UNESCO-RAPCA project

Flood risk assessment in San Sebastián, Guatemala: a methodology for data-poor environments

This case study has been developed within the framework of the ITC - UNESCO project *Regional Action Program for Central America (RAP-CA),* which is a subprogram of the programme "*Capacity Building for Natural Disaster Reduction Program" (CBNDR),* funded by the Netherlands government through UNESCO. This program, launched in 1999, focuses on capacity building for natural disaster reduction. For more information visit the following link http://www.unesco.org/science/earthsciences/disaster/disasterRAP-CA.htm

Summary

This exercise deals with the design of vulnerability functions regarding flood risk assessment for the city of San Sebastián, Guatemala. The hazard's main source of information is the reconstruction of the 1998 flood scenario based on data gathered from the experience of the inhabitants of city. Vulnerability information is obtained from a small-scale census carried out by Peters and collaborators (2002). Although insufficient as to carry out a conventional flood hazard and risk analysis, the existing data is processed in such a way that a preliminary but reliable flood hazard scenario can be created allowing the definition of vulnerability functions and estimation of expected loss.

Disclaimer

The material in this exercise is for training purposes only. The results should not be used in actual planning of the city of San Sebastian as ITC does not guarantee the accuracy and precision of the input data and adequacy of the methodology developed during the exercise.

The GIS software that will be used in this exercise is the Integrated Land and Water Information System (ILWIS), version 3.x, developed by the International Institute for Geo-Information Science and Earth Observation (ITC). Information: www.itc.nl

Introduction

Very often hazard and risk assessment studies should face the fact that not all the required input data for carrying out conventional analysis is available. Hazard and risk conventional analysis have as pre-requisite the existence of sufficient and appropriate data sets, which would allow the implementation of complex examination procedures leading to an accurate characterization of the specific threaten phenomena and the most likely magnitude of their impact. The most common situation is, however, lack of sufficient and appropriate data, shortage of budget for data collection, or even time constraints. Despite this situation hazard and risk assessment analysis should be produced. Working in data-poor environments, especially in developing countries, tends to be the rule and not the exception. This situation puts forward the need for the developing of suitable methodologies allowing the utmost generation of reliable information from few basic data to be used for the decision-making process.

Peters (2003) suggested the use of secondary data sources, namely small-scale census and reconstruction of community-based knowledge (historic records of hazardous events still present in the community's memory), as a possible alternative to tackle the difficulties posed by the lack of sufficient scientific data. Disadvantages of this technique are several: the so called "community's memory" can be biased in relation to the specific event's experience of the informants; the event's time frame from which data is gathered rarely can be extended beyond one generation; events occurring outside populated areas tend to be underestimated or even ignored influencing estimations of recurrence periods. The main advantage, however, is that the technique would allow a "rapid" definition of preliminary hazard and risk scenarios, which could be used for supporting decision-making processes. Besides, a preliminary hazard and risk diagnostic could help in deciding how to allocate the already scarce resources.

The following exercise introduces an alternative methodology that makes use of community's experience on flood historical events to derive the information required to carry out a flood risk assessment in the municipality of San Sebastián, Guatemala.

The municipality of San Sebastián is located in the Sierra Madre mountain range, in the middle part of the Samala river basin and in the surroundings of the Santa Maria–Santiaguito volcanic complex, active since 1922. This geographical location added to the frequent heavy rains in the Central America Pacific Coast (occasionally magnified by tropical depressions or hurricanes), makes this region prone to a range of natural hazards, the most recent ones being earthquakes, Lahars and floods. The minor tributaries of Samala River such as Tzununa, Ixpatz and Cachel cause most of the flood hazard. Besides the natural causes, anthropic factors like drastic changes in the land cover and uncontrolled and unplanned urban growth along river banks, are narrowing the riverbeds, lowering their discharge capacity and causing frequent flooding, even at a comparatively less precipitation, and exposing more elements at risk (Peters, 2003)

The reader is invited, after going through the exercise, to critically review the methodological and technical concepts upon which the exercise has been designed. For more information about the methodology herein described the reader is referred to the work by Peters (2003) "Flood risk assessment for the town of San Sebastián in Guatemala".

Objectives and practical application

- Reconstruction of flood hazard scenario based on field-collected data regarding previous events.
- Design of vulnerability functions for flood risk assessment based on damage records from previous events.
- Assessment of the expected flood damage (loss, risk) for the urban area of San Sebastián, Guatemala.

Expected outputs

- ✓ Reconstruction of the 1998 flood scenario.
- ✓ Vulnerability functions for each type of building materials.
- ✓ Vulnerability assessment map.
- ✓ Expected loss map.

