Comparative risk assessments for Guadeloupe: earthquakes and storm surge

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To cite this version:

Arnaud Réveillère, Daniel Monfort, Sophie Lecacheux, Ludovic Grisanti, Héloïse Muller, et al.. Comparative risk assessments for Guadeloupe: earthquakes and storm surge. EGU General Assembly 2012, Apr 2012, Vienne, Austria. hal-00709386

HAL Id: hal-00709386
https://hal-brgm.archives-ouvertes.fr/hal-00709386

Submitted on 18 Jun 2012

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Comparative risk assessments for Guadeloupe: earthquakes and storm surge

Réveillère, Monfort, Lecacheux, Grisanti, Müller, Bertil, Rohmer, Sedan, Douglas, Baills, Modaressi

Presentation outline

- Assets estimation & seismic loss estimation methodology
- Validation based Les Saintes 2004 M6.3 earthquake
- Probabilistic seismic losses
- Probabilistic storm surge hazard methodology
Probabilistic risk assessment & comparison

> Risk is characterized by:

- its likelihood → Return period
- its measurement → Direct economic losses

> Incomplete but quantitative measure of the disaster

<table>
<thead>
<tr>
<th>Form of damage</th>
<th>Tangible</th>
<th>Intangible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Physical damage to assets:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- buildings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- contents</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- infrastructure</td>
<td></td>
</tr>
<tr>
<td>Indirect</td>
<td>Loss of industrial production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Traffic disruption</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- emergency costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Loss of life</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- health effects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Loss of ecological goods</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Inconvenience of post-flood recovery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Increased vulnerability of survivors</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Uhlemann et al., 2011

Grüntthal et al., 2006, for the city of Cologne
Assets estimation – construction cost / m²

> **based on the construction value** rather than on the market value of the building
  
similarly to Kleist & al., 2006; FEMA, 2003; Dutta et al., 2003

> **Local and recent data** are used, if possible

<table>
<thead>
<tr>
<th>Construction type</th>
<th>Construction cost (€ per net floor area)</th>
<th>Source (incl. year and location)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual housing</td>
<td>1127</td>
<td>EPTB 2010 for Overseas Territories</td>
</tr>
<tr>
<td>Collective housing</td>
<td>1000</td>
<td>Based on the average social housing price in Guadeloupe</td>
</tr>
<tr>
<td>Shelter</td>
<td>600</td>
<td>Assumption</td>
</tr>
<tr>
<td>Industrial / large business</td>
<td>1390</td>
<td>Based on market price</td>
</tr>
</tbody>
</table>
## Assets estimation – average surface

### Living Surface
*per occupancy type*

<table>
<thead>
<tr>
<th>Occupancy type</th>
<th>Average living space per dwelling</th>
<th>Source (incl. year and location)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional housing</td>
<td>71 m²</td>
<td>INSEE, 2006, for Guadeloupe</td>
</tr>
<tr>
<td>Recent private housing</td>
<td>101 m²</td>
<td>INSEE, 2006, for Guadeloupe</td>
</tr>
<tr>
<td>Villa</td>
<td>150 m²</td>
<td>Assumption</td>
</tr>
<tr>
<td>Collective housing</td>
<td>65 m²</td>
<td>INSEE, 2009 for France &amp; DGAFP, for France</td>
</tr>
<tr>
<td>Makeshift shelters</td>
<td>50 m²</td>
<td>Assumption</td>
</tr>
<tr>
<td>Industrial buildings</td>
<td>300 m²</td>
<td>CCI, for Guadeloupe</td>
</tr>
</tbody>
</table>
Assets estimation – overall methodology

Living Surface per occupancy type

Ratio of living space on net floor area

Occupancy type per SDRS type

Building value per construction type, per net floor area

Net floor area per SDRS type

Content estimation relatively to the occupation type

Structure replacement value per SDRS type

Content replacement value per SDRS type

« SDRS type »: building vulnerability typology defined by the « Regional Scenario for Seismic Risk » study & surveys. Cf. Bertil et al., 2009
**Assets estimation - results**

> Per vulnerability type

<table>
<thead>
<tr>
<th>SDRS type</th>
<th>Building stock in Guadeloupe</th>
<th>Replacement value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td><strong>Description</strong></td>
<td><strong>Nb of dwellings</strong></td>
</tr>
<tr>
<td>HABFOR</td>
<td>makeshift shelter</td>
<td>6 424</td>
</tr>
<tr>
<td>MCPIER</td>
<td>stone houses</td>
<td>609</td>
</tr>
<tr>
<td>CASTRA</td>
<td>traditionnal houses (wood)</td>
<td>15 710</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

> Total assets

<table>
<thead>
<tr>
<th>Economic sector</th>
<th>Guadeloupe exposed assets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (G €)</td>
</tr>
<tr>
<td>Private housing</td>
<td>36.5</td>
</tr>
<tr>
<td>Industry</td>
<td>1.1</td>
</tr>
<tr>
<td>Commerce &amp; service</td>
<td>5.7</td>
</tr>
<tr>
<td>Schools &amp; hospitals</td>
<td>4.4</td>
</tr>
<tr>
<td>Others (roads, energy &amp; water supply, etc.)</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>47.6</td>
</tr>
</tbody>
</table>
Loss estimation per Damage State

