	
Return period/Flood risk indicators				
	Losses (PhP)	Perc (%)	Losses (PhP)	Perc (%)
2 year flood				
Total number of people with an inadequate supply of food and non-food basic needs.	5,054	48%	5,943	69%
Total amount of income lost -not earned- in PhP	530,636		703,103	
Total Number of people with inadequate housing safety.	3,549	34%	3,465	40%
Total cost of replacement for damage in the housing component (PhP).	706,110		1,037,100	
Total number of people at risk due to partial or total disruption of basic services and facilities.	4,781	46%	4,697	51%
Total cost of basic services not provided (PhP).	17,960		17,472	
Total cost of damage and disruption of commercial activities and community services (PhP).	493,781		1,466,760	
Total losses for a 2-year return period flood.	**PhP 1,748,000**		**PhP 2,187,000**	
10 year flood				
Total number of people with an inadequate supply of food and non-food basic needs.	6,832	65%	6,769	79%
Total amount of income lost -not earned- in PhP.	1,022,147		1,296,857	
Total Number of people with inadequate housing safety.	5,971	57%	6,300	73%
Total cost of replacement for damage in the housing component (PhP).	3,107,160		4,136,000	
Total number of people at risk due to partial or total disruption of basic services and facilities.	5,922	56%	6,350	69%
Total cost of basic services not provided (PhP).	141,840		54,144	
Total cost of damage and disruption in commercial activities and community services (PhP).	1,556,526		6,586,100	
Total losses for a 10-year return period flood.	**PhP 5,827,673**		**PhP 12,073,101**	
20 year flood				
Total number of people with an inadequate supply of food and non-food basic needs.	7,588	71%	7,189	84%
Total amount of income lost (not earned).	1,375,240		1,619,869	
Total Number of people with inadequate housing safety.	7,049	67%	7,441	86%
Total cost of replacement for damage in the housing component (PhP).	5,094,560		6,056,400	
Total number of people at risk due to partial or total disruption of basic services and facilities.	6,430	61%	6,832	74%
Total cost of basic services not provided (PhP).	304,416		102,984	
Total cost of damage and services not provided (PhP).	3,107,106		8,295,200	
Total losses for a 20-year return period flood.	**PhP 9,881,300**		**PhP 16,074,500**	

To better appreciate the significance of the losses estimated in the previous Table 10.17, some of the figures regarding finances managed at ward level are presented in Table 10.18.

Table 10.18 example of the economic resources managed in the studied wards (in Philippine Pesos - PhP)

Aspect	Triangulo	Mabolo
Average annual commercial gross sales per ward	4,395,000	19,033,000
Ward Budget for functioning and development programmes (2005)	1,796,500	2,466,188
Calamity fund (5 % ward budget)	90,000	123,300
Budget for health and nutrition programmes	45,000	50,000

Source: Triangulo and Mabolo Barangay development plans

From this table it can be seen that the losses of the 2-year flood are fairly equivalent to the funds available for the annual functioning and developmental programmes in each ward. The calamity fund represents less than the 5% of the losses associated with the smallest modelled flood (i.e. a 2-year return period). Regardless of the number and magnitude of events this fund represents 5% of the ward annual budget and is used for relief and food assistance to evacuees and the most affected poorest families.

Finally, the losses for the 10-year return period flood in Triangulo are comparable to the annual commercial gross sales of their commercial area. In the case of Mabolo they are rather equivalent to the 20-year flood. The significance of the losses associated to these more extreme events are understandable as they are associated with deeper and long-standing flooding. However, in the vicinity of the elevated commercial areas big losses may become increasingly associated with higher frequency of smaller events.

10.5.7 Validation of the risk assessment

To become tools for planning and risk management any risk assessment would need to be validated. Municipal authorities and other decision-makers may need to know how reasonable are the consequences depicted by these analyses in order to take decisions accordingly. Ideally, the probable impacts and effects estimated in this type of examinations are compared against data on damages of various flood magnitudes that have actually taken place. In Naga, and more specifically in the two Barangays studied, this type of corroboration is constrained by the very limited data on flood damage available. Not to mention that no data at all on cases of internal mobility, illnesses and morbidity, number of days not worked, and damage caused at household level is collected after flood events.

Nevertheless, some minimal information on two events was found in secondary sources or provided by officers in the municipality and the Barangays disaster coordination. These data are provided in Table 10.19 in order to illustrate the magnitude of impacts and the social and economic losses to the study area.

Table 10.19 Damage assessment survey for the study area from typhoons Loleng (1998) and Unding-Yoyong (2004)

Aspects surveyed	Triangulo	Mabolo
Typhoon Loleng (October 21, 1998)		
Population Affected	4,008	5,672
Percentage of total households	61 %	99 %
Number of Dead/Injured	1/-	2/3
Number of houses totally damaged	175	70
Number of houses partially damaged	393	246
Property Damage in PhP	2,800,000	1,500,000
Damage to infrastructure	5,700,000	710,000
Business losses*	43,950	190,330
Total Losses	**8,602,518**	**2,454,458**
Government assistance	58,568	54,128
Typhoon Unding (November 19, 2004)		
Population Affected	2,910	2,776
Percentage of total households	35%	31%
Number of Dead/Injured	1/1	1/-
Number of houses totally damaged	29	83
Number of houses partially damaged	456	369

Source: Social Welfare and Development Office (DSWD) and Office of the City Major. Business losses* were estimated by the consultant (ADPC, 2001) based on secondary information.

The figures presented correspond to flood damage rapid assessments undertaken after by the Social Welfare and Development Office (DSWD) and the Office of the City Mayor; for Typhoons Loleng in 1998 and Unding in 2004 both were associated with a 10-year return period event. It is evident that the data on these two events differs and roughly matches the estimates of the risk assessment proposed in this chapter and summarised in Table 10.17. There are numerous and valid reasons for these disparities. Firstly, no clear definitions were found for the characterisation of a household or individual as 'affected'. Most probably these estimates are based on reports of relief distribution and housing damage. However during focus group discussion with Barangays officers it was found that these 'rapid surveys' are not always carried out immediately after the flood. The municipal officers, who have to validate the assessments done by the local Barangay officers, usually arrive one or two weeks after the event. By this time many of the households have already fixed or rebuilt their houses and are therefore not included in the official assessments.

Regarding the damage to agriculture, which represents a large share of the losses particularly in Mabolo, the data found was not disaggregated at the ward level. Yet, given the date of typhoon Loleng (October 21) it is very possible that the rice crop was lost as it coincided with the harvest period during the wet season (see Section 5.4.4).

Finally, it has to be considered that in the first case (Typhoon Loleng) the data is presented in economic values corresponding to year 1998. On the other hand the commercial and industrial growth experienced in the last decade in these Barangays has increased the amount of wealth under risk and the number of people settled in these wards; which therefore increases the estimates of the several aspects considered for this study.

10.6 Risk assessment for the future development situation

Risk is a dynamic process which, at least for the studied communities, is constantly modified by changes taking place either in the flood hazard itself, the vulnerability of the families or in their socioeconomic and physical context.

The previous section depicts the risk that the communities in the studied area may experience under the base line conditions evaluated as the *present* scenario assumed as year 2005. However, as analysed in Chapter 7, the urban development process that these two wards are undergoing is rapidly changing these conditions to the point that any risk analysis may become outdated.

The risk assessment for the *future* situation, assumed herein as year 2012, was performed in order to provide an insight into the dynamics of flood risk at ward level. In this section the risk analysis was carried out only for the households' **socioeconomic indicator**. The loss of income was analysed once again as result of the occurrence of the three flood events. Yet, this time, it is assumed that the flood hazard is being modified as a result of the fast expansion processes experienced in the urban environment; which in addition does not comply with adequate planning processes.

The procedure followed for this scenario made use of the inundation maps for *future* situation developed for the 2, 10 and 20-year scenarios by means of the hydrological modelling in Chapter 7; and presented in Figure 7.17. The depth and duration flood matrix in Table 10.1 was again applied to these maps in order to obtain hazard categories. Afterwards these hazard maps were crossed with the map of *homogenous units of households* indicating the percentage of livelihood groups per polygon and their average daily income.

In order to portray the risk for the future situation some adjustments needed to be done to the units of households: firstly it was assumed that, given the current trends in population growth in Naga, by the year 2012 the population settled in these wards would have increased substantially. Therefore a growth rate of 1.65% was applied to the number of households used for the *present* scenario based on the projections of the City Planning and Development Office (CPDO, 2005). The results used in the income risk assessment are presented in Table 10.20.

Table 10.20 Projected population by year 2012 in the studied wards

Projected Population (2012)	TRIANGULO	MABOLO
Number of Households	1,672	1,450
Total number of people	8,360	7,250

Secondly, regarding the risk of income loss, and with the aim to establish meaningful comparisons between the *present* and *future* scenarios, it was assumed that despite the population growth, the proportions of workers in the different livelihood types will remain stable. For instance, in the *present* scenario, the number of families in Triangulo whose main income is earned by *Labourers* was estimated as 398 (26.2%). Using the same proportion the number of labourers by 2012 is expected to be around 445. This may not be the case in the real situation, particularly when considering that the existence of new commercial opportunities and the development of housing plans for the Urban Poor may increase the proportion of labourers and informal workers in both wards.

Thirdly, it was also necessary to assume that the average income per livelihood type has increased according to the annual inflation rates, as well as the poverty and food thresholds. The wages used for the *Present* situation were increased by applying a factor of 1.06. This factor was derived by averaging the core inflation experienced in the Philippines in the period 2000 to 2006 as reported by the National Statistical Coordination Board (NSCB, 2007). The final estimated values for the minimum daily wages as well as the thresholds corresponding to the year 2012 are presented in Table 10.21.

Table 10.21 Estimated Poverty and Food thresholds for year 2012

Income Indicator	**5 member-family**		**7 member-family**	
	Monthly (PhP)	Daily (PhP)	Monthly (PhP)	Daily (PhP)
Poverty threshold	8,586	275	12,017	385
Food threshold	5,667	189	7,931	265

According to these estimates, by the year 2012 a family of seven may need to earn a minimum of PhP 385 Philippine pesos in order to stay above the poverty line. Also the same family will need at least PhP 265 in order to provide adequate food intake for each of their members.

