Education, Research, Training and Capacity Building Activities in AIT

(Research & Training Node for Sentinel Asia)

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Remote Sensing and GIS Field of Study

Education

✓ Master and PhD Programs
✓ Diploma and Certificate Programs
✓ 3 Regular Faculties, 1 JAXA Seconded Faculty
✓ Approximately 60 students (2006)

Multidisciplinary Programs (SET & SERD)
✓ New Master Program on Disaster Management (starts in August 2007)

Research/Training Center
✓ Geoinformatics Center carries out research, training and capacity building activities
Capacity Building: Mini-Projects

by

Geoinformatics Center (GIC)
Mini-Projects - Characteristics

- Training and comprehensive capacity building through real-world problems such as flood, drought, landslide, etc.
- Involve data/service provider agencies and services/products user agencies,
- Explore the theoretical aspects and identify most appropriate data analysis and integration technique
- Calibration/validation through field observations
- Generate products with participation of both users and service providers
- Develop case studies to share in the region
Mini-Projects in 2006

Capacity building projects are being sponsored by the Japan Aerospace Exploration Agency (JAXA) in developing countries.

Projects:

- **Flood** – 5 Projects (Bangladesh, Cambodia, China, Laos & Nepal)
- **Drought** – 1 Project (Philippines)
- **Landslide** – 3 Projects (Philippines, Sri Lanka & Vietnam)

Activities:

1. Workshop and Training in AIT– Aug/Sep, 2006
## Flood Projects

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Country</th>
<th>Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bangladesh</td>
<td>Flood Forecasting &amp; Warning Center (FFWC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local Government Engineering Dept. (LGED)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bangladesh Disaster Preparedness Center (BDPC)</td>
</tr>
<tr>
<td>2</td>
<td>Cambodia</td>
<td>Geography Department, Ministry of Land Administration Urban, Planning and Construction (MLUPC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hydrology and Water River Works Dept., Ministry of Water Res. and Meteorology (MOWRAM)</td>
</tr>
<tr>
<td>3</td>
<td>China PR</td>
<td>Beijing Normal University</td>
</tr>
<tr>
<td>4</td>
<td>Lao PDR</td>
<td>Environmental Research Institute (ERI), Science Technology and Environment Agency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Department of Meteorology and Hydrology (DMH)</td>
</tr>
<tr>
<td>5</td>
<td>Nepal</td>
<td>Department of Water Induced Disaster Prevention (DWIDP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Survey Department</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Department of Hydrology and Meteorology (DHM)</td>
</tr>
</tbody>
</table>
# Drought and Landslide Projects

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Country</th>
<th>Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Philippines</td>
<td>Philippine Rice Research Institute (PhilRice)</td>
</tr>
<tr>
<td></td>
<td>(Drought)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Philippines</td>
<td>Philippines Inst. of Volcanology &amp; Seismology (PhiVolcs)</td>
</tr>
<tr>
<td></td>
<td>(Landslide)</td>
<td>National Mapping &amp; Res. Info. Agency (NAMRIA)</td>
</tr>
<tr>
<td>8</td>
<td>Sri Lanka</td>
<td>National Building Research Organisation (NBRO)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Survey Department</td>
</tr>
<tr>
<td>9</td>
<td>Vietnam</td>
<td>Institute of Geography, VAST</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min. of Natural Resources and Environment (MONRE)</td>
</tr>
</tbody>
</table>
Bangladesh: Flood Mapping by Integrating Remote Sensing Data & MIKE 11 Model

Munshiganj
Cambodia: Flood Hazard Mapping in Three Provinces of Cambodia under Mekong Basin Basin

Kompong Cham, Prey Veng and Kandal Provinces
China: Flood Risk Assessment using Remote Sensing & Hydrologic model in the Xiang Jiang River
Laos: Application of RS-GIS for Flood Extent Study in Savannakhet Province
Philippines-II: Modeling of Rain and Earthquake Triggered Landslides using RS and GIS-based Slope Stability Models

