

# UNESCO-RAPCA project

## Developing a methodology for multi hazard vulnerability (risk) assessment: case study of the Arenal de Monserrat micro basin, San Salvador

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

In this exercise the reader is requested to develop a methodology for vulnerability (risk) assessment in a multi hazard environment using data on the Arenal de Monserrat micro basin, El Salvador. Hazard scenarios are given; the aim is to develop single hazard vulnerability (risk) scenarios and to appropriately combine them allowing the creation of a total vulnerability (risk) map.

### Disclaimer

The material in this exercise is for training purposes only. The results should not be used in actual planning of the Arenal de Monserrat micro basin as ITC does not guarantee the accuracy and precision of the input data and adequacy of 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 3.2, developed by the International Institute for Geo-Information Science and Earth Observation (ITC). Information: [www.itc.nl](http://www.itc.nl).

### Introduction

Very often hazard scenarios for specific locations cannot be completely depicted with the assessment of a single threatening phenomenon or event. In some cases different menacing events could onset simultaneously (or with relatively short time lag between them). For example, earthquakes can trigger landslides, floods, and even fires; hurricanes commonly bring along floods and landslides; etc. In this case, characteristics of the secondary events are dependent on the magnitude of the first one. In other cases, the sites of interest can be located in areas where different types of events can occur within certain time frame but not necessarily at the same time; for instance a town located on a flood prone and seismically active zone. Events could take place independently of each other. In both such situations a multi-hazard approach is required, and consequently a multi-hazard risk assessment.

Single hazard risk assessment methodologies are well described in the current literature. The question posed in this exercise concerns the multi hazard situation. Could the multi hazard risk assessment simply be accounted as the sum of the individual hazard risk evaluations? Or, as previously stated, should the multi hazard risk assessment have into account whether events are independent of each other to determine the total risk scenario?

In this exercise the reader is requested to develop a methodology for carrying out a qualitative multi-hazard vulnerability (risk) analysis using data on the Arenal de Monserrat micro basin, El Salvador. Hazard scenarios

are given; the aim is to develop single hazard vulnerability (risk) scenarios and to appropriately combine them allowing the creation of a total vulnerability (risk) map.

### Objectives and practical application


- Develop a methodology for analysing vulnerability (risk) in a multi hazard environment
- Create a qualitative multi hazard vulnerability (risk) map for the Arenal de Montserrat micro basin in El Salvador.

### Expected outputs

- ✓ Outline of the developed qualitative multi hazard vulnerability (risk) assessment methodology.
- ✓ Qualitative multi-hazard vulnerability (risk) assessment map for the Arenal de Montserrat micro basin

### Instructions

#### 1.1 Getting familiar with the data

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  - Open and analyse the different data sets depicting the landslide and flood hazard scenarios. Compare them against drainage network, slope steepness, geology and soils map. Draw some conclusions regarding the characteristics of the areas belonging to the high hazard classes.
  - Open and analyse the data set on elements at risk. Write down those attributes that could be used for the vulnerability (risk) assessment process.

#### 1.2 Multi hazard vulnerability (risk) assessment

As stated in the introduction, the main objective of this exercise is to develop a multi hazard risk assessment methodology using the existing data on the Arenal de Montserrat micro basin. Multi hazard risk assessment methodologies have been discussed by different authors (Badilla et al, 2002 <http://www.adpc.ait.ac.th/audmp/rllw/themes/th1-westen.pdf>; Geoscience Australia & Bureau of Meteorology <http://www.ga.gov.au/pdf/GA1486.pdf> among others). The reader is invited to review the methodologies discussed in the mentioned documents before continuing with the exercise.

As the starting point for the developing of a multi hazard vulnerability (risk) assessment methodology, the reader is invited to analyse the following suggestion:

- ✓ Individual hazard vulnerability maps are combined into a single global vulnerability map (cross operation). Keeping in mind differences in hazard scenarios, i.e. return periods.
- ✓ The output map is analysed and further subdivision is made between those areas exposed to a unique hazard and those areas exposed to two (2) or more hazards for the specified time frame of analysis.
- ✓ The final multi hazard vulnerability map will be defined as follows
  - The vulnerability in those areas subjected to a single hazard is defined by the vulnerability corresponding to that specific hazard
  - The one representing the larger expected damage determines the vulnerability in those areas subjected to more than one type of hazard. For instance, if the classes low seismic hazard vulnerability and high flood hazard vulnerability overlap in a certain area, the global vulnerability of that area is defined as high, provided that the same time frame is considered.



