Space-based Application for Coastal Vulnerability Assessment in Indonesia

M. ROKHIS KHOMARUDIN
Remote Sensing Application Center
National Institute of Aeronautics and Space, Indonesia
Outline

- Introduction
- Coastal Vulnerability Assessment
- Remote Sensing vs Coastal Vulnerability Assessment
- Current Status of Research in Indonesia
- Future Research
- Conclusion
Introduction

Mega-Stress for Mega-Cities

13 November 2009

A Climate Vulnerability Ranking of Major Coastal Cities in Asia

Many of the largest cities in Asia are located on the coast and within major river deltas, making them highly susceptible to the impacts of climate change. Mega-Stress For Mega-Cities shows that all of the cities analysed are currently extremely exposed to threats from storms and flooding to sea level rise, with huge numbers of people and assets at stake, and highlights the need for co-operation between developed and developing countries to prepare some of Asia's largest cities for the potentially devastating impacts of climate change.

Sources:
http://www.epa.gov/climatechange/impacts-adaptation/coasts.html
http://www.wwf.org.uk/news_feed.cfm?uNewsid=3454
Introduction (Source: WWF)

Vulnerability Score = 8

- Environmental Exposure 6
- Storm threat 2
- Sea-level rise 8
- Flooding/drought 9

Socio-Economic Sensitivity 10
- Population 10
- Assets threatened 9

Inverse Adaptive Capacity 7

1 m sea-level rise
2 m storm surge

Cities:

- Dhaka: 9
- Jakarta: 8
- Manila: 8
- Calcutta: 7
- Phnom Penh: 7
- Ho Chi Minh: 6
- Shanghai: 6
- Bangkok: 5
- Hong Kong: 4
- KL: 4
- Singapore: 4
Introduction

• Indonesian Facts

- Number of people: 237.6 million (65% people live in the coastal areas)
- Number of islands: 17,508 islands
- Coastline: 95,181 km (number 4 in the world)
- Number of cities in coastal area: 75%
## Introduction

<table>
<thead>
<tr>
<th>So..?</th>
<th>Coastal Vulnerability Assessment is needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whats is?</td>
<td>A coastal vulnerability assessment is the result of a process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in the coastal system. This involves social, economic and environmental aspects, but also the institutional context. (deltares.nl)</td>
</tr>
</tbody>
</table>
|What for?| - Integrated Coastal Zone Management and Development,  
- Stimulating awareness  
- Long term sustainable development of coastal zones (deltares.nl)  
- Save people lives and reduce impact of climate change |
|Tools?  | Remote Sensing? |
Coastal Vulnerability Assessment

Assessment Methods

• Index-based methods;
• Indicator-based approach, also including related GIS applications;
• GIS-based decision support systems (DSS);
• Methods based on dynamic computer models

(EEA Paper (2011))
Coastal Vulnerability Assessment

- Multi-scale Coastal Vulnerability Index (McLaughlin and Cooper (2010))

![Diagram showing coastal characteristics and socio-economic factors related to coastal vulnerability assessment.](image-url)

- Solid geology
- Drift geology
- Shoreline type
- Elevation
- River mouths
- Orientation
- Inland buffer

- Coastal forcing
  - Significant wave height
  - Tidal range
  - Difference in storm and modal wave height
  - Storm frequency

- Socio-economic
  - Population
  - Cultural heritage
  - Roads
  - Railways
  - Landuse
  - Conservation status
## Remote Sensing vs Coastal Vulnerability Assessment

- **Coastal Forcing**

<table>
<thead>
<tr>
<th>No.</th>
<th>Variables</th>
<th>Remote Sensing Data Used</th>
</tr>
</thead>
</table>
Remote Sensing vs Coastal Vulnerability Assessment

- Coastal Characteristics

<table>
<thead>
<tr>
<th>No.</th>
<th>Variables</th>
<th>Remote Sensing Data Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Solid Geology</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Drift Geology</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Shoreline Type</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Elevation</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>River Mouth</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Orientation</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Inland Buffer</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Remote Sensing vs Coastal Vulnerability Assessment

- Socio-Economic

<table>
<thead>
<tr>
<th>No.</th>
<th>Variables</th>
<th>Remote Sensing Data Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Population</td>
<td>references</td>
</tr>
<tr>
<td>2</td>
<td>Coastal Heritage</td>
<td>Blue, et al. (2013)</td>
</tr>
<tr>
<td>3</td>
<td>Road</td>
<td>Yes (high resolution image)</td>
</tr>
<tr>
<td>4</td>
<td>Railways</td>
<td>Yes (high resolution image)</td>
</tr>
<tr>
<td>5</td>
<td>Landuse</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Conservation Status</td>
<td>Need additional data</td>
</tr>
</tbody>
</table>

