SMART Research using Linked Data – Sharing Research Data for Integrated Water Resources Management in the Lower Jordan Valley

Benedikt Kämpgen, David Riepl, Jochen Klinger

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May 25 2014
Pressure and competition on natural freshwater resources

“Groundwater is like your savings account, it's okay to draw it down when you need it, but if it's not replenished, eventually it will be gone.”

http://politics.slashdot.org/story/13/02/13/1731237/ nasa-huge-freshwater-loss-in-the-middle-east
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## Integrated Water Resources Management (IWRM)

- **Example: Jordanian Water Strategy**

<table>
<thead>
<tr>
<th>Objective</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td><em>Decrease the leakages from sewer pipes in As Salt, Fuheis and Mahis</em></td>
</tr>
<tr>
<td>Economical</td>
<td><em>Improve meter reading and billing accuracy to reduce administrative losses</em></td>
</tr>
<tr>
<td>Ecological</td>
<td><em>Implementation of Spring Protection Zones for Azraq, Baqourria, Hazzir and Shorea Springs</em></td>
</tr>
</tbody>
</table>
Outline

- Water Scarcity in the Lower Jordan Valley
- Challenges of IWRM
- SMART Knowledge Base Approach
- IWRM Process for Wadi Shueib
- Lessons Learned
- Related Work
- Conclusions
Illustration of IWRM process result: decision matrix with normalised indicators values for scenarios in Wadi Shueib in 2025
IWRM (Multi-Criteria) Decision Problem

Illustration of IWRM process result: decision matrix with normalised indicators values for scenarios in Wadi Shueib in 2025

No sharing of scenarios
Illustration of IWRM process result: decision matrix with normalised indicators values for scenarios in Wadi Shueib in 2025

No sharing of indicators
Illustration of IWRM process result: decision matrix with normalised indicators values for scenarios in Wadi Shueib in 2025

No sharing of research data
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SMART Knowledge Base Approach

- Sharing scenarios
- Sharing indicators
- Sharing research data

Triple Store

- RDF
- RDF
- RDF

Dropedia

- HTML

SMART-DB-WRAP

- XML

SMART-DB

IWRM ontology

Sharing scenarios
Sharing indicators
Sharing research data

SMART Knowledge Base Approach

B. Kämpgen et al., SMART Research using Linked Data
SMART Knowledge Base Approach

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RDF

Sharing scenarios

Sharing indicators

Sharing research data
Formalising the IWRM Domain

IWRM Ontology

**Why?**

**What?**

**How?**

**What if?**

B. Kämpgen et al., SMART Research using Linked Data

High-level overview of IWRM domain using RDF Data Cube Vocabulary for modelling research data
Formalising the IWRM Domain
IWRM Ontology

High-level overview of IWRM domain using RDF Data Cube Vocabulary for modelling research results
SMART Knowledge Base Approach

Sharing scenarios
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RDF
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HTML
XML

Sharing scenarios
Sharing indicators
Sharing research data

B. Kämpgen et al., SMART Research using Linked Data
Collaborative Modelling
Dropedia

Add/edit geography and meta-infos and upload files: Wadi Shueib

<table>
<thead>
<tr>
<th>General Info</th>
</tr>
</thead>
</table>

**Geography**

<table>
<thead>
<tr>
<th>Name</th>
<th>Wadi Shueib, Wadi Shuayb, Wadi Shaib, Wadi Shu'aib</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID-Code</td>
<td>AM</td>
</tr>
<tr>
<td>System</td>
<td>MWI</td>
</tr>
<tr>
<td>e.g. AM0512</td>
<td></td>
</tr>
<tr>
<td>(Super-)Catchment</td>
<td>Lower Jordan River Basin</td>
</tr>
<tr>
<td>Region</td>
<td>Al Balqa Governorate</td>
</tr>
<tr>
<td>Country</td>
<td>Jordan</td>
</tr>
<tr>
<td>Area [km²]</td>
<td>198 km²</td>
</tr>
<tr>
<td>Kml-File</td>
<td>File: Wadi Shueib catchment boundary.kmz</td>
</tr>
</tbody>
</table>