Instructions

1.1 Reconstruction of the 1998 flood hazard scenario.

A conventional flood hazard assessment requires a complete characterization of the basin's hydrolological regime and detailed geomorphological mapping as basic inputs. These data were not available for San Sebastián and was not feasible to rapidly acquire it. To overcome this situation and produce a flood hazard risk scenario, Peters (2003) proposed an alternative methodology. According to the author, it would be possible to use data collected through direct interviews with the affected community to reconstruct the main characteristics of past events. That information could then be used for risk assessment purposes.

In November 1998, as a result of the Mitch hurricane, a severe flood affected the city of San Sebastián. Despite the lack of local records of the precipitation intensity, it is considered that the rainfall occurred during the Mitch event can be regarded as among the most severe in recent history, which allow hypothetically classifying them as the maximum precipitation values for the 25-50 years return period flood (Peters, 2002).

This part of the exercise deals with the reconstruction of the 1998 flood hazard scenario based on the information provided by the affected communities. The scenario will later be used for the generation of the vulnerability functions used in the risk assessment and expected loss estimation.

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- Use the point data set, collected in the field, on the water depth of the 1998 flood event to reconstruct the flood hazard scenario in the urban area of San Sebastián. Analyze the point data set and define an appropriate interpolation technique. Peters (2003) suggested the use of Krigging (Spherical model; Nugget: 400; sill: 1850; Range: 170) as the most suited interpolation technique. Compare Peter's suggestion with your findings, draw your conclusions and proceed with the reconstruction of the flood hazard scenario. Explain your choice for a specific interpolation method.

1.2 Analysis of the reconstructed 1998 flood hazard scenario.

The question of model reliability is posed after having derived the flood hazard scenario using the interpolation process: how could the reconstructed scenario be validated? A simple answer could be: by comparing the flood depth patterns against a detailed terrain model of the affected area. Lower areas would correspond to higher water depth values. This approach, however, does not consider the effects that other objects such as buildings or infrastructure could have on the flood depth distribution patterns.

The available data on ground height value collected by Peters (2003) is used here to validate the reliability of the 1998 reconstructed flood hazard scenario.

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- Prepare a DTM for the urban area of San Sebastián using the height value data collected in the field.
- Compare the DTM against the flood hazard scenario. Can you, based on this comparison, explain the flood's water depth distribution patterns in the urban area of San Sebastián? Explain your findings.

1.3 Analysis of the 1998 flood damage report against the reconstructed flood hazard scenario.

The next step after defining the flood hazard scenario is to compare it against the flood damage report in order to derive the relationships that could explain such damage pattern. Different building types are analyzed regarding the characteristics of the flood and the inflicted damage level.

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- Compare the 1998 flood-damage map against the reconstructed 1998 flood hazard scenario and draw some conclusions about the damage pattern: consider aspects such as building materials and damage level against water depth and distance to the nearest streams.

1.4 Defining vulnerability functions.

Due to the lack of information, flood vulnerability functions will be designed considering only water depth and distance to the nearest steam. For creating the vulnerability functions follow the flow chart shown in figure 1

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- Use the 1998 flood damage report and the reconstructed 1998 flood hazard scenario to derive the vulnerability functions for each type of building materials.

