Probabilistic Modelling of Natural Risks at the Global Level:

The Hybrid Loss Exceedance Curve

DEVELOPMENT OF METHODOLOGY AND IMPLEMENTATION OF CASE STUDIES

PHASE 1A: COLOMBIA, MÉXICO AND NEPAL

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consulting engineer

GAR11 Meeting, May 10 of 2011, Geneva
Loss exceedance curve?

*Because correlates economic loss with annual occurrence frequency*

*Because display “All” plausible events*
Hybrid loss exceedance curve?

Because correlates economic loss with annual occurrence frequency

Because display “All” plausible events

Because use two different universal sets
- *Retrospective: from disaster database’s*
- *Prospective: from disaster models*
Loss Exceedance Curve

✓ Correlates event frequency with expected economic loss.

Retrospective Analysis:
- Minor events (low affectation)
- High frequency

Prospective Analysis:
- Mayor events
- Low frequency
Retrospective Analysis

Analysis of what happen before.

Take into account minor events which can’t be modeled, due the complexity of the hazard models and the level of detail required for the exposure and vulnerability.

Useful for disasters with high frequency and low impact in assets, like:

- Hydro-meteorological
- Landslides
Retrospective Analysis

Requirements:
- Exhaustive inventory of past events.
- Detailed report of disaster consequences.
- Reports starting from one affected element.

DesInventar database
- [www.desinventar.org](http://www.desinventar.org)
- [www.desinventar.net](http://www.desinventar.net)
Retrospective Analysis

**DesInventar database**
- Reports disaster consequences in a third political level.
- Reports human and material affectation.
- Uses several event types.

**Economic model**
Retrospective Analysis

Colombia

[Graph showing accumulation of economic loss in USD millions over time with specific events highlighted.]
Retrospective Analysis

Colombia

![Graph showing accumulated economic loss over time for various events and return periods.]

- **Volcanic**
- **Earthquake**
- **Other events**
- **Hydrometeorological**
- **Landslides**

Legend:
- Very low
- Low
- Medium
- High

- **Economic loss participation [%]**
- **Return period [years]**

- **Earthquake**
- **Earthquake (AAL)**
- **Landslide (AAL)**
- **Hydro-meteorological (AAL)**
- **Other events (AAL)**
- **All events (AAL)**
- **Volcanic (AAL)**
Retrospective Analysis

México

Event, economic loss (\$USD) Millions

Accumulate economic loss (\$USD) Millions

Annualized loss
Accumulated
Events
México

Retrospective Analysis

![Graph showing economic loss over time for different events in México](image)

- Volcanic
- Earthquake
- Other events
- Hydrometeorological
- Landslides

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Return Period [years]</th>
<th>Economic Loss Participation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volcanic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthquake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrometeorological</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Landslides</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Earthquake
- Earthquake (AAL)
- Landslide (AAL)
- Hydro-meteorological (AAL)
- Other events (AAL)
- All events (AAL)
- Volcanic (AAL)
Retrospective Analysis

Nepal

Diagram showing economic loss per event and accumulated economic loss over time, with a focus on annualized loss and events.
Retrospective Analysis

**Nepal**

![Graph showing accumulated economic loss over time for different events in Nepal.](image-url)
Retrospective Analysis

Colombia

México

Nepal
Retrospective Analysis

**Colombia**

**México**
Prospective Analysis

Analysis of expected events.

Predicts future major events using well-characterized hazard models, using actual exposure and vulnerability.

Useful for disasters with low frequency and important impact in assets, like (mostly):
- Hurricanes
- Earthquakes
Prospective Analysis

Requirements:
- Hazard Model.
- Exposure database.
- Vulnerability models.

CAPRA Platform
• www.ecapra.org
Prospective Analysis

**Hazard Model**
✓ Exhaustive catalogue of events.
✓ Mutually exclusive.
✓ Probabilistic representation.

**Exposure Model**
Assets in the threatened area, including economical and human expose value.

**Vulnerability**
Behaviour model for each different structural system defined in the exposure database
Prospective Analysis
hazard model

Colombia

PGA [gals]

México

Nepal
Prospective Analysis

Exposure Model - Colombia

Distribution of exposed value of constructions

<table>
<thead>
<tr>
<th>Use group</th>
<th>Construction area (m²x10⁶)</th>
<th>Economic value (US$x10^{6})</th>
<th>Construction area / population from use group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential LP</td>
<td>81,123</td>
<td>17,259</td>
<td>m²/inhab LP 4.1</td>
</tr>
<tr>
<td>Residential MP</td>
<td>297,368</td>
<td>172,987</td>
<td>m²/inhab MP 13.7</td>
</tr>
<tr>
<td>Residential HP</td>
<td>27,700</td>
<td>25,572</td>
<td>m²/inhab HP 23.5</td>
</tr>
<tr>
<td>Commercial</td>
<td>234,469</td>
<td>129,370</td>
<td>m²/WF 20.0</td>
</tr>
<tr>
<td>Industry</td>
<td>129,840</td>
<td>114,624</td>
<td>m²/WF 50.0</td>
</tr>
<tr>
<td>Private Health</td>
<td>263</td>
<td>269</td>
<td>m²/1000 Inhab 6.1</td>
</tr>
<tr>
<td>Private Education</td>
<td>27,844</td>
<td>16,603</td>
<td>m²/Stud 2.2</td>
</tr>
<tr>
<td>Public Health</td>
<td>232</td>
<td>181</td>
<td>m²/1000 Inhab 5.4</td>
</tr>
<tr>
<td>Public Education</td>
<td>84,111</td>
<td>47,031</td>
<td>m²/Stud 6.8</td>
</tr>
<tr>
<td>Government</td>
<td>4,776.6</td>
<td>2,636</td>
<td>m²/PE 5.0</td>
</tr>
<tr>
<td>Total</td>
<td>887,527</td>
<td>526,531</td>
<td>m²/Urban Pop 27.3</td>
</tr>
</tbody>
</table>

LP: Low-income population; MP: Medium-income population; HP: High-income population
Prospective Analysis

Exposure Model - México

Distribution of exposed value of constructions
Prospective Analysis

Exposure Model - Nepal

### Distribution of exposed value of constructions

![Distribution map of Nepal showing the distribution of exposed value of constructions.]

