Support of Disaster Management by Land Administration and SDI

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Institute of Geodesy, Cartography and Remote Sensing (FOMI), Hungary

FIG Working Week, 2011.
Bridging the Gap between Cultures
Marrakech, Morocco, 18-22 May, 2011.

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Hungary

- Area: 93 000 sqkm
- Population: 10 million
- Economy: (GDP based)
  - Services (62%)
  - Industry (27%)
  - Agriculture (5%)
- GDP: 9 800 Euro/Capita
- Cadastre & Land Registry:
  - No. Of Parcels: 7.6 million
  - No. Of Properties: 10 million
  - No. Of Transactions via online Land Registry Services:
    - 4.2 million (2010)
**Hungarian Land Administration**

- Ministry of Public Administration and Justice
  - Overall administrative supervision of Land Offices
  - First level authority in LA cases

19 County Land Offices + Land Office of the Capital
- County level supervision of District Land Offices
- Second level authority in LA cases
- Planning and coordination

District Land Offices (19)
- Daily updating of unified Land Registry
- Cadastral mapping
- Land valuation, land protection, land use
- Data service
- First level authority in LA cases

- Department of Land Administration at Ministry of Rural Development
  - Overall professional supervision of LA

FÖMI
- R+D activities
- Support of Land Offices
- Operation of TAKARNET
- Topographic mapping
- Remote Sensing activities
- State Boundary Survey
- Quality Management
- Satellite Geodesy

National Cadastral Program Ltd.
- Financial management
- Ownership of Cadastral Map Databases

**Organization of FÖMI**

- Director General
  - Secretary
  - Chief Legal Adviser
  - Deputy Director General (Economy)
  - Deputy Director General (Operations)
    - Directorate of Geodetic Networks
    - Directorate of Land Administration
    - Directorate of Deformation
    - Directorate of Remote Sensing
    - Directorate of Services
    - Directorate of Information Technology

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Bridging the Gap between Cultures
Marrakech, Morocco, 18-22 May 2011
FÖMI’s activities in SDI & LA I.

• Providing the basis of positioning
  – Geodetic network (traditional and GPS based)
  – R+D on Space Geodesy (VLBI, Geodynamics, Radar Interferometry)
  – Official GNSS Services
  – State Boundary Survey
  – Large Scale (1:10 000) topographic mapping

• Providing the operation and development of LA IT systems
  – Operating the network of LA (TAKARNET)
  – Land Registry Services via TAKARNET
  – Operating of Central Unified Land Registry Database
  – Continuous development of IT systems

• Providing and development of Remote Sensing Applications
  – Operating and development of Land Parcel Identification System
  – Operating and development of CORINE Land Cover Databases
  – R+D on different Agricultural Remote Sensing Applications
  – R+D on Digital Image Processing

GNSS Infrastructure
FÖMI’s activities in SDI & LA I.

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State Boundary Survey
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Land Registry Services
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Land Parcel Identification System

<table>
<thead>
<tr>
<th>Boundary of physical block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boundaries of eligible and non-eligible areas</td>
</tr>
<tr>
<td>Unique block identification number and hectares of eligible area</td>
</tr>
<tr>
<td>Orthophoto</td>
</tr>
<tr>
<td>Cadastral layer</td>
</tr>
</tbody>
</table>
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CORINE Land Cover Database
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Regweed Monitoring by Remote Sensing
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VINGIS, IT system of Wine-growing Regions
FÖMI’s activities in SDI & LA II.

- Central Data Archive and Data Services
  - All geo-related data (including historical documents) are available at Central Data Archive
  - Operating of GeoPortal of FÖMI (http://www.geoshop.hu)
  - Continuous development of Services

- R+D activities on Geoinformation
  - Management of Nation-Wide Databases (High-resolution elevation model, Cadastral Database, Topographic Databases)
  - Development of Geoinformation technologies, services
  - Participation in European-wide GIS projects (e.g. GIS4EU, HUMBOLDT, ESDIN, EURADIN)
  - Management of INSPIRE related activities and databases

- Educational and international activities
  - Department of Geoinformation technologies of University of West Hungary is working at FÖMI
  - FÖMI has cooperation agreements with the main Universities of Hungary on research and developments and educational activities
  - FÖMI has representatives in the main professional associations (e.g. FIG, IAG, ISPRS, ICA etc.)
  - FÖMI acts as a national representative in EuroGeographics
  - FÖMI is a Legally Madated Organization (LMO) in INSPIRE Framework