Once the assessment for minimum wages per-livelihood-type and thresholds for the *future* situation were obtained the same table crossing and other calculations performed for the risk assessment in the *present* scenario were carried out. The data on income not perceived, families falling below the food and poverty threshold and the total losses caused by the three floods were obtained and are presented in Table 10.22.

By comparing the estimations on Tables 10.11 and 10.22 it can be seen how (in terms of income loss) the figures have nearly doubled in both wards for all the return periods modelled, which is also shown in Figure 10.13.

Table 10.22 Risk analysis for the socioeconomic conditions of the families as a result of the 2, 10 and 20 yrp floods in the future scenario

	TRIANGULO		MABOLO	
Return period/Flood risk indicators				
	Households (No.)	Perc (%)	Households (No.)	Perc (%)
2 year flood				
Number of Households below the food threshold as result of loss in income.	711	43%	855	59%
Number of Households below the poverty threshold as result of loss in income.	328	20%	412	28%
Total number of families with income affected	**1,112**	67%	**1,231**	72%
Total number of people with an inadequate supply of food.	4,977	43%	5,985	59%
Total number of people with an inadequate coverage of basic needs.	6,307	54%	6,881	68%
Total amount of income lost (not earned).	**PhP 1,088,865**		**PhP 1,239,650**	
10 year flood				
Number of Households below the food threshold as result of loss in income.	918	55%	1,011	70%
Number of Households below the poverty threshold as result of loss in income.	512	31%	709	49%
Total number of families with income affected	**1,206**	72%	**1,231**	85%
Total number of people with an inadequate supply of food.	6426	55%	7,077	70%
Total number of people with an inadequate coverage of basic needs.	7,224	62%	8,183	81%
Total amount of income lost (not earned).	**PhP 1,827,050**		**PhP 2,617,840**	
20 year flood				
Number of Households below the food threshold as result of loss in income.	956	57%	1024	71%
Number of Households below the poverty threshold as result of loss in income.	542	32%	728	50%
Total number of families with income affected	**1,281**	77%	**1,247**	86%
Total number of people with an inadequate supply of food.	6,692	57%	7,168	71%
Total number of people with an inadequate coverage of basic needs.	7,763	66%	1,231	85%
Total amount of income lost (not earned).	**PhP 2,286,320**		**PhP 2,939,380**	

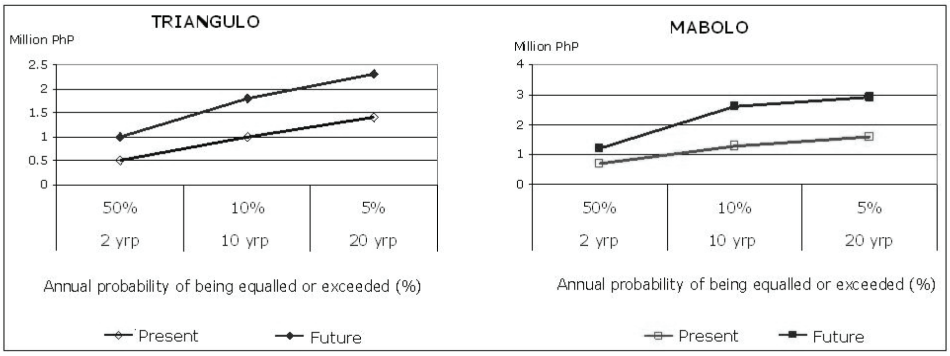


Figure 10.13 Contrasting income losses for the households in the studied area between the present (2005) and future (2012) scenarios

As evidenced the future scenario does not show a trend in preventing or decreasing the potential income losses for the households. This implies that the modifications in the landscape may have a positive effect in protecting the new commercial and industrial inversions but they do not decrease the risk for the communities settled in the low lying areas.

Furthermore, the detailed analysis of the effect of these interventions in the flood risk per livelihood type presented in Table 10.23 shows that, as a result of the increased flood hazard, each flood event will comparatively affect an average of three to four percent more of *labourers* and *informal workers* than the previous ones.

Table 10.23 Changes in flood risk per livelihood type between the present *and* future *scenario*

Livelihood Categories	**TRIANGULO**			**MABOLO**		
	Flood scenario (yrp)			**Flood scenario (yrp)**		
	2	**10**	**20**	**2**	**10**	**20**
Labourers						
Present -2005	87%	88,4%	91%	82,5%	93,5%	95%
Future - 2012	86,1%	91,2%	93%	86	86,5	98
Informal workers						
Present -2005	82,5%	83,5%	89%	81,5%	91%	93%
Future - 2012	84%	87%	90%	83%	94%	94,5%
Formal workers						
Present -2005	44,3%	62,5%	72%	64,55%	83%	89
Future - 2012	45%	60,5%	68%	62%	81,5	86,5
Skilled workers						
Present -2005	11%	23%	39%	28%	59%	69
Future - 2012	9,2%	19,5%	31%	25%	54%	65

The estimations of income losses for formal and skilled workers show an opposite tendency and the percentage is decreased with an average of 4% as result of the landscape modifications, as displayed in Figure 10.14.

The tendency of increased flood risk for poorer groups, at least in terms of income loss, is easily understandable. Modifications in the landscape are made by the wealthiest groups in order to protect their investments. Therefore, the income of formal and skilled workers is less affected as their place of work has been protected from flooding. In contrast the poorer groups are more exposed as the flood hazard has been shifted from raised terrains. Areas where flooding was marginal before will have to face deeper flood stages that will increase not just the number of people affected but also the percentage of income lost per household. Most probably, households that before were facing flood risk within *manageable* ranges will see themselves in a situation were the risk has reach terms of *unmanageability* and even *disaster*.

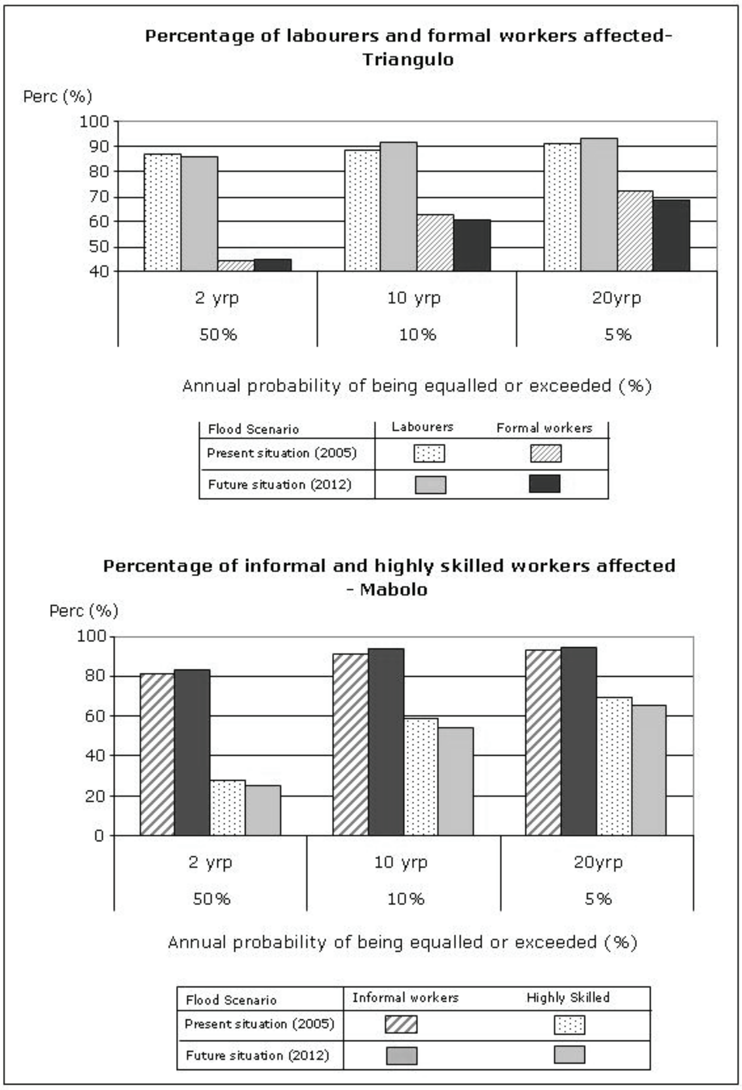


Figure 10.14 Contrasting situation for changes in flood risk, per livelihood type, between the present and future scenario

10.7 Risk assessment under a climate change scenario.

Today, it is widely agreed by the scientific community that climate change is already a reality. The Intergovernmental Panel on Climate Change (IPCC) has concluded that human activities are altering the Earth's climate system and will continue to do so (IPCC, 2007). These alterations are expected to occur in the form of increased climate variability and moreover changes in the frequency, intensity, duration and uncertainty in the occurrence of hydrometeorological events (IFRC, 2002b).

These changes are also expected to lead to increased risks of floods and other climatic phenomena in many regions. Current studies also suggest that peak wind and precipitation intensity of tropical cyclones are likely to increase over some areas (Boer et al., 2001). On the other hand the losses associated with extreme and increasingly not so extreme climatic events are expected to increase dramatically, as more people will be affected in shorter periods of time.

Although there are no detailed studies on how climate change will affect the region were the study area is located. Nevertheless, the IPCC findings are that global warming is manifesting itself in the Philippines through the more frequent occurrence of severe El Niño and La Niña events; on top of deadly and damaging typhoons and other severe storms; floods, flash floods, landslides, drought and forest fires (Cruz et al., 2007).

Recent studies suggest that in the Philippines global warming may lead to an upward trend in the destructive potential tropical cyclone and, taking into account an increasing coastal population, a substantial increase in hurricane/typhoon-related losses in the 21st century. Intensified and more recurrent droughts and floods associated with El Niño events in many different regions are likely to occur (PAGASA, 2001; Emmanuel, K., 2005).

Given the climatologic and geographical situation of Naga, it is very likely that besides the potential increased number of inundations related to more severe typhoons and rainstorms it will also face increased flooding related to high tides and storm surges as result of rising sea level. The assumption is that people in the lowest-lying wards will have to deal with more recurrent and perhaps intensified floods in shorter periods of time with very little time to recover between events.

During fieldwork the manifestations of the changes in hydrologic conditions were discussed mostly within the group of farmers and labourers that still depend on small scale rice crops. According to them, agriculture was starting to be considered as unprofitable. In their words, 'the meagre gains in the normal years do not compensate for the losses when droughts and flooding occur more frequently'. In fact several of the interviewed farmers were already planning to abandon farming as their main source of livelihood and either look for other income alternatives or move to other areas.

