Disaster Risk Assessment:
Disaster Risk Mapping

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Session Outline

• Essentials on Risk Mapping
  – Map scale, grid size, aggregation unit
• Requirements for Risk Mapping
  – Data, software tool, and equipments
• Thematic Mapping Approaches
  – Hazard/event intensity, exposure, risk maps
• National Risk Atlas
  – Structure, map design, map indexes
What is Risk Mapping?

- Risk mapping is the process of establishing the spatial and temporal extent of risk (combining information on probability and consequences).
- Risk mapping requires combining maps of hazards, exposure, and vulnerability functions.
- The results of risk mapping are usually presented in the form of maps that show the magnitude and nature of the risk.
## Map Scale

<table>
<thead>
<tr>
<th>Mapping Scale</th>
<th>Application Level</th>
<th>Purposes of GIS Application</th>
<th>Data Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1,000,000 or smaller</td>
<td>National</td>
<td>● Formulation of national disaster risk management strategy; ● Inventory of major hazards in the country; ● Identification of areas affected or threatened for an entire country</td>
<td>National scale information is as required. The required details of the input data is low.</td>
</tr>
<tr>
<td>1:100,000-1:1,000,000</td>
<td>Provincial</td>
<td>● Draft regional development projects or large engineering projects; ● Utilised more for spatial analysis at this scale, although the type of analysis will mostly be qualitative, due to the lack of detailed information.</td>
<td>The required details of the input data is still rather low.</td>
</tr>
<tr>
<td>1:25,000 - 1:100,000</td>
<td>District or county</td>
<td>● Conduct the prefeasibility study of developmental projects; ● GIS analysis capabilities are used extensively for hazard zonation.</td>
<td>Sufficiently detailed slope information is required to generate Digital Elevation Models, and derivative products such as slope maps.</td>
</tr>
<tr>
<td>1:5,000 - 1:25,000</td>
<td>Municipality or Community</td>
<td>● Formulate projects at feasibility levels; ● Generate hazard and risk map for existing settlements and cities; ● Planning disaster preparedness and disaster relief activities.</td>
<td>The hazard data is more quantitative, derived from laboratory testing of materials and in field measurements.</td>
</tr>
<tr>
<td>1:2,000 or larger</td>
<td>Site</td>
<td>● Planning and design of engineering structure and in detail engineering measures to mitigate natural hazards; ● Data management and 3D visualization.</td>
<td>Nearly all of the data is of a quantitative nature.</td>
</tr>
</tbody>
</table>
Resolution

Fig. 27: Levels of detail and their suitability for computer modelling and simulation [Munich Re]
Exposure Mapping

3-digit postcode

5-digit postcode

addresses/georeferencing

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Inventory: Geocoding Match Levels

CRESTA

Increasing Uncertainty

Increasing Resolution

County

City

Postal Code

Street Address

Coordinate
Requirements – Data

- Base maps
- Basic data
- Intermediate data
Requirements – Software Tools

- GIS
  - ArcGIS, MapInfo
- Image processing
  - ERDAS
Risk Mapping Process

Risk = f (Hazard, Exposure, Vulnerability)
Damage Assessment Methodologies

- PGA
- Frequency
- Amplitude

PGA → MMI → Modified MMI (site effects) → Damage Ratio

Ground Motion → Spectral Acceleration → Structural Response → Damage Assessment

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Hazard Intensity Maps

Return Period = 500 yrs
Return Period = 1000 yrs
Return Period = 2000 yrs

Sources: Grunthal et. al., 2006

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Hazard Intensity Maps

*Peek Ground Acceleration (g) Expected at 10% Probability in 50 Years (Class B Sites)*

*Sources: GNS, 2003*
Event Intensity Maps

Map Version 2 Processed Mon May 12, 2008 02:07:00 AM MDT – NOT REVIEWED BY HUMAN

<table>
<thead>
<tr>
<th>POTENTIAL DAMAGE</th>
<th>None</th>
<th>Weak</th>
<th>Light</th>
<th>Moderate</th>
<th>Strong</th>
<th>Very strong</th>
<th>Severe</th>
<th>Violent</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEAK ACCL (mpg)</td>
<td>&lt;1.7</td>
<td>1.7-1.4</td>
<td>1.4-2.9</td>
<td>2.9-9.2</td>
<td>9.2-16</td>
<td>16-34</td>
<td>34-65</td>
<td>65-124</td>
<td>&gt;124</td>
</tr>
<tr>
<td>PEAK VEL (g/s)</td>
<td>&lt;0.1</td>
<td>0.1-1.1</td>
<td>1.1-3.4</td>
<td>3.4-8.1</td>
<td>8.1-18</td>
<td>18-31</td>
<td>31-60</td>
<td>60-110</td>
<td>&gt;110</td>
</tr>
<tr>
<td>INTENSIVE INTENSITY</td>
<td>I</td>
<td>II-III</td>
<td>IV</td>
<td>V</td>
<td>VI</td>
<td>VII</td>
<td>VIII</td>
<td>IX</td>
<td>X+</td>
</tr>
</tbody>
</table>

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Event Intensity Maps

EMS-98 Shaking Effects

1  Not Felt
2-3 Weak
4  Largely Observed
5  Strong
6  Slightly Damaging
7  Damaging
8  Heavily Damaging
9  Destructive
10+ Very Destructive

1935 Quetta Earthquake
500 km

www.asc-india.org

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Ground Shaking Hazard Map of the western side of City of Manila
Flood Intensity Maps (Water depth)

Sources: Grunthal et. al., 2006
Flood Hazard Intensity Map

- detailed assessment of flood depth
- return period: 30, 100, 1000yr
- water depth in 0.25m / 0.5m steps
- scale 1:5000
- high topographic accuracy 10cm

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Quality control

HAITI Earthquakes
12/01/2010 09:53:09 PM UTC

Legend
- Built-up areas
- Modified Mercalli Index
- 7: moderate damage
- 7.2
- 7.4
- 7.6
- 7.8
- 8
- 8.2
- 8.4: heavy damage

GDACS Situation Report
On 12/01/2010 09:53:10 PM UTC an earthquake of magnitude 7.0 and depth 1km has struck an very highly populated area in the Ouest Province (population 2.2 million) in Haiti.
GDACS estimates the likelihood for need of international humanitarian intervention to be high (Red alert).