Southern Leyte, Philippines

LANDSAT TM IMAGE OF LEYTE ISLAND
BANDS 452
Sri Lanka: Use of a Slope Stability Index Based Predicting Tool for Landslide Hazard Mapping
Vietnam: Application of Remote Sensing and GIS for Landslide Hazard Mapping in a Mountainous Areas
Data Collected through Field Visits …

- Scar of Huoi Thon major landslide
- Soil sampling at a shallow landslide location in Huoi Thon
- A wide open crack in the road produced by an active landslide in Hong Ngai
- A shallow slide in Bac Yen
- Point positioning using GPS
- Typical land cover
Cambodia

Flood Hazard Mapping in Three Provinces of Cambodia under Mekong Basin

A Detail Example for Flood Hazard Mapping
Study area covers 3 provinces (Kompong Cham, Prey Veng, and Kandal) with a population of 245,000.
2000 Flood (Dartmouth Flood Observatory)

- Aug., 2000
- 208,200 sq. km area flooded; 1,139 dead; 6.5 Million displaced
- Property Damage: 78 Million US$
Main Objectives of the Study

• To integrate a flood simulation model and remotely sensed data with the available topographic and socio economic data.
• To validate the model by comparing the simulated flood inundation area and depth with the available flood maps and remote sensing image.
• Prepare a hazard map using depth map and the socio-economic data.
Data Used

1. Hydrologic Data
   - Water level
   - Discharge

2. Vector Data
   - River network
   - Road network
   - Administrative boundary
   - Location of schools

3. Topographic Data
   - Spot height
   - WGS84 Ellipsoidal heights
   - Hydrological Atlas / Bathymetry
   - GPS Survey data

4. Satellite Images
   - RADARSAT (2000)
   - LANDSAT ETM (2005)

5. Ancillary Data
   - Population density in 2004
   - Settlement in 2004
   - Flood Depth in 2000 from MIKE 11
Available Satellite Data of Study Area

Landsat: Jan, 2005

Methodology

- Hydrological Data
- Topographic and GPS Data
- Satellite Image LANDSAT ETM
- Population density
- Road network

- HEC-RAS
- TIN
- Land use map

Flood hazard map

Vulnerability Assessment
Field Survey

Right Bank: 95.15Km
Left Bank: 43.62 Km
PP-Kg.Cham:
During Field Survey

Field Work, Right River Bank

Heavy rain on the way to Kampong Cham

Discussion During the Work

Not only GPS field Work

No Other Road Better than this

Getting ready to field work

Off the river bank - No flood

Oh, Yes we all did that.
Comparison of Results

RADARSAT-1 Image, September, 2000
Flood Affected Villages

Village Affected by flood and non-flood

<table>
<thead>
<tr>
<th>No. village</th>
<th>Flooded</th>
<th>Non flooded</th>
</tr>
</thead>
<tbody>
<tr>
<td>1076</td>
<td></td>
<td>1693</td>
</tr>
</tbody>
</table>

Population and household affected and no affected

<table>
<thead>
<tr>
<th>Total Both Sexes</th>
<th>Total Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>flooded</td>
<td>1214067</td>
</tr>
<tr>
<td>non-flooded</td>
<td>1211019</td>
</tr>
</tbody>
</table>
Area For Flood Hazard Mapping

District Names
- Kaoh Soutin
- Khsach Kandal
- Pea Reang
- Sithor Kandal
- Srei Santhor

River Network
Weighted Population Map

Population per commune X Weighted Landuse = Total Weight

Weighted Population per pixel
Enlarged Weighted Population Map
Reclassified Landuse Map

Landuse
0 - Water And Forest And Shrublands
1 - Soils&Rocks And Grasslands
2 - Agricultural Lands
3 - Urban Built Up Areas

District Boundary
Flood Depth Map
Final Flood Hazard Map
Conclusions for Cambodia

<table>
<thead>
<tr>
<th>Hazard Rank</th>
<th>Land Affected, ha</th>
<th>% of total land</th>
<th>Population affected (10^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agriculture</td>
<td>Build Up</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Low</td>
<td>305</td>
<td>396</td>
<td>0.09</td>
</tr>
<tr>
<td>Medium</td>
<td>2387</td>
<td>3400</td>
<td>0.70</td>
</tr>
<tr>
<td>High/V.High</td>
<td>12646</td>
<td>12734</td>
<td>3.70</td>
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</table>

- The Extent of the flood depth from HEC-RAS is comparable with the flood map derived from RADRASAT data. Hence, approach could be replicated in other parts of the basin.