In order to evidence the implications of such changes at community level this research developed another potential risk scenario specifically looking at income loss. It was assumed that communities in the studied wards will face more frequent (and perhaps more intense) inundations in the near future. Therefore the climate change scenario assumed that the area has been hit by a relatively small inundation (2-yrp flood) and, while the households have not yet been able to recover, a new flood equivalent to the 10-year return period takes place. In this case the aim is to see how more recurrent floods will affect the income of the families and how consecutive losses will put some groups of households (even those in wealthier groups) at risk of disaster.

The risk estimation, in this case, was limited to the socioeconomic conditions. This aspect was found indicative enough for the risk circumstances to be experienced by the households. Regarding the time of occurrence, this new scenario was also determined as occurring in the medium term and therefore the statistical data estimated for the previous future scenario (income level, poverty and food thresholds as well as number of households in Tables 10.20 and 10.21) were used herein.

The data on income loss, families falling below the food and poverty threshold and the total losses caused by the concurrent flooding scenarios were obtained as shown in Table 10.24.

Table 10.24 Risk analysis for livelihood conditions of the households as result of concurrent 2 and 10 yrp floods in a future scenario.

	TRIANGULO		**MABOLO**	
Return period/Flood risk indicators				
	Households (No.)	Perc (%)	Households (No.)	Perc (%)
Concurrent 2 and 10 year flood				
Number of Households below the food threshold as result of loss in income.	970	58%	1,060	73%
Number of Households below the poverty threshold as result of loss in income.	335	20%	247	17%
Total number of families with income affected	**1,305**	78%	**1,290**	89%
Total number of people with an inadequate supply of food.	6,790	58%	7,410	73%
Total number of people with an inadequate coverage of basic needs.	9,130	78%	9,033	89%
Total amount of income lost (not earned).	**2,475,000**		**3,282,000**	

By comparing the estimations presented herein with those performed for the present and future scenario (in Tables 10.11 and 10.22) some conclusions could be drawn.

Firstly, it was found that the combined amount of income loss is just slightly smaller than when these events are assumed to occur in a different year. This is explainable as the scenario assumed that when the second inundation took place the households have not yet recovered to their pre-flood status; in consequence, the income earned was still reduced. For example it was assumed that when hit by the second event a given *labourer* was earning 10-50% less daily income as result of the initial flood.

Secondly, it was observed that the number of people affected by subsequent floods is bigger than when these events are assumed to take place, for instance, in a different year. This because of the fact that households that initially faced *normal or no losses* during the first episode may face risk of *unmanageability* or even *disaster* as result of the damage and disruption caused by a subsequent inundation.

Thirdly, it was also found that, in absolute terms the amount of income lost in a second event may be less (because less income is being earned). However, at household level the significance of a second reduction in the income will have a bigger impact on their wellbeing. Most of the families, particularly the poorer ones, may have already decreased or depleted their financial coping mechanism; therefore a further reduction of earnings or the total lack of income, triggered by a subsequent flooding, may put even wealthier families to face *unmanageable* levels of risk.

The maps in Figure 10.15 illustrate the risk of increasing poverty faced by the households in the studied wards as result of income loss during subsequent floods.

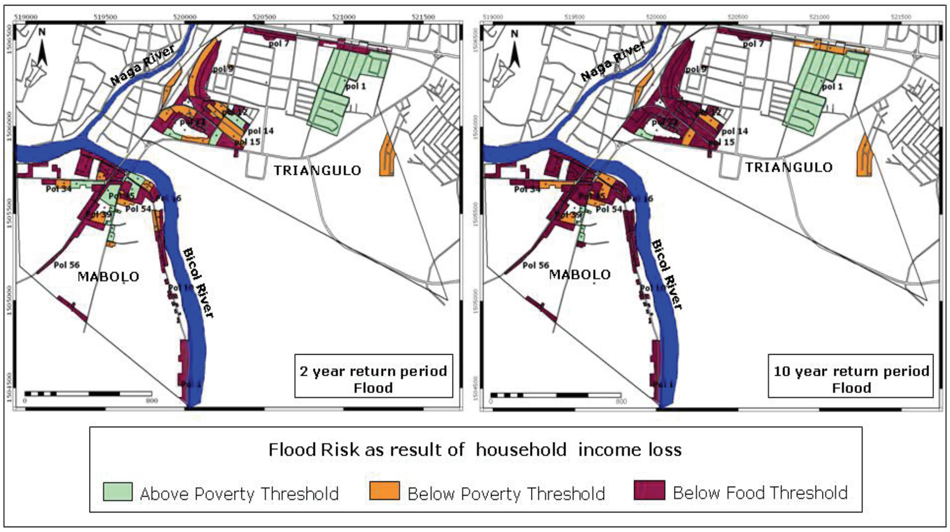


Figure 10.15 Spatial representation of flood risk for the households as result of income loss after subsequent 2 and 10 yrp inundations.

From these maps it can be seen how, regarding income losses, a successive second flood will put nearly the 80% percent of the households in both wards at risk of poverty and marginalisation. The probability that this type of scenarios will become common on the medium term (as a result of climate change and global warming threats) constitutes a crucial issue for the communities and authorities in the study area.

The combination of income losses, housing damage and disruption of basic facilities will probably exceed the levels of *manageability* of the households. The exhaustion of savings and other financial coping mechanism used in previous besides the new damage undergone by new events determine that there is no time for the family to properly recover and regain their previous 'normal' status. The risk of marginalisation as result of consecutive floods may be considered a *disastrous* by most of the families in the study area.

10.8 Main findings and discussion

The approach to the analysis of flood risk for the several scenarios performed in this chapter constituted a critical step towards the understanding of the risk dimensions at ward level. The contextualised quantitative and qualitative assessments provided insight into the consequences that damage and losses represent for the communities in the studied wards.

The separate evaluation according to categories of income, housing and other aspects present in the studied area, allowed the research to substantiate the impact that inundations may have on individual families. It also allowed to compare the dissimilar impact of these events on households' wellbeing depending on their socioeconomic characteristics.

The analyses performed illustrate that while the risk derived from extreme events is broadly perceived and well represented by information at municipal scale, the incidence of changes in the landscape, minor but repetitive events or the harm caused by subsequent events is better represented at ward level or per group of households. Increased poverty, marginalisation, homelessness and a general decrease in wellbeing are the uncovered risks that lie behind the calculations for income losses, housing damage and disruption of basic and social services. Rather than estimating the extent of harm, the risk scenarios also helped to illustrate the few manageability options that people in these communities have in order to cope on their own with these adverse effects.

The flood risk assessment proposed in this chapter should help both the communities and the local and municipal authorities looking to improve their risk management and planning measures. Given the losses estimated in the assessments presented above, the municipality should stop overlooking the inclusion of the flood risk problematic in the existing and planned developmental programmes and policies. The fact that nearly three quarters of the families in each ward cannot supply adequate food to their members during 10 and 20-year return period events and furthermore will have to evacuate because of the poor safety of their houses needs to be put on the political agenda in Naga. Moreover where it was observed that during small events (perceived as normal at higher administrative level) nearly 50% of the households in Triangulo and 60% in Mabolo may fall below poverty and food thresholds because of the loss of income expected.

Local authorities should be also concerned with the fact that the losses derived from a 20-year flood (represented by PhP 9.8 million in Triangulo and PhP 16 million in Mabolo) are equivalent to the annual commercial gross sales. This type of repetitive damage each time a flood takes place may jeopardise the economic growth of Naga and its position as a haven for investment in the Bicol Region.

There is also a need to perform this type of analysis for urban expansion and commercial development. The assessments demonstrate that though new industries and business may bring more economic opportunities to the people in these wards, the modifications in the landscape needed to protect these

investments, will negatively affect the poorest sectors of these communities. Families making a living from labour, farming and informal work are the most disadvantaged, because they occupy the lowest lying sectors of these areas with no means to keep away from the increasing flooding threat.
In summary, this chapter demonstrated once again the possibility to incorporate local perspectives into spatial and GIS-based risk assessments. The manageability and unmanageability concepts introduced above as well as in the spatial representations of flood risk were derived directly from the local knowledge shared by the people in these communities. On the other hand the assessments performed in this chapter provide several entry points to tackle one of the problems in the municipality which is the *perceived* lack of data to carry out this sort of risk analysis. For instance the data used throughout the diverse analysis was collected through surveys and making use of information and tools for spatial analysis already available in the Electronic Data Processing Unit (EDP) such as GPS and GIS software. Another type of risk scenario analysis that suits the requirements for urban planning and risk management in the Local Government Unit can be implemented on the basis of the information retrieved from the community in terms of a participatory approach. Offices that can benefit from the type of analysis provided in this chapter are among others the City Disaster Mitigation, Planning and Development Office, Social Welfare and Development, City Health Office, Urban Poor Affairs Office, Environment and Natural Resources, Labor and Employment, Transportation and Communication, Trade industry, Local Development and Investment, Metro Naga Water District, Department of Agriculture, Civil Defense.

Risk assessment at a very detailed level, can be performed by the municipality, NGOs or consultants with the joint assistance of Barangay authorities, leaders and laypeople which in turn can help to search for alternative methods/means/tools for tackling the flood risk problematic.

The chapter also points to further research that develops this type of approaches into fully operational methods. There is a need that contemporary research agendas of geo-information Science deal with the type of assumptions and fuzziness of some of the categories that deal with the type of risk assessment performed in this chapter but are beyond the scope of the present research.

Chapter 11: Findings, Conclusions and Recommendations

This chapter presents a summary of findings, conclusions and recommendations derived from the results of the research of which the two main objectives were:

1. *To contribute to the ongoing development of knowledge about how risk and disasters are perceived, experienced and managed by communities at local urban level*
2. *To investigate how spatial analysis techniques available in geo-information systems can be used to incorporate local flood related knowledge and perspectives into GIS-based flood risk assessment relevant for planning and disaster risk management*

11.1 Local flood risk related knowledge

In order to understand how the risk of disasters is perceived, experienced and managed by communities living in hazard-prone areas this research made use of a learning-based approach. Various forms of knowledge (basic, applied, technical, and tacit) available with different actors are considered necessary to explain the complex social and developmental problems of flood hazard, vulnerability, capacity and risk.