FÖMI’s Geoportal: http://www.geoshop.hu
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High Resolution (5m) DEM
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Topomap and orthophoto database
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Real study in the collaboration of LA & SDI

- On 4th October 2010 a red-mud accident happened at sludge reservoir of alumina factory Ajka, HUNGARY
- Approximately 1 million cubic meters of red-mud flooded the environment
- Red-mud is alkaline (13 pH value was measured!)
- 10 peoples died in the flood because of injuries on their skin and/or the flood itself and 123 injured
- The Government needed different data and statistics (as soon as possible) for decision making
- FÖMI was asked to complete and analyse data
The Damaged Reservoir

Cleaning on the street

The level of alkaline flood!
Delineation of Areas Affected by Red-mud flood

- 4 days after the disaster delineation of flooded areas started on ultra-high resolution satellite images
- Technologies based on the operational Remote Sensing techniques developed by FÖMI and elaborated for monitoring agricultural losses
Delineation of flood on Rapideye image

Final delineation on Rapideye Image on 07.10.2010
Analyses on flooded areas by FÖMI

- Delineation by Remote Sensing techniques and GIS databases managed by FÖMI (e.g. Central Unified Land Registry Database, LPIS) provide a good basis for fast and effective analyses on flooded areas
- 5 days after the disaster decision makers received the different statistics, databases and maps for action

Land Use Analysis on flooded area
Areas in Agro-Environmental Farming Programme

Nitrate-sensitive areas next to flooded area (based on LPIS)
**Statistics based on preliminary estimation of buildings**

<table>
<thead>
<tr>
<th>Settlement</th>
<th>Number of buildings (total)</th>
<th>Number of houses</th>
<th>Number of buildings (for office, retail, farm and other purposes)</th>
<th>Number of houses</th>
<th>Number of buildings (total)</th>
<th>Number of houses</th>
<th>Number of buildings (for office, retail, farm and other purposes)</th>
<th>Number of houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>APÁCATORNA</td>
<td>253</td>
<td>65</td>
<td>186</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>7</td>
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<tr>
<td>BÓBA</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BORSZÓRCSÖK</td>
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<td></td>
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<td>DEVÉKEDER</td>
<td>3813</td>
<td>1710</td>
<td>2103</td>
<td>725</td>
<td>460</td>
<td>425</td>
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<tr>
<td>KAMOND</td>
<td>846</td>
<td>847</td>
<td>375</td>
<td>2</td>
<td>3</td>
<td>3</td>
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<td>2</td>
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</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>KOLONTÁR</td>
<td>750</td>
<td>267</td>
<td>483</td>
<td>253</td>
<td>32</td>
<td>161</td>
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<tr>
<td>MÁGYPFEJET</td>
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<td></td>
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<tr>
<td>SOMLÓJENÖ</td>
<td>615</td>
<td>147</td>
<td>468</td>
<td>46</td>
<td>3</td>
<td>3</td>
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<tr>
<td>SOMLÓVÁSÁRHELY</td>
<td>1438</td>
<td>449</td>
<td>980</td>
<td>23</td>
<td>12</td>
<td>11</td>
<td></td>
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<tr>
<td>TÜSKEVÁR</td>
<td>686</td>
<td>209</td>
<td>477</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<tr>
<td>VEZSEPRÉMSÁLSA</td>
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<td>52</td>
<td>150</td>
<td>5</td>
<td>2</td>
<td>2</td>
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<tr>
<td>ZALASZEZSHÍR</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8213</strong></td>
<td><strong>3179</strong></td>
<td><strong>5034</strong></td>
<td><strong>1018</strong></td>
<td><strong>411</strong></td>
<td><strong>607</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Statistics based on preliminary estimation of agricultural cultivation

