Lahti Urban Laboratory: A web-based map platform for urban planning

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Presentation Outline

- Lahti
- Urban Planning
- Web-based GIS
- Application Design and Demonstration
- Issues in open source web-based maps
Lahti – city on watershed divide

Päijänne - Kymijoki

Porvoonjoki
Vesijärvi (vesi = water, järvi = lake)

108 km²
max. depth 42 m
coastline 181 km
39 islands
Catchment area 515 km²
Landforms in Lahti (Salpausselkä ridge)

Source: gtk.fi
Problems in Vesijärvi catchment: Wastewater, Stormwater, Urban Planning

- Surface water wash-out from streets, roofs
- Not treated
- Water pollution

Source: USDA, 2011
Disruption of water cycle in urban area
Stormwater pipes directly enter the lake ...
Urbanization in Finland – also deforestation

Forest $\rightarrow$ built area

1975

Forest $\rightarrow$ asphalt

2014

New residential area planned instead of forest in 2015...
Urban Planning in Finland

- Two levels:
  - General Plan (Yleiskaava)
  - Detailed Plan (Asemakaava)
    - Approval process with multiple phases
    - Citizen participation is encouraged

- Available at kartta.lahti.fi website
Example: Yleiskaava (Lahti 2025)
Example: Asemakaava (Kytölänmäki variant 3)
kartta.lahti.fi – Kaavoitus – Asemakaavoitus - Asemakaavaehdotukset
Question: Impact of urbanization on water quality in the lakes?

→ long-term monitoring at experimental sites

<table>
<thead>
<tr>
<th></th>
<th>Ainonpolku (city center)</th>
<th>Kilpiäinen (residential area in forest)</th>
<th>Kytölä (forest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>area (ha)</td>
<td>22.2</td>
<td>51.1</td>
<td>127.0</td>
</tr>
<tr>
<td>Impervious area</td>
<td>78.4%</td>
<td>25.6%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Runoff coefficient (in summer)</td>
<td>0.87</td>
<td>0.27</td>
<td>0.19</td>
</tr>
<tr>
<td>Changes in catchment</td>
<td>-</td>
<td>-</td>
<td>Destroying of forest in 2014</td>
</tr>
</tbody>
</table>
The experimental sites in Lahti
Lahti Web GIS required Application Functionality

- View Land Cover Changes
- Compare Land cover data sources
- View data from experimental stations
- Edit land cover scenarios
- Compare results of stormwater quality simulations
Geospatial web services

- Registered users can conduct own analyses in desktop GIS systems
- Potential 3\textsuperscript{rd} party applications using up-to-date spatial datasets

We use:
- Mapserver
- TinyOWS

**Web Server** (ArcGIS server, Geoserver, MapServer...)

- **WMS** (web map service)
  - Raster (land cover, Rainfall, terrain)
- **WFS** (web feature service)
  - Vector (trees, Rivers, pathways)
- **WMTS** (tile service)
  - Base map “tiles”
- **SOS / WoF** (sensor observ. service)
  - Time-series (runoff, Rainfall...)

(OpenLayers™ Quantum GIS Arc GIS)
Interface: WFS (Web Feature Service) and WMS example: add land use WFS layer in QGIS
Technical challenge in web-based GIS:
Display speed of detailed city-scale map layers over web

Solution: Use “Map Tile” caching mechanism

Air Photograph (ETRS/TM 35 FIN projection)

3rd party map source:
• MML Base Map
• OpenStreetMap

WMS

MapProxy Cache (on-demand)
Or
Custom Cache (precalculated)

“Tiles”: small images at predefined scales

End-user Application

Source:
mapproxy.org
maptiler.org
Technical Challenge: Info Tool

- When user clicks polygon, request only the nearby polygon as WFS and display the rest as WMS or Tiles
Editing tool (uses WFS-T with TinyOWS software)

Here user changes land-use scenario
Application Layout

- Base maps
- User-defined maps
- Land cover tools
- Simulation model tools (planned)

Tested browser: Internet explorer 10, Firefox, Chrome
Experimental Watersheds data collection

- Mobile transmission
  - SSL secured connection
  - Kytölä
  - Kilpiäinen
  - Ainonpolku

- Server Labkonet
- Postgresql Database
  - Script for data transfer (Python)

- Server Geoinformatics.aalto.fi (Apache)
  - Web service interface
    - Map Application
      - Charts
        - R, matplotlib
        - 3rd-party apps

- Map applications

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Kytölä
Kilpiäinen
Ainonpolku

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Server Labkonet
• Extra requirements for Lahti:
Show stations in map, show time series, access data from Matlab and R software
Database: PostgreSQL + PostGIS

- **observations**
  - **SensorID**
  - TimeUTC
  - DataValue
  - Qualifier

- **catchments**
  - CatchmentID
  - CatchmentName
  - Description
  - Area
  - Geometry