The participatory methods applied were aimed at eliciting flood-related local knowledge among communities 'at risk' in order to make it relevant, available and accessible for planning and decision-making at local and municipal level. Members of flood-affected communities have developed a vast and diverse amount of knowledge over the years.

Workshops and meetings with local actors, exploratory local visits and collection of secondary data were used to depict the initial situation. This first step provided an overview of the flood situation and context, key organizations, groups and individuals, nature and importance of the relationships inside the community, and relevant policies and legislation among others. During the fieldwork stage a number of participatory techniques and tools were used for bringing out and understanding the point of view of the local communities regarding flood risk issues. Some of these methods were mixed with the use of GIS, e.g. individual in-depth interviews; joint GIS-assisted transect walks, field mapping and a GIS-assisted household survey.

The local knowledge and perceptions found were analyzed in order to implement the notions of flood hazard, vulnerability, mechanisms for coping and risk (found as tacit elements in the community's perceptions of threat) in risk assessment.

In the following sections to the main elements of the local knowledge retrieved will be summarized.

11.1.1 Characteristics of local knowledge

Local flood related knowledge is available among many different actors (local communities, authorities, media, NGO's, government organizations, private companies etc.). In this research three main groups of actors were evaluated: local communities, Barangay authorities and municipal authorities, with emphasis on the first two groups. The two Barangays that were selected for the research had historical records of flooding and typhoons striking almost every year. Therefore communities settled in these Barangays have become familiarized with these events and have developed attitudes and practices that help them to deal with these phenomena. It was also found that in the case of households and local (Barangay) authorities this knowledge is developed because of the direct confrontation with the event itself (flooding, strong winds). Citizens have developed 'place-based knowledge' related to the nature and origin of meteorological events, their interaction, behaviour and likelihood of damage. This knowledge is reinforced by information disseminated by the media (local radio and TV stations). The Barangay officers have a more comprehensive understanding of the local flood problems than the average households, as they have to deal with problems throughout their ward. They also form the link between local households and the municipal authorities.

Authorities at municipal level developed knowledge on flood problems by having to deal frequently with disaster response in the aftermath of flood events. These local government officers mostly live in more developed areas that are not so severely threatened by floods, and therefore have a different type of knowledge than the local communities.

In the process the researcher also became an (external) actor, with a different attitude towards flood risk than the local communities. For her flooding was something to analyze, measure and model, whereas for the communities in the study area flood risk is a fact in their everyday life.

Local knowledge was found to be both individual as well as collective. Personal experiences of individuals dealing with floods are often shared with neighbours and people living in the neighbourhood through the various social networks. In the conversion of individual to collective knowledge the barangay officers play a major role.

It was found that at Barangay level the individual and collective knowledge within the communities was extensive in terms of identifying and characterizing flood phenomena. The knowledge was also coherent and precise, in particular with respect to defining spatial distribution, magnitude and duration of historical events.

Local knowledge is context-specific. For instance the knowledge of local communities in Mabolo is related to their still semi-rural context, whereas in Triangulo it is more urban-related.

The local knowledge is also complex, as the components of hazards, vulnerability, manageability and coping strategies are fused with other components related to livelihood and environment. They often don't see the hazard as a single component that they identify separately but it is a part of their overall life world.

Community knowledge is not homogeneous through space and time. Communities are constantly changing; households move, change their composition, livelihood, buildings etc. Furthermore the environment in which they live also changes. Urban development's take place, flood mitigation measures are put into place. Another aspect is that the memory of a specific event decays after a certain period of time. Communities will loose the collective knowledge of certain past events as they are replaced by new ones. All these aspects make that community knowledge is dynamic.

The research does not assume that local knowledge is faultless or better than the so called 'scientific' knowledge. People's flood-related knowledge is different and arguably more diverse. It may also be more difficult to systematically collect. However, it is very relevant and has to be integrated with more technical knowledge and procedures. In order to manage the risk that floods pose to 'at risk' communities there is a need to consider their point of view. This can be done by eliciting and understanding how they perceive the threats from their flood-prone environment and how they behave accordingly.

11.1.2 Knowledge on flood phenomena

Flooding in the studied wards can be caused by hydrological events that can occur in isolation (e.g. river overflowing) or simultaneously, for instance when heavy rains take place during the high tide period. In the last decades the natural propensity to flooding in the study area has been aggravated by human-made modifications in the morphology of the terrain, particularly related to land-filling and improper drainage construction as described in sections 4.3.3 and 7.2.

In both communities it was found that people have a vast knowledge on both the type of flood events as well as their behaviour through space and time as a result of urban expansion and changes in the landscape. The communities were able to identify all the types of events that can affect them, the period of the year in which they usually take place as well as the magnitude, extension and duration of different types of flooding which were described in Tables 6.1 and 6.2. They were also able to indicate their impact over the different administrative zones within their wards.

People in the communities accept floods as part of their daily life and they are aware of the implications of being settled in the floodplains of the Bicol and Naga Rivers. These communities usually do not perceive the occurrence of floods and typhoons as something that can be entirely prevented. Rather these phenomena are seen as something they have to deal with because of the limited choices they have for finding convenient alternative locations and affordable land. They are perfectly aware that it is the availability of socioeconomic resources and opportunities which constrain the manageability of different events and therefore determine the type and duration of the disruption to be experienced because of flooding.

Moreover, flooding is not the only problem that communities in the study area face. During the wet season they also have to deal with other threats such as starvation, illnesses, and homelessness. Therefore, it is not surprising that flood management as such does not rank very high in their concerns (as shown in Table 9.1). With many lacking adequate water, housing, sanitation, education, health and employment flood is just another problem and in their own words "every day is a struggle".

Similar to the families in the studied communities, municipal authorities are also occupied with the everyday, pressing problems of poverty and lack of development. Therefore, at municipal level the flood topic is not a 'cross-cutting' issue for the normal management of the city. In the Local Government Unit (LGU) this lack of a comprehensive understanding of the flood phenomena is manifested in the fact that flood-related knowledge and awareness is compartmentalized. For example, the preparedness and relief mechanisms are well organized in the city's emergency response. Therefore officers from the City Health Office (CHO) or the Social Welfare Department (CSWDO) are more familiar with flood risk-related issues, because part of their task is to take care of those severely affected by flooding. People from the Planning and Development Office (CPDO) instead are less familiar with the problematic because they do not perceive flood management as something they have to deal with in their normal official tasks. Because of the response-oriented attitude at municipal level the perceptions of the municipal officers on the flood risk management are mostly related with decreasing the number of casualties, and they are most concerned how `manageable` (for the LGU) the aftermath of a flood crisis will be. Hence, they pay less attention to how flood risk can be mitigated or avoided, how 'manageable' the situation is for the communities at risk and how (un)able the people are to cope in the short or medium term on their own with the adverse effects. This lack of concern influences also the information management processes, as will be further elaborated in 11.3.

11.1.3 Local coping strategies

The participatory activities carried out as part of this study revealed that in these communities <u>numerous coping mechanisms</u> exist to deal with the disruption created by flooding (an overview of these was presented in table 5.5). The main aim of these strategies is to avoid or decrease the disruption and damage of the most important aspects of people's everyday life such as their own safety, the safety of their residence and valuables and their livelihood activities.

While some of these strategies were found to be <u>temporary</u> and practiced just for survival during the event or in the aftermath, some others have become <u>permanently</u> integrated in their daily life (e.g. raising houses, building mezzanines).

Some of the coping mechanisms have the aim to reduce the impact of a possible flood (e.g. raising a house). Some others are more related to coping with the negative impacts of a flood. These are strategies to deal with the reduction of resources. Decreasing the food intake, pawning or selling valuables, borrowing money at high interest rates increase the poverty and marginality of the people in these communities. Related to that is the subdivision of coping mechanisms in those that are executed before, during or after the occurrence of a flood (see table 5.5). Coping mechanisms are also chosen depending on the way how a flood is evolving. The timing at which households have to start implementing coping mechanisms is an indicator for their overall vulnerability. For instance, households that do not have the resources for elevating their house need to adapt coping mechanisms already at very low water levels (*ankle* level).

Some of the coping strategies adopted by certain groups of households may affect the exposure and resistance of others. This is more than evident when 'wealthy' households or commercial enterprises elevate the terrain level for protecting their dwellings or warehouses. During flooding the water that used to spread over a larger terrain is now blocked from entering elevated areas and is transferred to lower adjacent areas in which the badly off are usually found.

Some coping strategies are increasing the threat posed by floods such as the use of waste to elevate the terrain level, leading to severe water pollution in case of floods. Plastic bags and containers can block the drainages and create ponds for mosquitoes and increase the likelihood of water-borne diseases. Strategies to avoid the risk from a given type of hazard may increase the risk for another type, for instance moving appliances and assets to a mezzanine or second floor to avoid flooding may leave them exposed if strong winds blow away the roof.

The continuous implementation of coping mechanisms without reducing the current situation of flood hazards and community vulnerability may lead to further marginalization and impoverishment. Especially in a situation when events are happening with short intervals people have increasing difficulty to implement the same coping mechanisms. Their resources are depleted, their resilience is reduced, and the tolerance band decreases. Many times it was found that despite their coping mechanism people are trapped in a cycle of poverty and increased vulnerability (see for instance Box 8.2).

11.1.4 Manageability

The *manageability* concept developed by the communities and extracted by using various participatory tools, is one of the major outcomes of this research. Manageability expresses the way local communities experience flooding in relation to their capacity to deal with the situation, depending on their resources and coping mechanisms. The manageability is expressed in a number of qualitative classes ranging from *normal* to *manageable*, *highly disturbing*, *unmanageable* and *disastrous*. In section 5.4.3 each of these classes is defined in terms of the water depth and duration, the disruption they cause as well as the available resources and coping mechanisms they involve.

The manageability classes are used throughout this research to convert flood extent maps into maps expressing the way communities deal with these events. Examples of that are, for instance, to:
- visualise the seasonal changes in flood impacts (section 5.4.4);
- understand how the people experienced past flood events and reconstruct historic flood events (chapter 6);
- convert all flood modelling results from past, present and future events into community-based manageability classes (chapter 7);
- determine how damage and losses can drive households from one category to another (chapter 10)
- visualize the possible impact of future flood scenarios, with changes in flood frequency and terrain elevations (section 10.5.4).