- Remote Sensing can generate the variables
- Remote Sensing is potential tools for calculating the coastal vulnerability assessment
- The errors have to be considered
Current Status of Research in Indonesia

• Research on Coastal Vulnerability Assessment
  – Individual Research
  – Group Research
    ACCCRN (Asian Cities Climate Change Resilience Network - MercyCorps, EEPSEA-Woldfish climate change and coastal studies team, WWF
Current Status of Research in Indonesia

- The researches on coastal vulnerability assessment in Indonesia have made a great progress – comprehensive research
- Almost researches used the combination of remote sensing and the socio-economic data to calculate the coastal vulnerability assessment – remote sensing as secondary data
- The used of remote sensing data in the coastal vulnerability assessment has to be improved, especially on the physical characteristics of coastal area and the socio-economic data
## Case Study

<table>
<thead>
<tr>
<th>Title of Research</th>
<th>COASTAL PHYSICAL VULNERABILITY OF SURABAYA AND ITS SURROUNDING AREA TO SEA LEVEL RISE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researchers</td>
<td>Sayidah Sulma (LAPAN), Eko Kusratmoko (UI), and Ratna Saraswati (UI)</td>
</tr>
<tr>
<td>Study Area</td>
<td>Surabaya</td>
</tr>
<tr>
<td>Methodology</td>
<td>Index-based Method</td>
</tr>
<tr>
<td></td>
<td>Variables:</td>
</tr>
<tr>
<td></td>
<td>Physics (Landform, coastline change rate, elevation, mean tidal range, mean sea level rise rate, mean wave height)</td>
</tr>
<tr>
<td></td>
<td>Socio-economic (Land use, Population Density, Percentage of Poor People)</td>
</tr>
<tr>
<td></td>
<td><em>Combination of Remote Sensing data, in situ, and socio-economic data</em></td>
</tr>
<tr>
<td>Results</td>
<td>See next slides</td>
</tr>
</tbody>
</table>
Total Coastal Vulnerability

Medium – High (33.89%);

Gresik: Kec. Panceng, Ujungpangkah, Bungah, Sidayu, Manyar dan Gresik.

Surabaya:
Kec. Krembangan, Pabean cantikan, Kenjeran dan Rungkut.

Sidoarjo:
There is no sub districts on this categories
Coastal Vulnerability
Gresik District

1. Fisherman Settlement

2. Abrasion in the fishpond area
Coastal Vulnerability

Surabaya City

Total Vulnerability in Surabaya, Gresik, and Sidoarjo

- Very low
- Low
- Medium
- High

 Santo Pesisir

Batas Administrasi
Kabupaten/Kota

Sumber:
Hasil analisis kerentanan fisik dan sosial

Datum: WGS 84
Proyeksi: SUTM 49

Datum: 20090504 120

Program Magister Ilmu Geografi
Fakultas Matematika dan Ilmu Pengetahuan Alam
Universitas Indonesia
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FUTURE RESEARCH
Population Numbers and Density Estimation

- Population Density Models from Urban Geography
- Areal Interpolation Methods
- Statistical Modeling Methods
Population Distribution Modeling

Where:
- $X_d$ is the number of people in administrative unit
- $P_i$ is the number of people in land use $i$
- $P_{ij}$ is the number of people in polygon $j$ in land use $i$
- $S_{ij}$ is the size of polygon $j$ in land use $i$ in administrative unit
- $W_i$ is the weighting of land use $i$; it is different during the day and night time, $\sum W_i = 100\%$.

\[
X_d = \sum_{i=1}^{n} P_i
\]

\[
P_i = \sum_{j=1}^{n} P_{ij}
\]

\[
P_{ij} = \frac{S_{ij}}{\sum_{i,j=1}^{n} S_{ij}} W_i \cdot X_d
\]

5565 People

Weighting is important!
Building Characteristics vs Socio-economic

- Business Area
- Slum Area
- Town housing
- Rural Area
Night light vs GDP

Figure 10. Light map of Germany and the associated graph of radiance and regional Gross Domestic Product. Note how points in the former East Germany have a different relationship to those in West Germany.

Source: Doll (2008)
Conclusion

- Research on coastal vulnerability assessment in Indonesia has made a great progress
- Remote Sensing is a potential tools for the Coastal Vulnerability Assessment
- Socio-economic variables estimation by using remote sensing data is a challenge for future research
THANK YOU FOR YOUR KIND ATTENTIONS