- Non-availability of sufficient elevation data for DEM generation was felt as the main problem during the study. ALOS data could be useful generating accurate DEM.
Nepal

Flood Forecasting and Early Warning System in Bagmati Flood Plain
Objectives

• To compute flood hydrograph by rainfall-runoff modeling using hydrologic and statistical data

• To prepare flood hazard maps for various return periods

• To generate loss functions, estimate flood loss and prepare flood loss map for Gaur municipality

• To suggest a mechanism for flood forecasting and early warning system
Methodology

- **Satellite image**
  - 1. DEM
  - 2. Flood map
  - 3. Landuse map

- **Rainfall data**
  - (1. TRMM & 2. Rain gauge data)

- **Hydrological model**
  - (1. HEC HMS and 2. Statistical)
  - (HEC RAS)

- **Flood hydrograph**

- **Hydraulic model**

- **Flood maps**

- **Comparison & Improvement**

- **Community survey**

- **Flood maps for Diff. Return periods**

- **Flood maps for Diff. Water levels**

- **Flood hazard maps**

- **Direct flood damage assessment**

- **Flood risk maps**

- **Population data**

- **Flood Early Warning System**
Data Available

- **Satellite imagery**
  - Aster
  - Landsat

- **Hydrological data**
  - Rainfall data
  - Discharge data

- **Vector data**
  - Topographic data
  - DEM
  - Landuse data

- **Ancillary data**
  - Socio-economic data
  - Census data
Observed peak discharge = 5600 cusecs
Simulated peak discharge = 5321 cusecs
Regression Analysis Approach of Extreme Discharge Prediction

Test Datasets
• TRMM 3-hourly rainfall data covering June to September 2004
• Daily discharge data of the same period (Dependent Variable)

Validation Data
• 2005 Monsoon (June to September)
• Predicted Variable is daily discharge data of Monsoon 2005
### TRMM Grids in the Study Area

#### Numbering TRMM Grids

<table>
<thead>
<tr>
<th>Grid 1</th>
<th>Grid 2</th>
<th>Grid 3</th>
<th>Out</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid 4</td>
<td>Grid 5</td>
<td>Grid 6</td>
<td>Grid 7</td>
<td>Out</td>
</tr>
<tr>
<td>Out</td>
<td>Grid 8</td>
<td>Grid 9</td>
<td>Grid 10</td>
<td>Grid 11</td>
</tr>
<tr>
<td>Out</td>
<td>Not Used</td>
<td>Not Used</td>
<td>Out</td>
<td>Out</td>
</tr>
<tr>
<td>Out</td>
<td>Not Used</td>
<td>Not Used</td>
<td>Out</td>
<td>Out</td>
</tr>
</tbody>
</table>

#### Block numbering assuming equal concentration time

- Block 1
- Block 2
- Block 3

**Discharge Station**
## Flood Maps

### Input Discharge

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 year</td>
<td>3750</td>
</tr>
<tr>
<td>5 year</td>
<td>6150</td>
</tr>
<tr>
<td>10 year</td>
<td>7750</td>
</tr>
<tr>
<td>20 year</td>
<td>9250</td>
</tr>
<tr>
<td>50 year</td>
<td>11250</td>
</tr>
<tr>
<td>100 year</td>
<td>12700</td>
</tr>
</tbody>
</table>