The understanding of coping strategies and manageability is considered a powerful tool for managing disaster risk at local and municipal level. For instance, it can help municipal authorities to monitor the effectiveness of their 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. Information on manageability can be obtained at a relatively low cost, but requires constant interaction with local communities.

The relation between the manageability classes and the socio-economic levels is an aspect that might need further study. The manageability concept requires a certain level of homogeneity with respect to socio-economic level. In the current classification it is not possible to clearly see the differences between households with strongly varying socio-economic levels, based just on manageability. For example, in the case of *disastrous*, a different approach would be needed for households with very low socio-economic levels, compared to those with a much higher one.

Another issue to take into consideration is that the manageability is dynamic, as flood events are changing over time, environmental aspects change and also the resources and coping mechanisms of the communities vary over time. Even within one year the manageability might change a lot (see Section 5.4.4). The criteria for defining the manageability classes will also change over time, and need to be regularly updated. Of course this poses a problem using the current manageability classification for prediction future scenarios as was done in Section 10.5.4.

11.2 Integration of local knowledge in GIS-based flood risk assessment

The second main objective of the research was to investigate how spatial analysis techniques can be used to incorporate local flood-related knowledge and perspectives into GIS-based flood risk assessment relevant for planning and disaster risk management. In order to achieve this goal a combination of techniques was used derived from different disciplines, which reinenforce each other in assessing flood risk at local level:

- Community-based methods
- Participatory GIS
- Flood modelling
- Spatial Multi Criteria Evaluation
- Data integration in a GIS

A more general point has to be made here. The use of participatory approaches is not very popular among earth scientists, hydrologists and civil engineers that are mostly in charge of flood hazard assessments. On the other hand, social scientists that have experience in the use of community-based methods have a certain fear of GIS, which is often considered as too technical. The researcher, being an earth scientist by background, therefore had to acquire skills in using of participatory approaches and integrate them with the GIS tools with which she was more familiar.

The local information was used to achieve the following sub objectives, as mentioned in Section 1.1:

- Analysing and converting local knowledge in spatial information which can be used as inputs for spatial analysis of flooding.
- Spatially reconstructing the past flood events, based on memories and experiences of the affected communities.
- Using a combination of hydrodynamic modelling and community-based criteria to determine changes in flood behaviour and threats as a result of urban development processes.
- Spatial Multi Criteria Evaluation using community derived factors contributing to the vulnerability of the households in the study area.
- Spatial analysis and representation of the flood risk using present, future and climate change scenarios.

In the following sections the main findings and conclusions are presented on the conversion of local flood knowledge into spatial information, and on the use of this data for flood hazard, vulnerability and risk assessment.

11.2.1 Converting local flood knowledge into spatial information

In Section 11.1.1 the characteristics of local flood-related knowledge were presented. There are a series of conventional tools that can be used to collect this knowledge, which have been widely used in community-based disaster management projects. The incorporation of spatial analysis tools in the collection of local knowledge offers a number of advantages that give this information an added value.

Local flood risk related information has an important <u>spatial component</u>. The severity of flood events differs in space, the households have different characteristics in different parts of the Barangays, and the environmental conditions also change spatially. The collection of local knowledge with its spatial components can be spatially captured and spatially analyzed. The geo-referencing capabilities of mobile GIS are therefore a very important advantage, and complement other type of information for instance the one stored in attribute tables.

The storage of local knowledge in a GIS also makes sure that the information is not lost. In many of the conventional community-based methods, the results of the surveys `disappear`, as the drawings, transects and community maps, end up in the garbage bin, a drawer, or at best in a report once the project has ended. The research results from this GIS-based analysis remain useable and can be easily updated in future.

GIS based local information can also be more easily shared with actors that were not part of the original community-based exercises. The information on flood scenarios, vulnerability factors and coping strategies can be used by the municipal authorities and NGOs that will be working in the Barangays in the future.

Local flood-related knowledge stored in a GIS can be visualized in many different ways, allowing for a better communication of the results to the local communities, municipality and other actors. As indicated in Chapter 3 the maps that were produced were used in workshops with the communities and in discussions with municipal officers.

Another advantage of the approach was that during fieldwork the respondents were not just passive providers of data. The participatory GIS tools allowed the respondents to input, validate, question and react according to their agreement with the spatial information that had been generated.

The information collected as a series of points, related to the locations of interviewed individuals or surveyed households can be used in a GIS as inputs for maps depicting the situation over the entire Barangay area. The interpolation of punctual information on water depth and velocity into flood scenarios for the entire study area is a good example of that (see Chapter 6). Point information can be used to identify the most vulnerable households and overlay these with the flood scenarios. Data obtained from interviews was also used to improve the Digital Terrain Model.

Point information was used to reconstruct a number of historic flood scenarios. When the existing flood hazard maps available with the municipality (figure 4.6) are compared with the community-based results as shown in figure 6.7, 6.12 and 6.16, it can be concluded that the latter ones provide a much more detailed picture. The spatial differentiation between Manageability classes is particularly high for the flood events with small and moderate return periods.

The evaluation of the completeness and consistency of the local knowledge, once it is stored in a GIS, can be done much more efficiently, as presented in Section 6.2.2.

Local knowledge stored in a GIS can be a very good source for validating information derived from other sources. For example the results of flood modelling, as presented in Chapter 7, were validated with the point information on historic flood events derived from the community. Without this information it would be impossible to evaluate the accuracy of these models.

Once such models have proven to be accurate, they can be used to analyse future flood scenarios. This prediction of future events is not possible based on local information alone, as the latter only refers to information of the past and the present.

11.2.2 Local knowledge and GIS-assisted risk assessment

Local knowledge extracted from the communities was analysed and introduced into the reconstruction of past events (Chapter 6), hydrodynamic analysis of flood hazard (Chapter 7), Multi-criteria vulnerability assessment (Chapters 8 and 9) and risk scenarios analysis(Chapter 10).

Local knowledge was integrated with hydrological modelling, and the results shown in Chapter 7 reveal aspects about flood hazard dynamics that cannot be obtained when these methods are performed in isolation. The use of the hydrodynamic SOBEK model allowed analysing a wide range of flood scenarios in an innovative way. The flood extension, water depth, flow velocity and period of inundation could be analyzed for flood events with three different return periods (2, 10 and 20-year), and for three different time periods: past, present and future scenarios in which changes in environmental setting and urban development have been taken into account. Through the classification of the results using the community-based manageability classes it was possible to broaden the analysis from a hydrological point of view (looking at flood characteristics) to the effect the floods will have on the local communities.

A key finding in the joint implementation of this combination of approaches was the confirmation that changes in flood hazard become more visible when small to moderate events such as the 2 or 10-year periods are included in the hazard analysis. These small flood events are usually overlooked in flood modelling, as they are not perceived as hazardous by the modellers or planners. Nevertheless in this research it was evident that the analysis of such events clearly reflects the changes in flood behaviour as result of for instance the coexistence of contrasting socioeconomic land uses (i.e industrial and residential for urban poor) and the effects of raising part of the terrain for commercial activities.

The hydrodynamic analysis demonstrated that poorly implemented modifications in the landscape often increase the hazard levels for the poorest sectors in the Barangays. By modifying the terrain to protect their investments the wealthiest shift the floodwaters, and thus the hazard, to the ones occupying the lowest surroundings. The analysis evidenced that these harmful development processes also mask the negative consequences that especially small flood events represent for certain groups. The compartmentalization of the terrain in higher and lower patches makes the overall threat go unperceived and unnoticed into conventional or large-scale hazard assessments.

The results from the hydrodynamic models can be used in several phases of disaster risk management. The main application presented in this research is their use in flood hazard and risk assessment. However, the results can also be used for emergency preparedness, where model results can be used to determine the time that floods will reach a certain height and broader processes of development planning.

The spatial assessment of vulnerability performed in Chapters 8 and 9 also benefited from the combined use of Spatial Multi Criteria Evaluation and local knowledge. The approach helped to overcome one of the problems faced by the application of only participatory approaches: how to extrapolate the information from household level to a more representative scale (homogeneous unit, administrative zone or ward). On the other hand, the integration of socioeconomic features from households into zones should not lead to a loss of detail in the information. This was carried out by dividing the ward into *homogenous units of households* whose social, economic, physical and environmental characteristics were similar.

In this task the structural or built environment helped to 'spatially' represent the socioeconomic conditions of the families. Physical aspects of buildings are strongly related with the social and economic status of the households living in it, as was evidenced by direct observation and in-depth interviews. However, physical aspects were not enough to explain why a given household living in a certain type of house is socially and economically vulnerable to floods and typhoons. Therefore the building classification was complemented with techniques such as direct mapping, narratives from people and transects with officers and local leaders that know the zones and the households settled there well.

The use of Spatial Multi-Criteria Evaluation for vulnerability assessment facilitated the introduction of tacit knowledge and peoples' priorities and perceptions into this type of analysis. The methods used by this module are interactive and use a logic that is understandable by local people. Therefore its use permitted the translation of local actor's perspectives into quantifiable spatial values for flood vulnerability and risk assessment.

The implementation of local knowledge into flood risk analysis for several scenarios performed in Chapter 10 constituted a critical step towards the understanding of the risk dimensions at ward level. The contextualised qualitative and quantitative assessments provided insights into the consequences that damage and losses represent for the communities in the studied wards. Indicators for the estimation of income loss, building damage and other aspects present in the studied area allowed substantiating the impact that inundations may have on individual families.

11.3 Recommendations

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 spatial analysis and modelling of flood risk. The resulting information should for the basis for subsequent flood risk management programmes by the local authorities. Unfortunately this could not be properly investigated in the Naga situation. The following section will discuss this issue and provide a number of recommendations.

11.3.1 Use of local flood risk assessment by municipal authorities in Naga

As mentioned in section 11.1.2 the Local Government Unit of Naga does not put a lot of emphasis on flood risk reduction, as they are more concentrated on disaster response. This lack of concern influences also the information management processes. For instance, it was found that the few flood hazard maps available are too general, and are not updated since they were produced (around 2001). In addition, the Civil Engineering Office (CEO) has no digital files of the existing drainage system and no drainage master plan. Most of the tasks and decisions about drainage construction and management are based on the tacit knowledge of the officers in charge. Although the Local Government Unit of Naga has an Electronic Data Processing Office (EDP) department, the municipality does not make use of the existing GIS capacity for flood risk reduction.