<table>
<thead>
<tr>
<th>Use group</th>
<th>Construction area [m²*10⁶]</th>
<th>Economic value [US$*10⁶]</th>
<th>Construction area / population from use group</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP</td>
<td>37.211</td>
<td>1,805.1</td>
<td>m²/inhab LP</td>
</tr>
<tr>
<td>MP</td>
<td>239.044</td>
<td>23,482.5</td>
<td>m²/inhab MP</td>
</tr>
<tr>
<td>HP</td>
<td>22.606</td>
<td>3,447.0</td>
<td>m²/inhab HP</td>
</tr>
<tr>
<td>Commercial</td>
<td>59.760</td>
<td>8,896.2</td>
<td>m²/WF</td>
</tr>
<tr>
<td>Industry</td>
<td>53.409</td>
<td>7,893.2</td>
<td>m²/WF</td>
</tr>
<tr>
<td>Private Health</td>
<td>6</td>
<td>0.86</td>
<td>m²/1000 Inhab</td>
</tr>
<tr>
<td>Private Education</td>
<td>33.057</td>
<td>3,572.0</td>
<td>m²/Stud</td>
</tr>
<tr>
<td>Public Health</td>
<td>60</td>
<td>7.10</td>
<td>m²/1000 Inhab</td>
</tr>
<tr>
<td>Public Education</td>
<td>54.810</td>
<td>5,156.6</td>
<td>m²/Stud</td>
</tr>
<tr>
<td>Government</td>
<td>6.960</td>
<td>664.8</td>
<td>m²/PE</td>
</tr>
<tr>
<td>Total</td>
<td>506.922</td>
<td>51,925.5</td>
<td>m²/Urban Pop</td>
</tr>
</tbody>
</table>

LP: Low-income population; MP: Medium-income population; HP: High-income population.
Prospective Analysis
vulnerability models

Non-reinforced masonry

Reinforced concrete frames

... and several more.
Summary Fiscal Sector Risk - Colombia

Fiscal, public and low income sector assets

Summary of seismic risk results for the fiscal portfolio of Colombia

<table>
<thead>
<tr>
<th>Results</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure value</td>
<td>US$ mill.</td>
<td>$173,226</td>
</tr>
<tr>
<td>Annual average loss</td>
<td>US$ mill.</td>
<td>$316</td>
</tr>
<tr>
<td>%</td>
<td></td>
<td>1.8</td>
</tr>
</tbody>
</table>

PML

<table>
<thead>
<tr>
<th>Return period</th>
<th>Loss</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>years</td>
<td>US$ mill.</td>
<td>%</td>
</tr>
<tr>
<td>100</td>
<td>$2,976</td>
<td>1.7%</td>
</tr>
<tr>
<td>250</td>
<td>$4,417</td>
<td>2.5%</td>
</tr>
<tr>
<td>500</td>
<td>$5,655</td>
<td>3.3%</td>
</tr>
<tr>
<td>1,000</td>
<td>$7,126</td>
<td>4.1%</td>
</tr>
<tr>
<td>1,500</td>
<td>$7,625</td>
<td>4.4%</td>
</tr>
</tbody>
</table>

Loss exceedance curve for the fiscal portfolio of Colombia (Seismic risk)
Summary Fiscal Sector Risk - México
Fiscal, public and low income sector assets

Loss exceedance curve for the fiscal portfolio of Mexico
Prospective Analysis

Summary Fiscal Sector Risk - Nepal
Fiscal, public and low income sector assets

Loss exceedance curve for the fiscal portfolio of Nepal

Summary of seismic risk results for the fiscal portfolio of Nepal

<table>
<thead>
<tr>
<th>Exposed value</th>
<th>US$ mill.</th>
<th>$15,479</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average annual loss</td>
<td>US$ mill.</td>
<td>207</td>
</tr>
<tr>
<td>%</td>
<td>13%</td>
<td></td>
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</tbody>
</table>

PML

<table>
<thead>
<tr>
<th>Return period</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>years</td>
<td>US$ mill.</td>
</tr>
<tr>
<td>100</td>
<td>$1,071</td>
</tr>
<tr>
<td>250</td>
<td>$1,365</td>
</tr>
<tr>
<td>500</td>
<td>$1,512</td>
</tr>
<tr>
<td>1,000</td>
<td>$1,784</td>
</tr>
<tr>
<td>1,500</td>
<td>$1,829</td>
</tr>
</tbody>
</table>
“Hybrid” loss exceedance curve

Colombia

México

Nepal
“Hybrid” loss exceedance curve

AAL Comparative

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Colombia</td>
<td>380</td>
<td>360</td>
<td>316</td>
<td>490</td>
</tr>
<tr>
<td>Mexico</td>
<td>2,760</td>
<td>2,540</td>
<td>810</td>
<td>2,424</td>
</tr>
<tr>
<td>Nepal</td>
<td>54</td>
<td>52</td>
<td>207</td>
<td>235</td>
</tr>
</tbody>
</table>