**Map**

Enter Geographic Coordinates manually or pick from the map:
31.9830555556, 35.7219444444
Enter address here

New Palestine Grid Coordinates:

http://dropedia.iwrm-smart2.org/
SMART Knowledge Base Approach

- Sharing scenarios
- Sharing indicators
- Sharing research data

Triple Store

- RDF to Dropedia
- RDF to SMART-DB-WRAP

IWRM ontology

HTML

SMART-DB-WRAP

XML

SMART-DB
Allow integration of climate data
SMART-DB-WRAP

Wrapping SMART-DB (Oracle DB) as Linked Data

<table>
<thead>
<tr>
<th>Object</th>
<th>URI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wadi Shueib as referred to in Dropedia</td>
<td>dropedia:Wadi_Shueib</td>
</tr>
<tr>
<td>Shorea Spring as referred to in Dropedia</td>
<td>dropedia:Shorea_Spring</td>
</tr>
<tr>
<td>Shorea Spring as referred to in SMART-DB</td>
<td>smart-db:/id/location/AM0528</td>
</tr>
<tr>
<td>Average Discharge in Dropedia</td>
<td>dropedia:Annual_Average_Discharge</td>
</tr>
<tr>
<td>Average Discharge from SMART-DB</td>
<td>smart-db:/id/analysisobject/Q</td>
</tr>
<tr>
<td>Dataset of locations from SMART-DB</td>
<td>smart-db:/id/location/ds</td>
</tr>
<tr>
<td>Dataset of indicators from SMART-DB</td>
<td>smart-db:/id/analysisobject/ds</td>
</tr>
<tr>
<td>Dataset of Mean Discharge for Shorea Spring from SMART-DB</td>
<td>smart-db:/id/location-dataset/AM0528/Q</td>
</tr>
</tbody>
</table>

http://smartdbwrap.appspot.com/
SMART Knowledge Base Approach

Sharing scenarios
Sharing indicators
Sharing research data

OpenVirtuoso + Reasoning

Triple Store

RDF

Dropedia

RDF

SMART-DB-WRAP

RDF

SMART-DB

XML

Oracle DB

HTML

IWRM ontology

Semantic MediaWiki

LDSpider

Google App Engine
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IWRM Process for Wadi Shueib

- [Riepl, 2013]
- 6 IWRM processes, 7 objectives, 22 indicators, 22 scenarios and 27 analyses are described in Dropedia

Setup
- AMD Athlon(tm) 64 Processor 3000+ with 2G memory with Ubuntu Linux
Metadata shared over Dropedia
Shorea Spring Overview

<table>
<thead>
<tr>
<th>Contents (hole)</th>
<th>Spring Metadata</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Spring</td>
<td>Geometry</td>
</tr>
<tr>
<td>2 Discharge-Timeseries</td>
<td>Name: Shorea Spring, Shorea, Shore'a', Shoreya'a</td>
</tr>
<tr>
<td>3 Attached Files</td>
<td>ID-Code (MWI-WIS &amp; J): AM0528</td>
</tr>
<tr>
<td>3.1 SMART-ID Analyses</td>
<td>Catchment: Wadi Shumib</td>
</tr>
<tr>
<td>4 General Description</td>
<td>Region: Al Balqa</td>
</tr>
<tr>
<td>5 Water</td>
<td>Country: Jordan</td>
</tr>
<tr>
<td>5.1 Water Discharge</td>
<td>Altitude [m asl]: 595 m</td>
</tr>
<tr>
<td>6 Water Quality</td>
<td>Aquifer: A7</td>
</tr>
<tr>
<td>7 Water Production</td>
<td>Spring type: Contact Spring</td>
</tr>
<tr>
<td>8 Resource Protection</td>
<td>Water type (salinity): Freshwater</td>
</tr>
<tr>
<td>9 Economy</td>
<td>Discharges to:</td>
</tr>
<tr>
<td>10 Other Information</td>
<td>Monitored Parameter(s): Discharge</td>
</tr>
<tr>
<td></td>
<td>Authors</td>
</tr>
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<td></td>
<td>Author(s):</td>
</tr>
<tr>
<td></td>
<td>Major Contribution:</td>
</tr>
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Discharge-Timeseries
SMART-DB climate data integrated
Shorea Spring Discharge