At municipal and ward level there are very few written documents and maps available to external actors in Naga (i.e. the researcher). For instance at ward level, as part of the disaster management duties, officers have to prepare a 'contingency plan' for emergency response. When a copy of this plan was requested it was found that the plan is a tacit agreement about tasks and responsibilities among local officers. When asked if they considered it important to convert the plan into a written document they responded that there is no need for that as 'they already know what to do...'

Through interviews with local government officers it was found that only some of them considered that a better information management system based on local knowledge would be of great help for improving their activities, while others were not convinced (see narratives 1 and 2 in Box 11.1). More than the tools and technology Naga is lacking the human resources and motivation to implement the use of geo-information and local knowledge for flood and risk management, as in most of the small municipalities in developing countries.

In order to incorporate the methodology presented in this research into DRM at municipal level, it is required that government officers and decision-makers recognize the importance of local flood risk assessment. Flood risk management based on local capacities needs to become a cross-cutting issue for the overall management and development of the city.

Box 11. 1 Excerpt of the interviews to local officers regarding the potential use of spatial information and local knowledge

<u>Narrative 1</u> Interview with Mr B. City Health Officer – CHO (May, 2005)

-‘ I think information displayed in formats such as maps can facilitate coordination of activities with other offices delivering services or programmes related with health issues (i.e CHO, ENRO, CSWO). It can also help us to focus more on matters such as stagnated waters treatment, for instance children living around these areas can be more closely monitored as well as the improvement of long term monitoring of patients’
-‘ ..maps can make some complex situations more understandable’
- ‘We could focus in areas where people perceived there are unhealthy conditions or environmental problems....’

<u>Narrative 2</u> Excerpt from interview with Mr F. City Engineer Officer – CEO Drainage Maintenance officer (May, 2005)

-‘I don’t see how maps or any other spatial information can improve our performance as we already know what to do…’
-‘..Activities for de-clogging are prepared or prioritized based on the knowledge we have develop through routines in our activities..’
- “I don’t think this type of information can ‘change the situation’…what should be done is to educate the people’

The same tools currently available in the Electronic Data Processing Unit (EDP) of the municipality which local officers use for monitoring tax collection (GPS and GIS software) can also be used for mapping flood scenarios and many other issues in the studied areas. Other software tools such as the hydrodynamic modelling software SOBEK might be more difficult to implement due to the high costs. However, it is also possible to use freeware or open source software for hydraulic modelling such as the 1Dimensional (1D) HEC-RAS programme. Also open source software for GIS (e.g. ILWIS) and mobile GIS (e.g. Cybertracker) can be used, allowing more work places at decentralized locations. Municipal and local Barangay officers and other community leaders should be trained in the collection of data and use of mobile GIS.

Nowadays there are new ways to enter and display spatial information in free access platforms such as Google Earth that are more visible and accessible for planners. With the expansion and coverage of the internet the possibilities are increasing that local communities can produce and handle their own information, and therefore contribute to the decision-making process. The increasing availability of new communication technology that has Geo-Positioning systems built-in such as iphones and mobile phones, will certainly attract Philippinos.

The methodology enables local authorities and communities to collect relevant information at a low cost which can be applied to make effective risk management decisions. Its utility can be maximised by making the GIS data available for other municipal activities as for instance planning, health, education, urban poor programmes and the like.

11.3.2 Some general recommendations

Some general recommendations derived from this study are addressed to other researchers and the local authorities in Naga (and to other municipalities in similar situations).

The multidisciplinary nature of local flood-related knowledge and of the tools to use these requires a team of professionals from different backgrounds: social scientists, economists, civil engineers and natural scientists. However, this research also demonstrates that an open attitude, common sense and the earnest application of participatory tools can allow even an earth scientist to apply the methodology by him/herself. Yet, the inclusion of professionals with a social sciences background is very desirable. Sociologists, social workers, social pedagogues are trained in behavioural aspects, working with conflicts, promoting participation and teamwork.

There is a need to further investigate in how far flood-affected communities will be able to adapt to weather phenomena correlated with global warming and climate change. The research evidenced that people in these communities are already adapted to deal with flooding until certain stages and still are able to cope and survive. What will be important to determine is whether those mechanisms will be helpful in a changing environment in terms of climate change, globalisation and increased demand for resources. Determining the extent to which people will be still able to *manage* flooding making use of the strategies they have developed until now should be the next focus for research in these communities.

Flood risk management is part of the task of the local authorities. Up to now those responsibilities have been more oriented toward response and provision of relief after a typhoon or flood took place, than towards a comprehensive management of the risk. After every event that hits the people, the municipality is providing first aid, food and some material for the people to repair their houses. However as an interviewee in one of the communities explained 'the municipality gave us *nippa* leaves to repair the roof of our house. However it is like throwing that money into the storm… as the *nippa* will be gone with the next typhoon'. As analysed in this research, measures that do not target the root causes of vulnerability (in the previous example this was the lack of resources for building safe houses) are just driving at risk people into more poverty and marginality.

This research showed that the policy of land-filling and landscape modifications solved the flood problems of the wealthy but created more problems for the poorer sections and indirectly for the municipality. Increased flood hazard for poor households living in low-lying areas implies more relief assistance from the municipality every time a flood takes place. This implies that the municipality is increasing the problem and the expenses for themselves. An adequate and innovative practice will be to allocate the lowest-lying areas close to the river (for instance where the programme for housing for the urban poor is located now) to the wealthy ones. They have the means to elevate the terrain and construct the drainages that are required. The municipality then can invest in elevating the terrain for the poor and in implementing the best construction practices and systems for their housing.

One of the local officers in Naga expressed that '*...Maps by themselves are not going to save people..*.' The researcher fully agrees with this statement, and it is her opinion that the action of many people is required for the reduction of disaster risk in Naga and in developing countries in general. However these actions need to be well planned, and for such planning relevant spatial local information is essential. A data poor environment does not exist, when you acknowledge the existence of local knowledge…

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SUMMARY

Quite often in the field of Disaster Risk Management the potential contribution of at-risk communities is underappreciated. Risk assessments are mostly based on scientific models which prioritise the use of probabilistic and spatial information. As a consequence, the outcomes portray the situation from the perspective of the scientists involved whereas the knowledge, experiences, capacities and priorities of communities at risk are often ignored as valuable input in the process. Arguments for the poor level of integration of local knowledge into conventional and GIS-based assessments are that it is perceived as 'unscientific', not always easy to retrieve, difficult to be expressed in quantitative terms or to be converted into a spatial format. This research developed an approach that recognises local knowledge as a crucial input in flood risk assessment and management. It focused on the way in which people in flood-prone urban environments perceive and understand the threats that these increasingly 'human-induced' events represent to their everyday life. By learning from local people and combining their experiences with the technical and GIS know-how the researcher's objective was to understand – in respect of flood risk-, what knowledge they have, how they apply it in their daily life and how it can be made available and become meaningful to other actors.

The study was carried out in two wards (locally know as Barangays): Triangulo and Mabolo in Naga City, the Philippines. Owing to its location, the presence of flood has caused problems throughout its history, and the local authorities have a clear interest in improving the flood disaster risk management. The communities in both wards have to cope with frequently occurring flooding events, which are mostly related to typhoons, and high intensity rainstorm events.

The methodology used for the study has followed a so-called 'learning-based' approach. During the extensive fieldwork period the researcher had the opportunity to get closer to the communities in their own context and attain a good understanding of many of the aspects related to their 'risk' reality. Through dialogue, debate and joint mapping it was possible to elicit their memories and experiences with past inundations, as well as the mechanisms and strategies they use in order to cope with these events. Later on, this knowledge was incorporated and spatially modelled in a GIS environment.

The initial step in the research consisted of the implementation of participatory and GIS-based methods that allowed eliciting and structuring the experiences of the flood-affected people in such a way that they provided a picture of the complicated flood problems. The hazard assessment was aimed at integrating flood extent mapping based on participatory approaches with hydrological flood modelling and GIS-based analysis. The first approach to the spatial analysis of flood hazard comprised the reconstruction of past events from the experiences of the community making use of the data gathered through the GIS-supported surveys and interviews. Through interviews and workshops the flood hazard was translated into so-called 'manageability classes' representing the way the communities considered the flood problems in terms of flood height, flood extension, period of flooding and the season in which the flooding takes place. Manageability expresses the way local communities experience flooding in relation to their capacity to deal with the situation, depending on their resources and coping mechanisms. The second method involved the use of hydrodynamic modelling using the SOBEK software. Flood modelling was carried out for three flood scenarios, related to floods with a 2, 10 and 20 year return period, which are comparable to three historic flood and Typhoon events, analysed using the community-based approach. Each of the three scenarios was analysed under three different situations of development, characterised by the three Digital Surface Models (DSM) for the past, present and future urban development, in which the new development areas are often constructed on elevated terrain, which causes higher flood problems to the communities settled in the lower parts. The results of the flood modelling were validated with the community-based flood extent maps, and the final flood hazard maps were represented in terms of the 'manageability classes' defined by the communities.

For vulnerability assessment also a participatory approach was used to identify and analyse the elements that constitute the households 'resource band' against flooding which included the aspects related to vulnerability and coping capacity. In order to upscale the household vulnerability analysis to ward level both Barangays were subdivided into `homogeneous units of households' which consisted of families with

more or less similar socio-economics conditions. Each of these homogeneous units was characterised with indicators such as socio-economic status, income source, total family income, people living below food and poverty thresholds, household size, dependency ratio, housing types, land tenure, health status, sources and access to drinking water, sanitary facilities, waste disposal practices, access to services and development-related infrastructure (drainage, public transport, roads and public facilities), and access to community services both during 'normal' and crisis times. The indicators and categories comprising the indicators were combined using Spatial Multi Criteria Evaluation.

The integration of the hazard and vulnerability information in a risk assessment was the final step in the research, using both qualitative and quantitative approaches. In the qualitative approach the flood hazard maps for the three flood events were combined with the vulnerability assessment using a qualitative matrix approach. A quantitative analysis was used to develop four risk scenarios for present (2005) and future (2012) urban development and climate change scenarios. The losses for these communities related to the occurrence of flood events with 2, 10 and 20-year return period were calculated by making use of indicators for livelihood, housing and public facilities. Flood risk was expressed in monetary terms such as the amount of income that will be lost, the cost of replacement of damaged elements and the like.