- Using the methodology herein suggested and taking into account the given hazard scenarios and elements at risk data, prepare the multi hazard vulnerability map for the Arenal de Monserrat micro basin.
- Explain the vulnerability functions you will use for creating the specific hazard vulnerability maps (landslides, floods). If required search the web or any other sources for extra information.
- Discuss the results explaining advantages and limitations of this approach.
- Would you propose a different methodology? If yes, then describe it and apply it using the data on the Arenal de Monserrat micro basin.

So far you have analysed the existing vulnerability conditions in the Arenal de Monserrat basin. Using the data on the municipality projected land use plan and the vulnerability functions you have previously defined, analyse the potential vulnerability conditions. Assume that the hazard scenarios are not modified. The data on the projected land use plans can be found in the files “UsoprojectadosueloAltaDensidadInfraestructura” (projected land use high infrastructure density) and “UsoprojectadoSueloBajaDensidadInfraestructura” (projected land use low infrastructure density).



- Analyse the multi hazard vulnerability scenario considering the projected land use plans for the Arenal de Monserrat micro basin.
- Discuss the results explaining advantages and limitations of the projected land use plan.
- What would you suggest regarding the projected land use plan ?

## References

UNESCO - ITC. Capacity Building for Natural Disaster Reduction (CBNDR) Regional Action Program for Central America (RAPCA). Análisis de riesgo por inundaciones y deslizamientos de tierra en la microcuenca del Arenal de Monserrat, San Salvador, Centro América. November 2003

## Materials

Basic data/map name	Format	Description	Comments
Lambert-1	Coordinate system	Coordinate system projection for Central America	
Dem	Georeference	Georeference 5 m pixel size used by the Dem	
Cuenca - 10	Georeference	Georeference 10 m pixel size used by most raster maps for the analysis process	
Contourlines	Segments	5 m contour interval	
Demarenal	Raster	5 m pixel size	Derived from Contourlines
BasinPerimeter	Raster	Arenal watershed perimeter	
SubCatchments	Polygons, Raster, Segments, points	Main (?) watersheds	Imported from dxf file
Rivers	Segment	Drainage network	
Roads	Segments, raster	Roads map	Attributes: only names.
Municipalities	Polygons, Raster, Segments, points	Municipalities Georeference 10 m pixel size (Cuenca- 10)	No attributes
Relief	Polygons, Raster, Segments, points	Geomorphological units (?) Arenal Basin	No Attributes
Geology	Polygon file	Local geology map	Attribute table: geological units are coded but there is not a complete description
Suelos	Polygons, Raster, Segments, points	Soil's distribution Arenal watershed	
IkonosArenal	Raster	Ikonos panchromatic study area Arenal Basin	
Vulnerability data/map name	Format	Description	Comments
Infrastructure	Raster, points	Infrastructure map	Points describing types of structures
Type_inf	Polygons	Polygons grouping blocks on infrastructure type	
Pop_Density	Polygons, Raster, Segments, points	Population density	Original source of population density values not present
Parcel_density	Polygons, Raster, Segments, points	Zonation of the Arenal Basin based on average extension of farming lots (?)	
BasicLandUse49	Polygons, Raster,	Basic land use map 1949	
BasicLandUse72	Polygons, Raster,	Basic land use map 1972	
DetailedLandUse02	Polygons, Raster,	Detailed land use map 2002	
ProjectedLandUseMapHigh-	Polygons,	Projected land use, high	Time span of the

InfrastructureDensity		infrastructure density	projection not specified
ProjectedLandUseMapLow-InfrastructureDensity	Polygons,	Projected land use, low infrastructure density	Time span of the projection not specified
<b>Hazard data/map name</b>	<b>Format</b>	<b>Description</b>	<b>Comments</b>
LandslideHazard	Polygons	Landslide hazard Zonation for the arenal Basin	Created in Pcraster using a deterministic approach, parameters not specified
FloodHazard	Polygons	Flood hazard zonation for the Arenal basin	Created in Pcraster using a deterministic approach, parameters not specified?