- **sensors**
  - SensorID
  - SiteID
  - VariableID
  - SensorCode
  - Description

- **sites**
  - SiteID
  - SiteCode
  - SiteName
  - SiteType
  - Latitude
  - Longitude
  - Elevation
  - Description
  - CatchmentID

- **variables**
  - VariableID
  - VariableName
  - VariableNameFi
  - VariableCode
  - Units
  - TimeUnits
  - TimeStep
  - NoDataValue
  - DataType
  - IsRegular
Web Map and Time Series Application uses: html and js (OpenLayers, GeoExt)
Forecasting Stormwater Quantity and Quality

• Regression-based (empirical) model
  – Event mean concentration method
    • Long term time scale (1 year or 1 season)
    • Rough spatial scale (spatial units in order of hectares)

• Physically-based (hydraulic) model
  – SWMM method
    • Short term time scale (individual rainfall events)
    • Fine spatial scales (individual buildings & trees)
Model: Regression based (event mean concentration)

- Sub-catchments
- Rainfall
- Landuse
- Runoff coefficient lookup table
- Pollutant loading lookup table

Rainfall-runoff calculation

Runoff volume map (for each grid cell)

Pollutant loading calculation

Aggregation to sub-catchments: total runoff, TP, TN, TSS

Pollutant loading map (for each pollutant and grid cell)
Associate land-cover with runoff coefficient and pollutant concentration (Nordeidet et al. 2004)

<table>
<thead>
<tr>
<th>Area</th>
<th>Runoff coefficient</th>
<th>TSS mg/l</th>
<th>COD mg/l</th>
<th>Total N mg/l</th>
<th>Total P mg/l</th>
<th>Pb µg/l</th>
<th>Zn µg/l</th>
<th>Cu µg/l</th>
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</thead>
<tbody>
<tr>
<td>Highways</td>
<td>0.90</td>
<td>150</td>
<td>100</td>
<td>2.0</td>
<td>0.40</td>
<td>70</td>
<td>500</td>
<td>100</td>
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<tr>
<td>Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Impervious area</td>
<td>&gt;30%</td>
<td>0.85</td>
<td>100</td>
<td>85</td>
<td>3.0</td>
<td>0.40</td>
<td>15</td>
<td>200</td>
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<tr>
<td></td>
<td>&lt;30%</td>
<td>0.80</td>
<td>70</td>
<td>60</td>
<td>2.1</td>
<td>0.28</td>
<td>11</td>
<td>140</td>
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<tr>
<td>Roofs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>0.28</td>
<td>11</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>&lt;30%</td>
<td>0.75</td>
<td>49</td>
<td>42</td>
<td>1.5</td>
<td>0.20</td>
<td>7</td>
<td>98</td>
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<td>Vegetation areas</td>
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<td></td>
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<td></td>
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<td></td>
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<td></td>
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<td>40</td>
<td>40</td>
<td>2.0</td>
<td>0.40</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>&lt;30%</td>
<td>0.10</td>
<td>40</td>
<td>40</td>
<td>2.0</td>
<td>0.40</td>
<td>10</td>
<td>30</td>
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<tr>
<td>Outlying fields</td>
<td>0.05</td>
<td>40</td>
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<td>2.0</td>
<td>0.40</td>
<td>10</td>
<td>30</td>
<td>10</td>
</tr>
</tbody>
</table>
Model: Physically-based (SWMM)

- Additional input data required:
  - Conduit and stormwater drainage network (including drainage pipe length, slope, diameter)
  - Soil hydraulic properties
  - Detailed digital terrain model

Question: Can we estimate conduit Dimensions based on other proxy data like drainage area?
Stormwater cycle Simulation **Input and output**

**Inputs (Geospatial web services)**
- Rainfall Grid WMS, WCS
- Sub-catchments map (WFS, WCS)
- Land Use Map WMS, WFS, WCS
- Drainage Network WFS

**Optional (SWMM)**

**Processing (Web Processing Service – WPS)**
- Infiltration
- Evapotranspiration ...
- Phosphorus cycle
- Nitrogen cycle
- Bacteria ...

**Outputs (Geospatial web service)**
- Runoff volume per sub-catchment
- Pollutant loading per sub-catchment
Model output example: Sub-catchment runoff coefficient
Some Issues with the Open Standards and Web GIS approach:

• Need more user-friendly tools to **edit the map**
  – Add new layers, change symbol, custom overlays

• Need **multi-scale** representation of same feature
  – For example road is line or polygon?

• Some urban plans and land use map data services are only available for display (WMS) but not for analysis (WFS or WCS)

• More small, specialized web apps are easier to explain than one big desktop-like web map page
Map Application Demo

https://geoinformatics.aalto.fi/kala/app/

For test account use

name: guest
password: virtaama
Thank you for your attention

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http://geoinformatics.aalto.fi