The main findings of the research are:

- At Barangay level the individual and collective knowledge within the communities was found to be extensive, in terms of identifying and characterizing flood phenomena, coherent, precise, context-specific, complex and dynamic.
- The use of local knowledge from communities is therefore relevant and an important asset for the flood risk management at local level. This resource 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 understanding of coping strategies and manageability is a powerful tool for managing disaster risk at local and municipal level. The manageability concept can provide local authorities with a better indicator on the effectiveness of their programmes and policies for the urban poor residing in flood-prone areas than using information on water depth and duration or on population distribution and characteristics separately.
- The flood-related local knowledge can be structured and systematically organised into spatial and non-spatial inputs in a GIS environment. Local flood risk related knowledge 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 the environmental conditions also change spatially. The research demonstrated that local knowledge with its spatial components can be spatially captured and spatially analyzed.
- The combination of local knowledge with hydrological modelling and spatial analysis is considered the optimal approach for risk estimations of future scenarios, which may include a range of urban planning alternatives and differences in flood behaviour due to climate change .

Finally this study demonstrated that by storing, manipulating and analysing local flood related knowledge in a GIS environment it's utility for planning and risk management is maximised, since it can be always retrieved and shared by other actors in the decision-making arena.

SAMENVATTING

De potentiële bijdrage van lokale gemeenschappen aan risicomanagement wordt vaak ondergewaardeerd. Risico bepalingen zijn meestal gebaseerd op wetenschappelijke modellen die prioriteit geven aan ruimtelijke en probabilistische informatie. De resultaten weerspiegelen dan ook meestal meer de meningen van de wetenschappers, terwijl de kennis, ervaring, capaciteit en voorkeuren van de lokale gemeenschappen die zelf in het risicogebied wonen hierbij vaak worden genegeerd. Het lage nivo van integratie van lokale kennis en ervaring in een GIS gebaseerde risicobepaling wordt vaak toegeschreven aan het feit dat deze kennis als niet wetenschappelijk wordt beschouwd, ze moeilijk kwantitatieve uit te drukken is, of om te zetten in een ruimtelijke formaat.

Dit onderzoek ontwikkelde een methode die lokale kennis als een cruciaal gegeven beschouwt voor overstromingsrisicobepaling en management. De focus was gericht op de ervaringen van mensen in overstromingsgevoelige urbane gebieden met de dreiging van overstromingen en hoe deze, steeds meer door de mens veroorzaakte, gebeurtenissen impact hebben op hun dagelijks leven. Door het leren van de ervaringen van de lokale bevolking, en die te combineren met technische GIS kennis, werd het mogelijk om te onderzoeken en te begrijpen welke kennis er aanwezig is in lokale gemeenschappen, hoe ze die toepassen in hun dagelijks leven en hoe deze kennis beschikbaar gemaakt kan worden voor andere belanghebbenden.

Het onderzoek werd uitgevoerd de wijken (barangays) Mabolo en Triangulo in de stad Naga in de Filippijnen. Vanwege hun ligging hebben deze gebieden een lange geschiedenis van overstromingen, en de lokale autoriteiten hebben er groot belang bij om het huidige nivo van overstromingsrisicomanagement te verbeteren. De gemeenschappen in beide wijken hebben vaak te kampen met overstromingen die meestal gerelateerd zijn aan tyfonen en zware stormen met hoge regenintensiteit.

De gevolgde methodiek had de karakteristieken van een ‘learning-based approach’. De onderzoeker had tijdens het veldwerk de mogelijkheid om in nauw contact te komen met de lokale gemeenschappen in hun eigen context en daardoor een ruimer begrip te krijgen over de realiteit van hun risico. Door middel van dialoog, debat en interactie was het mogelijk om hun herinneringen en ervaringen met overstromingen te onthullen, evenals de mechanismes en strategieën die ze gebruiken om met deze gebeurtenissen om te gaan. Deze kennis werd later ingebracht in ruimtelijke modellering in een GIS omgeving.

De eerste aanzet van het onderzoek bestond uit het gebruik van participatieve en GIS gebaseerde methodes voor het onthullen en in kaart brengen van de ervaringen van de lokale bevolking met overstromingen zodat er een volledig beeld ontstond van de complexe problematiek. De bepaling van overstromingsgevaar was gericht op het integreren van informatie over historische overstromingen gebaseerd op participatieve methodes met hydrologische modellering en GIS analyse. De eerste aanpak van de ruimtelijke bepaling van overstromingsgevaar bestond uit de reconstructie van historische gebeurtenissen vanuit de ervaringen van de mensen in de lokale gemeenschappen, waarbij gebruikt gemaakt werd van de gegevens die verzameld waren m.b.v. participatieve GIS technieken. Door middel van interviews en workshops was het mogelijk om het overstromingsgevaar te vertalen naar zogenaamde ‘beheersbaarheid klassen’, die de mate aangeven waarop de lokale bevolking het probleem inschat met betrekking tot de waterhoogte, uitbreiding, periode en seizoen waarin de overstroming plaatsvindt. De beheersbaarheid refereert aan de ervaring van lokale gemeenschappen met overstromingen in relatie tot hun capaciteiten om de impact te absorberen, afhankelijk van hun hulpbronnen en weerstandsmechanismes . De tweede methode voor het bepalen van overstromingsgevaar maakte gebruik van hydrodynamisch modellering, met behulp van de Sobek software. Drie

overstromingscenario's met verschillende terugkeerperiodes van 2, 10 en 20 jaar werden gemodelleerd. Deze zijn representatief voor drie historische overstromingen veroorzaakt door tyfonen die eerder geanalyseerd waren met behulp van de participatieve methodes. Elk van deze drie scenario's werd geanalyseerd voor drie verschillende periodes in de tijd (verleden, heden en toekomst). Elk van deze werd gekarakteriseerd door een digitaal hoogtemodel dat de situatie weergeeft m.b.t. stadsuitbreidinggebieden, welke in Naga meestal worden aangelegd op verhoogde stukken land, waardoor de lager geleden gemeenschappen geconfronteerd worden met een groter overstromingsprobleem. De resultaten van de overstromingsmodellen werden gevalideerd met de historische overstromingsscenario's die gereconstrueerd waren via de participatieve methode. De uiteindelijke gevarenkaarten werden geclassificeerd met behulp van de beheersbaarheidklassen die door de gemeenschappen bepaald waren.

Voor de analyse van de kwetsbaarheid werd ook gekozen voor een participatieve methode, om de verschillende elementen te identificeren en analyseren die de zogenaamde 'kwetsbaarheidmarge' van huishoudens m.b.t. overstromingen bepalen. Voor het opschalen van het nivo van huishoudens naar dat van de barangays, werd gebruikt gemaakt van homogene eenheden van huishoudens met min of meer dezelfde socio-economische omstandigheden, Elke van deze homogene eenheden werd gekarakteriseerd met een aantal indicatoren, zoals sociaal economisch nivo, bron van inkomsten, familie inkomen, het aantal mensen dat onder de armoedegrens leeft, de grootte van huishoudens, de afhankelijkheidratio, gebouwentypes, gezondheid, toegang tot drinkwater, sanitair, afvalverwerking, toegang tot diensten en infrastructuur (zoals drainage, openbaar vervoer, en wegen), en toegang tot gemeenschapsdiensten tijdens normale en crisis periodes. De indicatoren weren gecombineerd met behulp van multi criteria analyse in een GIS.

De integratie van de informatie over gevaren en kwetsbaarheid in de risicoanalyse was de laatste stap binnen het onderzoek, waarbij gebruik gemaakt werd van kwalitatieve en kwantitatieve methodes. In de kwalitatieve methode werd de gevarenkaart gecombineerd met een kwetsbaarheidskaart, via een kwalitatieve risico matrix. Een kwantitatieve methode werd gebruikt voor 4 risico scenario's voor de huidige situatie en de mogelijke situatie in 2015 waarbij rekening gehouden werd met stadsuitbreiding en met de effecten van klimaatverandering. De verliezen van gemeenschappen als gevolg van overstromingen met 2, 10 en 20 jaar herhalingstijd werden berekend en uitgedrukt als verliezen in inkomen, en de kosten van beschadigde elementen.

Het onderzoek leverde de volgende resultaten op:

- De collectieve kennis die aanwezig is binnen de barangays m.b.t. de overstromingsproblematiek is zeer uitgebreid, coherent, exact, context specifiek, complex en dynamisch.
- Het gebruik van kennis van lokale gemeenschappen is een belangrijke voorwaarde voor risicomanagement op lokaal nivo. Dit is vooral belangrijk in ontwikkelingslanden, waar de cruciale informatie en de technische en financiële middelen om deze te verzamelen, vaak ontbreken.
- Het begrip van de "coping strategies" en de "beheersbaarheid" (manageability) is een belangrijk hulpmiddel voor rampenbestrijding op lokaal and gemeentelijk nivo. Het 'beheersbaarheid' concept kan lokale autoriteiten een goede indicatie bieden voor de effectiviteit van hun programma's en beleid voor de arme stedelijke bevolking in overstromingsgebieden. Deze indicatie is beter dan het afzonderlijk gebruik van waterdiepte, overstromingsduur en bevolkingskarakteristieken.
- De lokale overstromingsgerelateerde kennis kan geïntegreerd worden op een systematisch manier in (ruimtelijke) gegevens binnen een GIS omgeving. Lokale overstromingsrisicoinformatie heeft een belangrijke ruimtelijke component. De intensiteit van overstromingen varieert ruimtelijk, de huishoudens hebben verschillende karakteristieken over de verschillende barangays, en het leefmilieu

verandert ook met de afstand. Dit onderzoek heeft aangetoond dat lokale kennis ruimtelijke kan worden verzameld en vastgelegd.

- De combinatie van lokale kennis met hydrologische modellering en ruimtelijke analyse biedt een ideale mogelijkheid voor het ondersteunen van schadeschattingen voor toekomstige overstromingsrisicoscenario's, waarbij rekening gehouden wordt met toekomstige stadsuitbreiding en de effecten van klimaatsverandering.

Tot slot heeft deze studie aangetoond dat door het opslaan en analyseren in een GIS omgeving deze kennis behouden blijft en maximaal toegepast kan worden in planning en risicomanagement, en het ook naderhand gebruikt kan worden door verschillende belanghebbenden bij het nemen van beslissingen.