GLIDE No. EQ-2010-000009-HTI

Map Information
The map overlays the 12 January 2010 earthquake in Haiti with data on built-up area, derived from Quickbird data using the JRC-FANTEX algorithm. Colours represent earthquake intensity zones (Modified Mercalli Index).
All the data belong to the Digital Map Archive repository.

Spatial Reference: GCS-WGS 1984
Map Scale: 1:50,000
Time Reference: 12th of January 2010
Background Data: Digital Map Archive
Quality control

HAITI Earthquakes
12/01/2010 09:53:09 PM UTC

I. Instrumental
Not felt by many people unless in favourable conditions.

II. Feeble
Felt only by a few people at best, especially on the upper floors of buildings. Delicately suspended objects may swing.

III. Slight
Felt quite noticeably by people indoors, especially on the upper floors of buildings. Many do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.

IV. Moderate
Felt indoors by many people, outdoors by few people during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rock noticeably. Dishes and windows rattle alarmingly.

V. Rather Strong
Felt outside by most, may not be felt by some outside in non-favourable conditions. Dishes and windows may break and large bells will ring. Vibrations like large train passing close to house.

VI. Strong
Felt by all; many frightened and run outdoors, walk unsteadily. Windows, dishes, glassware broken; books fall off shelves; some heavy furniture moved or overturned; a few instances of fallen plaster. Damage slight.

VII. Very Strong
Difficult to stand; furniture broken; damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by people driving motor cars.

VIII. Destructive
Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

IX. Ruinous
Damage great in specially designed structures, well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

X. Disastrous
Some well built wooden structures destroyed; most masonry and frame structures destroyed with foundation. Rails bent.

XI. Very Disastrous
Few, if any masonry structures remain standing. Bridges destroyed. Rails bent greatly.

XII. Catastrophic
Total damage - Everything is destroyed. Total destruction. Lines of sight and level distorted. Objects thrown into the air. The ground moves in waves or riples. Large amounts of rock move position.

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GLIDE No. EQ-2010-00009-HTI
Quality control
Flood Hazard Zoning Map

Intensity

- strong
- medium
- weak

Probability

- high
- medium
- low
- very low

Land use planning
- no new constructions allowed
- constructions allowed with restrictions
- information for the land-owners

Switzerland
Exposure Mapping

- Population in terms of its poverty or vulnerability;
- Buildings in terms of their structure type (wood-framed, concrete-framed, steel-framed, etc.) and functionality (i.e. residential, commercial, industrial, and public);
- Livelihoods, i.e. livestock, crops, industries (the number, location and extent of exposure);
- Critical facilities, i.e. healthcare (hospitals, clinics, basic health unit, etc.), educational institutions (university, college, school, etc.), warehouses, stockpiles, banks, police stations, fire stations, etc.; and
- Infrastructures, i.e. roads, bridges, airports, ports, railways, dams, telecommunication network, power supply, etc.
### Inventory: Earthquake Vulnerability Classifications

- Vulnerability damage curves developed for every possible combination to assure all aspects of the structure are incorporated

<table>
<thead>
<tr>
<th>Construction Class</th>
<th>Other Primary Characteristics</th>
<th>Secondary Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Frame</td>
<td>Occupancy</td>
<td>Soft Story</td>
</tr>
<tr>
<td>Unreinforced Masonry</td>
<td>Year Built</td>
<td>Foundation Bolting</td>
</tr>
<tr>
<td>Reinforced Masonry</td>
<td>Number of Stories</td>
<td>Torsion</td>
</tr>
<tr>
<td>Steel-Braced Frame</td>
<td></td>
<td>Opening Resistance</td>
</tr>
<tr>
<td>Concrete Shear wall etc.</td>
<td></td>
<td>Cladding Type</td>
</tr>
<tr>
<td></td>
<td></td>
<td>etc.</td>
</tr>
</tbody>
</table>
Choropleth Method

3-digit postcode

5-digit postcode

addresses/georeferencing

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Gridded Method
Dysametric method

2000 Census Block Group
Persons per 30m pixel
- 0.00006 - 0.5
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- 3.00 - 4.00
- 4.00 - 5.00
- 5.00 - 7.00
- 7.00 - 10.00
- 10.00 - 15.00
- 15.00 - 146.00
- Zero Population - Exclusion
Vulnerability curves for typical building types (Sauter and Shah, 1978)
Development of recovery functions

Damage functions for Water Treatment Plants (ATC-25)

Recovery functions for Water Treatment Plants (ATC-25)
Earthquake Risk Maps

AEP = 0.1%

AEP = 0.05%

AEP = Annual Exceedance Probability

Sources: Grunthal et al., 2006

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Flood Risk Map

1% AEP = 100 Yr Return Period

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Flood Risk Map

- Potential damage in million EURO/ha
- Annual Probability = 0.2%
- Scale 1:200,000
Map Template

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Any Questions?