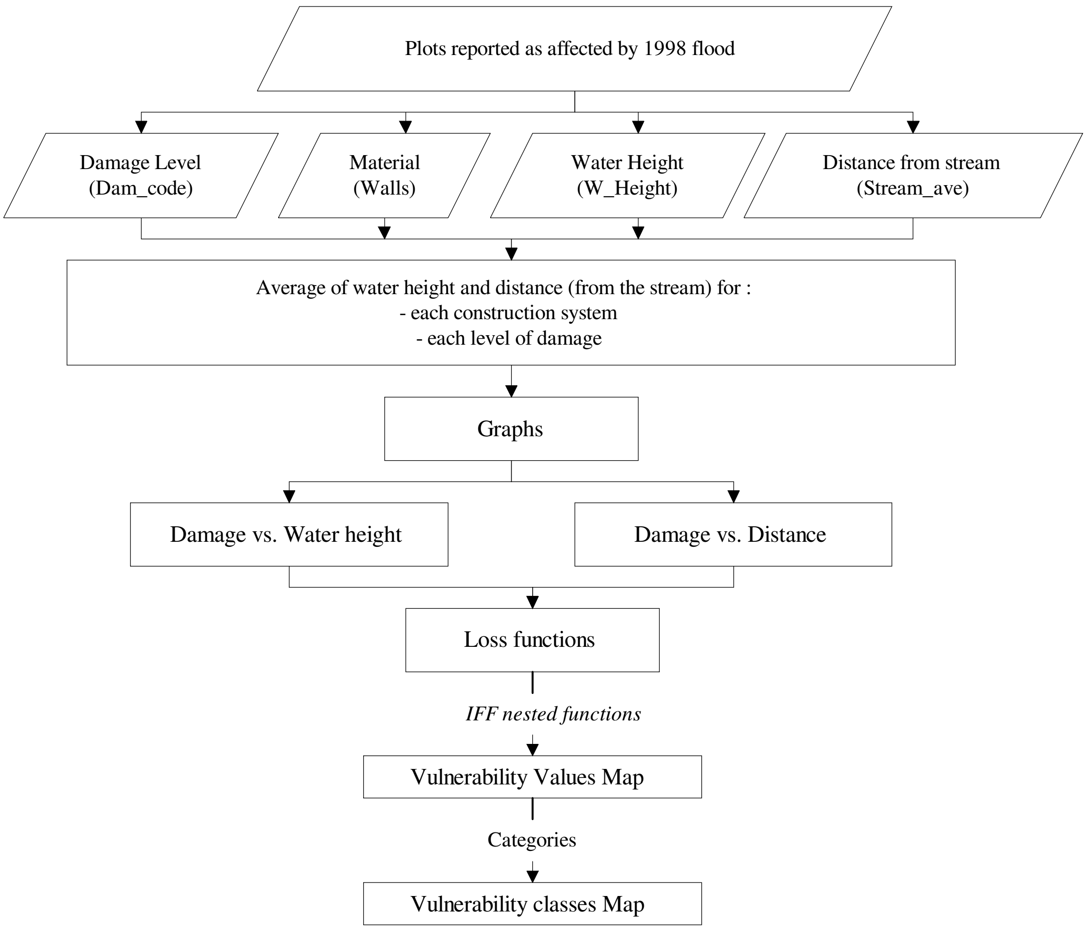

Figure 1: Defining vulnerability functions (Peters, 2003)

1.5 Creating the vulnerability maps.

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- Create vulnerability maps for the urban area of San Sebastián using the estimated loss functions and the existing cadastral data set (collected in the field).
- Using the information provided in table 3, create an expected loss map for the city of San Sebastián.
- Could the expected loss map be used to prioritize San Sebastián urban areas for intervention aiming at reduction of expected loss? Explain your answer giving some examples.
- Design a map to present your results.

References

Peters, G. G. Flood risk assessment for the town of San Sebastián in Guatemala. MSc thesis ITC 2003

UNESCO - ITC. Capacity Building for Natural Disaster Reduction (CBNDR) Regional Action Program for Central America (RAPCA). Zonificación de Amenazas Naturales en la cuenca del río Samalá y Análisis de vulnerabilidad y riesgo en la población de San Sebastián Retalhuleu, Guatemala, Centro América. September 2003

Table 1. Materials

Basic data/map name	Format	Description	Comments
Aerialphotomosaic	Raster	Photo mosaic covering urban area of San Sebastian	Ortho-rectified
Elevations	Points	Elevation values San Sebastián urban area	Data collected in the field by Peters (2003) could be used to derive DTM and compare against water depth from the 1998 flood.
Perimeter	Polygon	Delimitation of study area in San Sebastián	
Streams	Segments	Streams San Sebastián	Main street considered as a canal during the 98 flood event
Roads	Segments	Roads urban area San Sebastián	
Ssroads	Polygons	Roads urban area San Sebastián	Attribute table allow classification on material types
Hazard data/map name	**Format**	**Description**	**Comments**
SSdamage	Points	Damage categories for the 1998 flood	
Sswheight	Points	Water height 1998 flood	
Vulnerability data/map name	**Format**	**Description**	**Comments**
Ssblocks	Points	Codes for San Sebastián urban blocks	Codes defined by Peters 2003
Sscantons	Points	Codes for San Sebastián urban wards	Code defined by Peters 2003
Ssurban	Segments	San Sebastián urban area, blocks and lot boundaries	Derived from aerial photo-interpretation
Ssinfraestructure	Points	Labels infrastructure and attributes	See attached tables for attribute's description
Ssurb_infra	Polygons	SSurban polygonized with infrastructure points	
Bridginfo	Points	Location of bridges in the urban area and attributes	
Ssmaterialsc	Table	Building materials and attributes.	See attached tables for attribute's description
Sssocioeconomic	Table	Socioeconomic conditions	
Content_lv	Table	Building's content value classes	See attached tables for attribute's description

Table 2. Description of cadastral database attributes (Peters, 2003)