RESUMEN

A menudo en el área del Manejo del Riesgo de Desastres la contribución de las comunidades no es tenida en cuenta. La mayoría de las evaluaciones de riesgo se caracterizan por usar modelos científicos que solo priorizan el uso de información probabilística y espacial. Estos diagnósticos, en consecuencia están generalmente enfocados desde la perspectiva de los profesionales involucrados, en tanto que los conocimientos, percepciones, capacidades y prioridades de las comunidades en riesgo son excluídos sin tener en cuenta que pueden constituir un valioso aporte a los procesos de manejo del riesgo. Algunas de las razones para la poca integración de las experiencias y perspectivas de riesgo de las comunidades en los análisis de riesgo, por ejemplo en aquellos que aplican tecnologías SIG, se basan en la percepción del conocimiento local como 'poco científico', difícil de recolectar y cuantificar y aun más de ser convertido o expresado en términos y formatos espaciales y geo-referenciados.

Esta investigación desarrollo una metodología que reconoce el conocimiento local como un recurso decisivo para los procesos de identificación y manejo del riesgo. El trabajo se enfoca en el entender la forma en la cual las comunidades que viven en áreas susceptibles a inundaciones, especialmente en ambientes urbanos, perciben y entienden las amenazas que estos fenómenos representan para su vida diaria. Al aprender de las comunidades y combinar las experiencias de los locales con el conocimiento técnico y el uso de los SIG, el objetivo de la investigadora fue entender – al menos en lo respecta al riesgo por inundaciones – el conocimiento que tienen las comunidades investigadas, como lo aplican en su vida diaria y como éste se puede transformar en información relevante y útil para los procesos de toma de decisiones, especialmente para la planificación del territorio y la gestión del riesgo de desastres.

El estudio fue llevado a cabo en dos barrios (conocidos localmente como 'Barangays'): Triangulo y Mabolo, en la Ciudad de Naga en Las Filipinas. La ocurrencia de inundaciones ha acarreado problemas a la ciudad desde tiempos históricos debido a su ubicación. Igualmente las comunidades en las dos zonas de estudio tienen que enfrentar inundaciones recurrentes, debidas a precipitaciones extremas asociadas a la temporada de huracanes. De allí que las autoridades municipales tengan un claro interés en mejorar el manejo que se le ha venido dando al riesgo por inundaciones y a los desastres acarreados por estas.

Para llevar a cabo el estudio se implementó una metodología caracterizada por su énfasis en el aprendizaje. Durante el trabajo de campo la investigadora tuvo la oportunidad de acercarse a las comunidades en su propio contexto y adquirir un amplio entendimiento del desarrollo de su vida diaria en medio de las condiciones de riesgo. A través de actividades que estimulaban el dialogo, debate e interacción fue posible sacar a flote sus recuerdos y experiencias con inundaciones anteriores y conocer las estrategias usadas para sobrevivir y enfrentar estos eventos. Finalmente, este conocimiento fue incorporado y modelado espacialmente en un ambiente SIG.

El paso inicial en la investigación consistió en la implementación de técnicas puramente comunitarias hasta la aplicación de SIG participativo y de técnicas convencionales de modelación en SIG. Estos métodos se usaron para recobrar y estructurar las experiencias de las comunidades con las inundaciones de tal forma que brinden un panorama lo mas completo posible acerca de de los complejos problemas enfrentados por ellos. La identificación y el análisis de la amenaza se enfocaron en la integración del mapeo de la extensión y duración de las inundaciones a partir del uso de métodos participativos con los resultados de modelaciones hidrológicas y análisis y modelación SIG. El procedimiento inicial, implementado para el análisis de la amenaza, esta relacionado con la reconstrucción espacial y temporal de inundaciones que han ocurrido en el pasado con base en los recuerdos y experiencias de las comunidades afectadas. Estas experiencias se recolectaron por medio de entrevistas y muestreos geo-

referenciados. A partir de conocimiento local obtenido por medio de entrevistas y talleres las percepciones de amenaza por inundación fueron traducidas en lo que en esta investigación ha sido llamado '*etapas de manejabilidad*' las cuales expresan la forma en que las comunidades experimentan y confrontan la problemática derivada de las inundaciones en términos de la altura, duración, área afectada y el período del año en el cual estas ocurren. La '*capacidad de manejo*' (o manejabilidad) expresa la forma en la cual las comunidades a nivel local confrontan las inundaciones en relación a su propia capacidad de enfrentar la situación con sus propios recursos y usando los mecanismos de protección que ellos mismos han desarrollado a través del tiempo. El segundo método involucró el uso de modelos hidrológicos en el programa SOBEK. Esta modelación se llevó a cabo para tres eventos con períodos de retorno de 2, 10 y 20 años; los cuales fueron comparables con las tres inundaciones históricas reconstruidas a partir de las experiencias de las comunidades. Cada uno de estos eventos fue analizado para tres escenarios de desarrollo urbano caracterizados por medio de los Modelos de Elevación Superficial (DSM) para las situaciones *pasada, presente* y *futura*. Esta modelación tuv en cuenta que los nuevos desarrollos son a menudo construidos en terrenos elevados artificialmente, lo cual agrava los problemas causados por las inundaciones a las comunidades asentadas en los terrenos bajos o aquellas cuyos habitantes no tienen los recursos económicos para elevarlos.

Los resultados de los modelos hidrológicos fueron validados con los mapas derivados por métodos participativos y los mapas de amenaza finales fueron representados en términos de la '*capacidad de manejo*' definida por las comunidades.

El análisis de la vulnerabilidad se llevó a cabo utilizando igualmente métodos participativos. En este caso se identificaron y analizaron los elementos que constituyen el 'conjunto de recursos' de las comunidades y familias así como los factores que contribuyen a hacerlos más susceptibles; los recursos existentes para contrarrestar los efectos negativos de las inundaciones también fueron tenidos en cuenta. Con el fin de llevar el análisis de vulnerabilidad del nivel familiar a una escala espacial mas representativa como es la de barrio o distrito, ambas áreas se subdividieron en '*unidades homogéneas de familias'* las cuales consistían de grupos familiares con condiciones socioeconómicas relativamente similares. En cada una de estas unidades se caracterizó la distribución de indicadores tales como estatus socioeconómico, fuentes de ingresos, ingreso total, numero de personas viviendo bajo niveles básicos de alimentación y pobreza, numero de personas por familia, personas dependiendo del ingreso, tipo de vivienda, propiedad de la tierra, salubridad, fuentes y tipo de acceso a servicios básicos (agua potable, unidades sanitarias), practicas para la disposición de basuras, acceso a servicios e infraestructura urbana (drenajes, transporte publico, vias y facilidades publicas) y el acceso a servicios comunitarios durante periodos de 'normalidad' y de crisis. Los indicadores y las categorías incluidas dentro de estos fueron combinados usando un modulo de Evaluación Espacial Multicriterio.

La integración de los análisis de amenaza y vulnerabilidad en la estimación y asignación cualitativa y cuantitativa de riesgo por inundación fue el paso final de la presente investigación. En el método cualitativo los mapas de amenaza para los tres periodos de retorno se combinaron con el analisis de vulnerabilidad por medio de una matriz de riesgo. El analisis cuantitativo fue usado para desarrollar escenarios de riesgo para los niveles de desarrollo *presente* o línea base (2005) y *futura* (2012) y de cambio climático. Las pérdidas para las comunidades a raíz de la ocurrencia de inundaciones con periodos de retorno de 2, 10 y 20 años se calcularon por medio de indicadores y dependiendo de aspectos tales como ingreso de acuerdo a la ocupación, daños en las residencias, servicios públicos etc. El riesgo por inundación fue expresado en términos monetarios tales como la cantidad de ingresos que se dejaran de percibir, costo de reemplazamiento de los elementos dañados entre otros.

Algunos de los principales hallazgos de esta investigación son:

- Inicialmente se encontró que el conocimiento presente entre las comunidades tanto a nivel individual como colectivo es vasto y muy completo particularmente a la hora de identificar y caracterizar los fenómenos hidrológicos que los afectan. El conocimiento local encontrado presenta también altos niveles de coherencia, identificación con el contexto además de ser complejo y dinámico.
- El uso del conocimiento local encontrado entre las comunidades en riesgo es por lo tanto relevante y constituye un importante activo para la gestión del riesgo a nivel local. El conocimiento local constituye un recurso particularmente importante para los países en desarrollo donde un gran porcentaje de la información necesaria para los análisis de riesgo así como los recursos técnicos y económicos para producirlos son escasos o aun inexistentes.
- El entendimiento de las estrategias para enfrentar las inundaciones y de la 'capacidad de manejo' (o manejabilidad) de las mismas por parte de las comunidades puede llegar a ser un elemento eficaz para el manejo y la gestión del riesgo a nivel tanto local como municipal. Mas que el uso separado de información acerca de las alturas alcanzadas por las inundaciones, su duración o en las características y distribución de la población afectada, el concepto de manejabilidad puede brindar a las autoridades locales un indicador amplio y eficaz de la efectividad de sus políticas y programas especialmente aquellos implementados para las comunidades mas pobres asentadas en áreas susceptibles a inundaciones.
- El conocimiento local, en este caso el relacionado con inundaciones, puede ser estructurado y convertido en información espacial y no espacial con potencial para ser integrada a un ambiente SIG. Tanto el conocimiento local como la información derivada de él tienen un componente espacial importante. La severidad de las inundaciones difiere en su distribución espacial, las familias tienen diferentes características de acuerdo al sector del barrio que ocupan y las condiciones ambientales y urbanísticas también varían en el espacio. La presente investigación demostró que el conocimiento de las comunidades y sus componentes espaciales pueden ser capturados, geo-referenciados e integrados a análisis espaciales.
- La combinación de conocimiento local con programas y modelos de vanguardia por ejemplo para modelación hidrogeológica y análisis espacial constituyen una plataforma ideal para respaldar las estimaciones y análisis de riesgo mediante el uso de escenarios a futuro, los cuales pueden incluir desde proyectos de expansión urbana hasta cambios debidos al cambio climático y calentamiento global.

Finamente este estudio demostró que al almacenar, manipular y analizar el conocimiento local en un ambiente SIG la utilidad del mismo se maximiza ya que siempre puede ser usado, compartido y puesto al servicio de otros actores en el área de la gestión del riesgo y el planeamiento territorial entre otros.

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