<table>
<thead>
<tr>
<th>EMS-98 DS</th>
<th>Structure damage ratio</th>
<th>Central damage factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>1</td>
<td>0-1%</td>
<td>0.5%</td>
</tr>
<tr>
<td>2</td>
<td>1-20%</td>
<td>10%</td>
</tr>
<tr>
<td>3</td>
<td>20-60%</td>
<td>40%</td>
</tr>
<tr>
<td>4</td>
<td>60-100%</td>
<td>80%</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

From Tyagunov et al. (2006) for German buildings typology

<table>
<thead>
<tr>
<th>EMS-98 DS</th>
<th>Replacement ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>1</td>
<td>1 %</td>
</tr>
<tr>
<td>2</td>
<td>2 %</td>
</tr>
<tr>
<td>3</td>
<td>12 %</td>
</tr>
<tr>
<td>4</td>
<td>25 %</td>
</tr>
<tr>
<td>5</td>
<td>50 %</td>
</tr>
</tbody>
</table>

Adapted from FEMA (2003) for US buildings typology

Loss ratio per DS
EMS 98 DS - % loss relation for:
- Structural repairs
- Content replacement
Validation using les Saintes (2004) EQ

Les Saintes M6.3 EQ hazard sc. → Damage State of exposed buildings → Loss ratio per DS EMS 98 DS - % loss relation for:
- Structural repairs
- Content replacement

Assets value Economic estimation of:
- Structural repair
- Content replacement

Les Saintes losses estimation

Damage & loss model

Available data

> Post-seismic damage observations
> Post-disaster cost estimations
Validation using les Saintes (2004) EQ

> Observations

- Damage: a few D4/D5 buildings, mostly light damages (cracks), concentrated in Les Saintes islands and the South of Basse Terre

- Direct economic losses:
  - CCR (French public reinsurance institution) : estimated 60 M€
  - 43% of households in Guadeloupe have a home insurance

→ Estimated cost: 140 M€

→ Overestimated cost. Hypotheses: no reimbursement of light damage (no declaration, insurance excess), signification of the CCR number, %loss - DS relation ...

> Loss modeling

- Damage localization and number coherent but slightly higher than the post-seismic observations

- Losses: 148 - 513 M€, central damage factor: 325 M€
Probabilistic seismic risk: losses (DS)

Probabilistic hazard assessment → Damage State of the exposed elements for a range of return time periods
SDRS Seismic vulnerability

> Loss calculations are based on a probabilistic seismic hazard map. This approach leads to slightly conservative results (Bommer and Crowley, 2006)

Damage map obtained using Armagedom loss estimation software (Sedan, 2003)
Probabilistic seismic risk: losses (€)

Probabilistic hazard assessment

Damage State of the exposed elements for a range of return time periods

Loss ratio per DS
EMS 98 DS - % loss relation for:
- Structural repairs
- Content replacement

Assets value
Economic estimation of:
- Structural repair
- Content replacement

Probabilistic direct losses for a range of return time periods

Preliminary results
The marine submersion of the coastal areas results from the conjugated effects of:

- the tide
- the atmospheric surge (due to wind and low atmospheric pressure)
- the waves set-up (local elevation of the mean sea level due to wave breaking)

The maximum level reached by the water is the run-up.
Probabilistic storm surge hazard: methodology

Database HURDAT (NOAA)

Selection of impacting cyclones (for waves and storm surge)

Parametric cyclonic wind and pressure fields

Offshore wave modelling (WAVES)

Nearshore wave modelling (SWAN)

Set-up calculation with empirical formula (Stockdon et al., 2006)

Time series of total water level

Statistical analysis with the POT method

Mapping of areas under specific return period levels

Données → Selection of 291 cyclones between 1910 and 2009

Data treatment → Parametric wind field (Holland’s model)

Cf. details in Lecacheux et al., 2012
Storm surge hazard: events modelling

- **WW3 (NOAA) (6')**
- **WW3 (2')**
- **SWAN (Univ. Delft) (100m)**

Waves (example: Dean 2007)

- **MARS (Ifremer)**

Atmospheric surge (example: Hugo 1989)
Probabilistic storm surge hazard: waves results

- Peaks Over Threshold sampling of the simulations for different locations around Guadeloupe

- Maximum likelihood fit with a Generalized Pareto Distribution

from Lecacheux et al., 2012
Further steps

> **Direct hazard comparison**
  - Validation of the economic losses (Les Saintes)
  - Finalization of the probabilistic storm surge hazard
  - Mapping inundated areas and estimating storm surge losses

> **Identification, quantification and propagation of uncertainties in the seismic loss calculation**

> Restriction to the area of Pointe à Pitre
Thank you!

Acknowledgement

- The research leading to these results has been carried out in the frame of the MATRIX Project, funded by the European Commission’s Seventh Framework Program [FP7/2007-2013] under grant agreement n° 265138. The BRGM research project RISCOTE has also co-funded the storm surge part.
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