### Inundated area

<table>
<thead>
<tr>
<th>Return period</th>
<th>Area inundated</th>
<th>% area inundated</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 year</td>
<td>363.4</td>
<td>36.9</td>
</tr>
<tr>
<td>5 year</td>
<td>403.9</td>
<td>41</td>
</tr>
<tr>
<td>10 year</td>
<td>422.9</td>
<td>42.9</td>
</tr>
<tr>
<td>20 year</td>
<td>437.7</td>
<td>44.5</td>
</tr>
<tr>
<td>50 year</td>
<td>454.8</td>
<td>46.2</td>
</tr>
<tr>
<td>100 year</td>
<td>465.6</td>
<td>47.3</td>
</tr>
</tbody>
</table>
Community Based Survey

- Community based survey
- Mud houses
- Brick mortar houses
- RCC frame houses
# Damage Function Analysis

## Summary of Survey Data for Residential Buildings

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Variables</th>
<th>Unit</th>
<th>Min</th>
<th>Max.</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Building age</td>
<td>year</td>
<td>2</td>
<td>53</td>
<td>15.77</td>
<td>51</td>
</tr>
<tr>
<td>2</td>
<td>Building plinth area</td>
<td>sq. m</td>
<td>20</td>
<td>338.72</td>
<td>121.56</td>
<td>318.72</td>
</tr>
<tr>
<td>3</td>
<td>Number of stories</td>
<td>No.</td>
<td>1</td>
<td>3</td>
<td>1.11</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Plinth height</td>
<td>m</td>
<td>0.1</td>
<td>3</td>
<td>0.35</td>
<td>1.9</td>
</tr>
<tr>
<td>5</td>
<td>Height of 1st Floor</td>
<td>m</td>
<td>2</td>
<td>3.15</td>
<td>2.69</td>
<td>1.15</td>
</tr>
<tr>
<td>6</td>
<td>Present replacement value of building structure</td>
<td>Thousands NRs</td>
<td>21.53</td>
<td>6458</td>
<td>632</td>
<td>436.87</td>
</tr>
<tr>
<td>7</td>
<td>Maximum flood height</td>
<td>m</td>
<td>0.1</td>
<td>3</td>
<td>0.9563</td>
<td>2.9</td>
</tr>
<tr>
<td>8</td>
<td>Flood duration</td>
<td>day</td>
<td>0.25</td>
<td>7</td>
<td>2.024</td>
<td>6.75</td>
</tr>
<tr>
<td>9</td>
<td>Cost of damage to building structure</td>
<td>NRs.</td>
<td>500</td>
<td>50000</td>
<td>8560</td>
<td>49500</td>
</tr>
<tr>
<td>10</td>
<td>Cost of damage to building contents</td>
<td>NRs.</td>
<td>200</td>
<td>50000</td>
<td>8505</td>
<td>49800</td>
</tr>
<tr>
<td>11</td>
<td>Cost of damage to outside facilities</td>
<td>NRs.</td>
<td>100</td>
<td>12000</td>
<td>2126.5</td>
<td>11900</td>
</tr>
</tbody>
</table>

## Descriptive Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std.</th>
<th>Variance</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage damage of Building Structure</td>
<td>490</td>
<td>38</td>
<td>0</td>
<td>38</td>
<td>8.79</td>
<td>3.971</td>
<td>80.474</td>
<td>.110</td>
<td>.720</td>
</tr>
<tr>
<td>Age (yrs.)</td>
<td>490</td>
<td>51</td>
<td>2</td>
<td>53</td>
<td>16.77</td>
<td>9.527</td>
<td>90.761</td>
<td>.110</td>
<td>3.843</td>
</tr>
<tr>
<td>Plinth Height (m)</td>
<td>490</td>
<td>1.90</td>
<td>.10</td>
<td>2.00</td>
<td>.3549</td>
<td>.29033</td>
<td>.084</td>
<td>1.713</td>
<td>.110</td>
</tr>
<tr>
<td>Flood Depth (m)</td>
<td>490</td>
<td>2.90</td>
<td>.10</td>
<td>3.00</td>
<td>.9563</td>
<td>.54924</td>
<td>.302</td>
<td>.989</td>
<td>.110</td>
</tr>
<tr>
<td>Flood Duration (days)</td>
<td>490</td>
<td>6.90</td>
<td>.10</td>
<td>7.00</td>
<td>2.0108</td>
<td>1.12229</td>
<td>1.260</td>
<td>.600</td>
<td>.110</td>
</tr>
<tr>
<td>No. of Storey</td>
<td>490</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1.11</td>
<td>.358</td>
<td>.128</td>
<td>3.351</td>
<td>.110</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>490</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Depth vs. Damage: Flood duration (B.M)