Attribute Name <u>Table</u>. *Column*	Description	Records
<u>**SSinfrastructure**</u>	In this **table** information about function and physical parameters of the buildings was stored	
Name	Unique identifier for each plot. The first character and number correspond to the Zone, the next two numbers identify the block or "Manzana", and the last two ones identify the plot inside the block.	i.e.Z1M101 for Urban,ZSB101 for rural plots
Type	Specify for each plot the kind of structure, if it corresponds to a house, building, church, etc	Appendix 1
Function	Identify the use given to the structure or space in the plot: residential, governmental, services within a list of 22 possible ones.	Appendix 1
Age	Recorded by selecting an age interval for buildings, among six possible ones	Appendix 1
State	Describes the actual condition of the physical part of the structure within a list of 10 possible ones.	Appendix 1
N_floors	The number of floors of each house or building was recorded using either of three possibilities.	Appendix 1
Damage	Qualitative assessment for the flood damage reported for a specific plot, with five categories from No damage to destroyed	see Table 3.3
Dam_code	Quantitative assessment for the damage, from 0 (No damage) to 5 (destroyed)	see Table 3.3
Height_cm	Water height (in centimeters) reached during the 1998 flood in a parcel	
<u>**SSMaterialsc**</u>	**Table**. Displays information about physical features and materials for each one of the structural components of buildings.	
Roof	Categorizes the material of the roof for a given dwelling using either of five possibilities.	Appendix 1
Walls	Eight options were available to specify material a building was made of	Appendix 1
Floor_M	Material covering the base of the building, six options were found	Appendix 1
Height_st	Measurement (in cm) of the height, above the street, of the first point from which water can enter inside a building, generally it coincides with the main entrance (but exceptions were found)	
Foundations	Determines whether the dwelling has solid bases beneath it	Yes/No
Fences	Inform about the existence of potential flood prevention. The height (in cm) of the same was recorded.	
<u>**SSsocioeconomic**</u>	This **table** stores information about social and economic characteristics of buildings and their inhabitants.	
Socioe_level	Characterizes the socioeconomic level of a building based on physical parameters like state, material, content and general wealth. Five options were available	Appendix 1
Content_Iv	Five possibilities were available to qualify contents of building, lists 1 to 4 were used for housing and list 5 for buildings with another function	See Table 5.3
Comcontent_vl	Displays the value of the content of buildings with function different from housing, like shops, stores, services etc	Appendix 1
Com_value	Displays the commercial value assigned to each parcel. For the valuation: type, function, state, construction system and number of floors.	Appendix 1
Crops_st	Determines whether people store harvesting products or not	Yes/No
Second_plot	Inform about the tenure of a second property (specially dwelling) in a different place or town	Appendix 1
Veh_Own	Depicts which households owning private or public transportation facilities	Yes/No

Table 3. Lists of assets for house's contents estimation. Prices are given in Quetzals (Peters 2003). Verify the exchange rate USD - Quetzals , www.oanda.com.

Item	List 1	List 2	List 3	List 4
Sofa set			(1) 1500	(1) 4000
Dining set	(1) 600	(1) 1000	(1) 2200	(1) 3500
Beds	(2) 600	(3) 4500	(4) 6000	(5) 9000
Mattress	(2) 300	(3) 1200	(4) 2000	(5) 2500
Auxiliary Tables	(2) 200	(2) 350	(3) 650	(5) 1200
Wardrobe	(1) 250	(2) 600	(3) 1000	(4) 2000
Sewing machine	(1) 1000	(1) 1300	(1) 1300	(1) 1500
Typewriter machine			(1) 1000	
Television Set	(1) 400	(1) 850	(2) 2300	(3) 5500
Radio System	(1) 250	(1) 1500	(2) 5000	(2) 8000
Computer set				(1) 3500
Video, DVD			(1) 1200	(1) 1800
Video camera				(1) 2000
Fixed Telephone			(1) 300	(1) 400
Mobile			(1) 600	(2) 1600
Washing Machine				(1) 5500
Refrigerator		(1) 1500	(1) 3000	(2) 7000
Vacuum cleaner				(1) 1000
Gas stove		(1) 1200	(1) 3000	(1) 3500
Microwave			(1) 850	(1) 1000
Electric stove				(1) 4500
Juicer-mixer			(1) 450	(1) 650
Rice cooker				(1) 900
Iron	(1) 150	(1) 150	(1) 250	(1) 250
Juicer				(1) 400
Coffee-machine				(1) 500
Electric fan		(1) 200	(1) 350	(2) 700
Bikes		(2) 1600	(4) 3600	(4) 5600
TOTAL	**3750**	**15950**	**36550**	**78000**