<table>
<thead>
<tr>
<th>Settlement</th>
<th>Forest</th>
<th>Number</th>
<th>Area (ha)</th>
<th>Arable land</th>
<th>Number</th>
<th>Area (ha)</th>
<th>Meadow</th>
<th>Number</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>APÁCATORNA</td>
<td>50</td>
<td>5.3</td>
<td>25</td>
<td>27.8</td>
<td>50</td>
<td>37.4</td>
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</tr>
<tr>
<td>BÓBA</td>
<td>1</td>
<td>0.1</td>
<td>1</td>
<td>0.1</td>
<td>1</td>
<td>0.2</td>
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<td></td>
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<tr>
<td>BORSZÓRCSÖK</td>
<td>5</td>
<td>0.6</td>
<td>3.5</td>
<td>0.3</td>
<td>5</td>
<td>0.7</td>
<td></td>
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<tr>
<td>DEVÉKEDER</td>
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<td>12.7</td>
<td>173</td>
<td>296.7</td>
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<td>11.8</td>
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<tr>
<td>KAMOND</td>
<td>5</td>
<td>4.3</td>
<td>68</td>
<td>42.6</td>
<td>5</td>
<td>34.3</td>
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<td>KARAKÓDÓRCSÖK</td>
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<tr>
<td>KOLONTÁR</td>
<td>1</td>
<td>0.1</td>
<td>23</td>
<td>39.3</td>
<td>1</td>
<td>0.3</td>
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<td>25</td>
<td>39.3</td>
<td>5</td>
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<tr>
<td>SOMLÓJENÖ</td>
<td>1</td>
<td>12.6</td>
<td>13</td>
<td>26.6</td>
<td>1</td>
<td>10.8</td>
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<tr>
<td>SOMLÓVÁSÁRHELY</td>
<td>4</td>
<td>2.6</td>
<td>99</td>
<td>182.5</td>
<td>4</td>
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<tr>
<td>TÜSKEVÁR</td>
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<tr>
<td>VEZSEPRÉMSÁLSA</td>
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<td>2.4</td>
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<td>2.8</td>
<td>1</td>
<td>2.8</td>
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<td></td>
</tr>
<tr>
<td>ZALASZEZSHÍR</td>
<td>0</td>
<td>0.6</td>
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<td>2.7</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59</strong></td>
<td><strong>40.3</strong></td>
<td><strong>434</strong></td>
<td><strong>432.5</strong></td>
<td><strong>587</strong></td>
<td><strong>415.7</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Statistics based on preliminary estimation of affected area

<table>
<thead>
<tr>
<th>County name</th>
<th>Settlement name</th>
<th>Settlement total area (ha)</th>
<th>Affected settlement area by estimation (ha)</th>
<th>Affected settlement area by estimation (%)</th>
<th>Affected built-up area by estimation (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veszprém</td>
<td>Devecser</td>
<td>6391</td>
<td>461.35</td>
<td>7%</td>
<td>75.56</td>
</tr>
<tr>
<td>Veszprém</td>
<td>Somlozsárlaphely</td>
<td>2314</td>
<td>223.07</td>
<td>10%</td>
<td>6.1</td>
</tr>
<tr>
<td>Veszprém</td>
<td>Kamond</td>
<td>2044</td>
<td>173.44</td>
<td>8%</td>
<td>3.03</td>
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<td>Veszprém</td>
<td>Kolontár</td>
<td>2165</td>
<td>103.09</td>
<td>6%</td>
<td>20.13</td>
</tr>
<tr>
<td>Veszprém</td>
<td>Tiszkovár</td>
<td>1695</td>
<td>97.56</td>
<td>6%</td>
<td>0.29</td>
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<tr>
<td>Vas</td>
<td>Bubba</td>
<td>1091</td>
<td>70.32</td>
<td>6%</td>
<td></td>
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<tr>
<td>Veszprém</td>
<td>Somlóvásárhely</td>
<td>812</td>
<td>67.84</td>
<td>8%</td>
<td>3.92</td>
</tr>
<tr>
<td>Veszprém</td>
<td>Apakatoma</td>
<td>726</td>
<td>63.18</td>
<td>9%</td>
<td>0.17</td>
</tr>
<tr>
<td>Veszprém</td>
<td>Kábercsényny</td>
<td>527</td>
<td>46.47</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Vas</td>
<td>Karakó</td>
<td>1032</td>
<td>39.88</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Vas</td>
<td>Kományaópata</td>
<td>1367</td>
<td>57.67</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Veszprém</td>
<td>Karákoszsársikl</td>
<td>709</td>
<td>15.66</td>
<td>2%</td>
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</tr>
<tr>
<td>Veszprém</td>
<td>Veszprémégyszől</td>
<td>869</td>
<td>5.84</td>
<td>1%</td>
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<tr>
<td>Veszprém</td>
<td>Zalaaszugó</td>
<td>682</td>
<td>4.50</td>
<td>1%</td>
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<tr>
<td>Veszprém</td>
<td>Nagypfökö</td>
<td>1013</td>
<td>0.52</td>
<td>0%</td>
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</tr>
<tr>
<td>Veszprém</td>
<td>Borszómacsikl</td>
<td>1177</td>
<td>0.15</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Total: 24614  | 1407.64 | 6% | 108.20