Depth Damage Curve

- $y = 5.024\ln(x) + 6.5435$
  - $R^2 = 0.9719$
- $y = 4.7372\ln(x) + 6.0769$
  - $R^2 = 0.9864$
- $y = 3.138\ln(x) + 4.3747$
  - $R^2 = 0.7042$

- **Legend**
  - Pink square: flood duration <= 1 day
  - Yellow triangle: flood duration 1 - 2 days
  - Blue triangle: flood duration > 2 days
  - Solid red line: Log (flood duration > 2 days)
  - Solid blue line: Log (flood duration 1 - 2 days)
  - Solid black line: Log (flood duration <= 1 day)

- **BM**

- **Geoinformatics Center**
Depth vs. Damage: Building Age (B.M)

Depth Damage Curve

\[ y = 4.3253 \ln(x) + 5.5564 \]
\[ R^2 = 0.8596 \]

\[ y = 2.6159 \ln(x) + 3.663 \]
\[ R^2 = 0.7667 \]
Flood Hazard Map

Gaur Flood Hazard Map

Average plinth level

<table>
<thead>
<tr>
<th>Type</th>
<th>Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>0.67</td>
</tr>
<tr>
<td>BM</td>
<td>0.42</td>
</tr>
<tr>
<td>Adobe</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Damage functions

<table>
<thead>
<tr>
<th>Type</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>$D=1.4687 \times \ln(x) + 1.8713$</td>
</tr>
<tr>
<td>BM</td>
<td>$D=4.1053 \times \ln(x) + 5.27$</td>
</tr>
<tr>
<td>Adobe</td>
<td>$D=15.161 \times \ln(x) + 17.502$</td>
</tr>
</tbody>
</table>
Flood Loss Estimation

Flood Loss Map

Estimated loss corresponding to $Q_{50} = \text{NRs 225 million}$

<table>
<thead>
<tr>
<th>Type</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>0</td>
<td>3.84</td>
<td>3.28</td>
<td>339</td>
</tr>
<tr>
<td>BM</td>
<td>0</td>
<td>11.04</td>
<td>8.44</td>
<td>3532</td>
</tr>
<tr>
<td>Adobe</td>
<td>0</td>
<td>39.33</td>
<td>29.13</td>
<td>1514</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Replacement Value</th>
<th>Number of houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 5,000</td>
<td>739</td>
</tr>
<tr>
<td>5,000 – 15,000</td>
<td>1083</td>
</tr>
<tr>
<td>15,000 – 25,000</td>
<td>827</td>
</tr>
<tr>
<td>25,000 – 50,000</td>
<td>1222</td>
</tr>
<tr>
<td>50,000 – 100,000</td>
<td>1040</td>
</tr>
<tr>
<td>&gt;100,000</td>
<td>474</td>
</tr>
</tbody>
</table>

Estimated values:
- RCC: 1100.00 – 11830.00 Nepalese Rupees/sq ft
- BM: 700.00 – 7530.00 Nepalese Rupees/sq ft
- Adobe: 200.00 – 2150.00 Nepalese Rupees/sq m
Flood Forecasting and Early Warning
Conclusions for Nepal

- Rainfall-runoff model in combination with the flood hazard maps provides a good basis for real-time flood forecasting.
- Flood damage functions were generated for buildings and a flood loss map was produced for Gaur Municipality.
- Downscaling of TRMM data could be useful in flood forecasting, especially for ungauged river basins.
Thank you for your kind attention