Applications of Satellite Data in Disaster Management

Manzul K. Hazarika, Ph.D.
Associate Director, Geoinformatics Center
Asian Institute of Technology (AIT)
Bangkok, Thailand

Disaster Risk and its Spatial Representation

\[
\text{Risk} = \text{Hazard} \times \text{Physical Vulnerability} \times \text{Amount/Number}
\]

- Hazard: (Probability of occurrence)
- Physical Vulnerability: (Degree of losses to elements at risk)
- Amount/Number: (Quantification of exposed elements)

Hazard:
- Type of hazard
- Intensity
- Duration
- Spatial Extent

Physical Vulnerability:
- Exposure
- Overlay of hazard & element at risk

Amount/Number:
- Field Data
- Type of elements at risk
- Numbers
- Economic value
- Location

Modeling + GIS
RS + GIS
State-of-the-Art Technology

Satellite Data can Play an Important Role in Elements-at-Risk Mapping (Acquired on 20/01/2009)

Framework for Disaster Risk Assessment and Disaster Management

- Environmental Factors
  - Geology
  - Soil
  - Landuse
  - Topography
  - Hydrology

- Triggering Factors
  - Rainfall
  - Volcanic Eruption
  - Earthquake
  - Landslide
  - Flood
  - Drought
  - Cyclone
  - Earthquake

- Hazard Inventory
  - Flood
  - Drought
  - Cyclone
  - Earthquake

- Elements at Risk
  - Buildings
  - Infrastructures
  - Population
  - Critical Facilities
  - Lifelines

- Socio-Economic Factors
  - Livelihoods
  - Literacy
  - Gender
  - Poverty
  - Culture

Risk = Hazard x Vulnerability

Quantitative Risk Assessment (Absolute Risk)
Qualitative Risk Assessment (Relative Risk)

Disaster Management
- Disaster Mitigation (Disaster Risk Management)
- Disaster Preparedness
- Disaster Response
- Disaster Recovery
Quantitative (Absolute) Risk Assessment - Asset

Risk = Hazard x Physical Vulnerability x Amount (Asset)

US $100,000
Hazard Exposure = 0.8
Vulnerability = 0.2

US $100,000
Hazard Exposure = 1.2
Vulnerability = 1.0

Asset Risk
Risk_{LT} = (0.1 \times 0.8) \times 0.2 \times 100,000 = 1,600 US$
Risk_{MT} = (0.1 \times 1.2) \times 1.0 \times 100,000 = 12,000 US$
Risk_{RT} = (0.1 \times 1.0) \times 0.6 \times 100,000 = 6,000 US$
Risk_{total} = 19,600 US$

Quantitative Risk Assessment - Probabilistic

Need at least 6-7 scenarios to develop a risk curve

Hazard

Water depth per return period

Return Period

50 years
10 years
2 years

Vulnerability curve

Vulnerability = Flood depth

0 1 2 3 4 5 6 meter

0 1 2 3 4 5 6 damage

Hazard Intensity = Flood depth

Risk curve

Need at least 6-7 scenarios to develop a risk curve

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 0 250000 500000 Consequences

RP PT A V V^2 A ΣV^2 A
A 2 0.5 100000 0 0 20000
B 2 0.5 50000 0.2 10000
C 2 0.5 20000 0.05 10000
D 10 0.1 100000 0.1 10000 10000
E 10 0.1 50000 0.1 50000
F 10 0.1 20000 0.5 10000
G 10 0.1 20000 0.5 10000
H 50 0.02 100000 0.4 40000 250000
I 50 0.02 50000 0.1 50000
J 50 0.02 200000 0.8 160000

Courtesy: ITC
Historical river discharge record was analyzed to find the frequency-magnitude relationship for flood.
ALOS PALSAR Data Acquired During Flood in 2008

Comparison for Model Result with Satellite Data Derived Flood Map
Field Data Collection for Vulnerability Assessment

Quantitative Risk Map for Flood in Sri Lanka

- Hazard
- Quantitative Vulnerability
- Amount of loss for various types of buildings
- Flood Risk Map
Accomplishments in Risk Assessment for other Hazards

<table>
<thead>
<tr>
<th>CYCLONE</th>
<th>HAZARD</th>
<th>VULNERABILITY</th>
<th>RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>DROUGHT</td>
<td></td>
<td></td>
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<tr>
<td>TSUNAMI</td>
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</tbody>
</table>

If exposed, vulnerability in case of Tsunami = 1 (mostly)

Applications of Disaster Risk Assessment in Disaster Management

1) Disaster Mitigation (Disaster Risk Management)
2) Disaster Preparedness
3) Disaster Response and Recovery
DRA in Disaster Mitigation (Disaster Risk Management)

- **Prospective Risk Management** (e.g., building codes, design, land-use regulations)
- **Corrective Risk Management** (e.g., retrofitting, relocation, restoration etc.)
- **Compensatory Risk Management** (e.g., insurance)

![Mortality Reduction through DRM](image1)

![Cost-Benefit Analysis](image2)

Source: GAR, 2011

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DRA in Disaster Preparedness

- **Evacuation routes** and locations of evacuation centers
- **Location of emergency units** (Fire station etc.)
- **Location for stockpiling of equipments and supplies**
- **Awareness and public information**
- **Early warning**

![Tsunami Evacuation Map of Gall City](image3)

![Tsunami Evacuation Time in Phuket](image4)
DRA in Disaster Response - Hue Province, Vietnam

Asian Institute of Technology
and
Search and Rescue Technical Center

DRA in Disaster Response - Value Added Map
Products
Conclusions

- Satellite Data are useful for hazard and risk assessment
- Risk maps are useful for effective disaster management
- Satellite data acquired during a disaster can be very useful for emergency response

Thank you for your kind attention