Final Delineation on WorldView2 image on 09.10.2010
Delineation of flooded area

- No success on the field with delineation of the affected area (during the first two days)
- WorldView2 „8-band Challenge“ project

Object based:

- Analysis of additional capability of WV2
- Comparison with Rapideye images
- Comparison with pixel-based methods

Automated Red-mud flood delineation by object-based classification with eCognition

Result of Classification

And its accuracy:
up: WV2, down: RapidEye
Sample points of Soil Information System by Kreybig on WV2 image color-composite (on 09.10.2010) (R: 5, G: 3, B: 2)

FÖMI analysed spectral characteristics of the environ of sample points (blue) with 2, 4, 6, 8, 10m radius

<table>
<thead>
<tr>
<th>ID</th>
<th>Soil</th>
<th>Color</th>
<th>Leachement</th>
<th>Water Keeping</th>
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<tbody>
<tr>
<td>5159/3/95</td>
<td>Gravelly</td>
<td>Red</td>
<td>Good</td>
<td>Weak</td>
</tr>
<tr>
<td>5159/3/90</td>
<td>Adobe Gravelly</td>
<td>Green</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>5159/3/91</td>
<td>Muddy Clay</td>
<td>Blue</td>
<td>Weak</td>
<td>Good</td>
</tr>
</tbody>
</table>

Spectral Characteristics of Flooded Sample Points and their environ with different physical property in WV2 spectral bands

Based on Leachment properties the largest difference is on the near-infrared bands (800-1000 nm)
Motion and stability monitoring by InSAR technology
(Working together with Urs Wegmüller – Gamma Remote Sensing Ag., Switzerland)

- Limitation on Ground and GPS measurements in motion and stability monitoring:
  - No Historical analysis, results only years after
  - Measurement of High-density built-up areas is expensive or impossible
  - Ground works, network development and measurements are needed

- InSAR technology (DInSAR and PSI techniques)
  - No need for:
    - Point Marking
    - Instrument
    - Ground works
    - Waiting (we have 19 years time-base)
  - Other Advantages:
    - Very high vertical accuracy
    - Very high Spatial Resolution
    - Measurements are available monthly
    - Technique is very useful on built-up areas

- InSar at FÖMI
  - Satellite Geodetic Observatory of FÖMI has a R+D project for the utilization of InSAR technology, which were used in monitoring of red-mud flood

Color-coded velocity map around the reservoir between 2003-2010

Color-coded average linear velocity map based on SANSAR A GeAE data between March 2008 and September 2010 around the flooded reservoir
Motion History of damaged reservoir between 2003-2010

- Preparation phase
  - Geodetic and Geoinformatic surveying
  - GIS Databases (DEM, Cadastre, Topography, Orthophoto, Land Registry, Remote Sensing Databases etc.)
  - GNSS Services
  - Measurement of motion-history of dangerous objects by InSAR technology (if possible)
  - Elaboration of monitoring technology instructions

- Monitoring of Dangerous Objects
  - Establishment of Local Monitoring Network
    - Determination of Network Points by traditional methods (e.g. GPS, Total Stations, Levelling)
    - Fit this network to HGRN (Hungarian GPS Geodynamics Reference Network)
  - Monitoring Measurements
    - 1D – Monthly InSAR analysis + Levelling
    - 3D – Based on Risk Level
    - Systematic GNSS measurement campaign OR on-line, continuous, real-time monitoring on local or on GNSS Service based technologies

- Data Analysis and Guidance
  - Geophysical Interpretation of Measurements
  - Change management by GIS technics
Further planned analyses around flooded area

- Remote Sensing techniques are able to serve accurate data in long term via measurement of damage of vegetation and the result of release ment
- Comparison of agricultural areas based on time-line satellite images before and after the flood:
  - Condition of Vegetation
  - Changes of Seeding Structure
  - Yield Analyses
  - Weed Infection Analyses
  - Continuous Monitoring of Environmental Damages by Remote Sensing

Conclusions

- FÖMI, as a part of Hungarian Land Administration plays an important role in National SDI
- Red-mud flood disaster showed, that the integration of different databases, technologies and knowledge base results a good and flexible service for decision makers, which raises the appreciation of our profession
- Integration of new technologies, such as InSAR, and the traditional ones (GPS, etc.) has a great potential in disaster management
Thank you for your attention

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See you at: http://www.fomi.hu