Links between Dropedia and SMART-DB (Equivalence Statements)
Shorea Spring 10-year average discharge

<table>
<thead>
<tr>
<th>Smart:analysis Object</th>
<th>Smart:day</th>
<th>Smart:obsValue</th>
<th>Smart:analysis Unit</th>
<th>Reflective Property</th>
<th>Comment</th>
<th>Scenario</th>
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<tr>
<td>Average Annual</td>
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<td>based on</td>
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<td><a href="http://reference.data.gov.uk/id/day/2005-12-31">http://reference.data.gov.uk/id/day/2005-12-31</a></td>
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<td><a href="http://reference.data.gov.uk/id/day/2010-12-31">http://reference.data.gov.uk/id/day/2010-12-31</a></td>
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</table>
Research and climate data can be explored:

Shorea Spring Discharge Over Time

### Cubes
- dropedia:SMART-2DDB-2DDSD

### Dimensions
- smartdbwrap:analysis_Object
  - smartdbwrap:analysis_Object
- smartdbwrap:analysis_Unit
- smartdbwrap:location
  - smartdbwrap:location
- smartdbwrap:month
- smartdbwrap:year
  - smartdbwrap:year

### Measures
- Measures
  - smartdbwrap:obsValue AVG
  - smartdbwrap:obsValue COUNT

### Columns
- smartdbwrap:obsValue AVG
- smartdbwrap:obsValue COUNT

### Rows
- smartdbwrap:year

### Filter
- smartdbwrap:location
- smartdbwrap:analysis_Object

<table>
<thead>
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<th>smartdbwrap:year</th>
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<tbody>
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<td>1</td>
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<tr>
<td>refgovukyear:1983</td>
<td>147.5</td>
<td>2</td>
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<td>refgovukyear:1993</td>
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<td>5</td>
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<td>refgovukyear:2003</td>
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- smartdbwrap:month
- smartdbwrap:year
  - smartdbwrap:year

### Measures
- Measures
  - smartdbwrap:obsValue_AVG
  - smartdbwrap:obsValue_COUNT

### Columns
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- smartdbwrap:obsValue_COUNT

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Lessons Learned

- **Proof-of-concept**
  - Sharing scenarios and indicators
  - Application over integrated research and raw data

- **Challenges**
  - Complex Modelling (e.g., Wastewater Recharge Ratio)
  - Usability and Training (e.g., culture of two-way sharing)

- **Opportunity**
  - Open Data trend (DataCite, FigShare, Pangea...)
  - Easier integration of new data sources by
    - ... Linked Data Wrappers
    - ... Equivalence statements
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## Related Work

<table>
<thead>
<tr>
<th></th>
<th>Decision Support</th>
<th>Collaboration</th>
<th>Publication</th>
<th>Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS / DSS Tools (WEAP...)</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wikis (WaterWiki...)</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Portals (CUASHI...)</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Semantic Approaches (Curators...)</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>SMART Knowledge Base (+)</td>
<td>(+)</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Conclusions

- Sharing of **scenarios and indicators** possible
- **Benefit** with applications over integrated data
- **New data sources** promise more benefits
- **Easier integration** with SW technologies

- Scientists from Jordan, Palestine, Israel talking about Open Data

- Current work: Collecting Open Data Best Practices: Share-PSI 2.0

http://www.w3.org/2013/share-psi/
Thanks!

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