“Disrupting” Groundwater Management

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Mashreq Water Knowledge Series
Disruptive Technologies for Improved Groundwater Management in the Mashreq Region
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Groundwater Management Challenges

**Information**
Understanding and monitoring groundwater systems (e.g. aquifers, extraction, recharge, quality)

Analytic insights into specific groundwater links to water cycle and inform longer-term planning and shorter-term operational decision support

**Institutions**
Institutional arrangements to work across spatial and sectoral scales

Capacity, policies, and instruments to effectively manage groundwater effectively and sustainably

**Investments**
Planning and operation of extraction and recharge investments in a systems context

Development and climate scenario-based investment planning considering technical, environmental, social, economic, financial, institutional, and other sustainability aspects
A new world of “Disruptive Technology”

“Disrupt” data value chains

- **Data Collection**: Monitoring/Surveys (in-situ sensors/IoT/Biometrics, earth observation (satellite, aerial, UAVs), crowdsourcing, digitization...
  - **Data Management**: Telemetry, 5G, cloud services, open data, Blockchain, ...
  - **Data Analysis**: Big data, Geospatial/ AI/Machine Learning, modeling/ scenario analysis, script repositories, Cloud/Edge/Quantum computing...
  - **Data Access**: Open data APIs, data visualization, gamification, mixed reality-AR/VR, ...
  - **Outreach**: Platforms/Social Media/Portals/ Apps/e-books/Competitions...

“Disrupt” production value chains

- 3D/4D printing/additive manufacturing...
- Digital Twin
- Automation/SCADA...
- Robotics/ Autonomous transport...
- Advanced materials/nanotech/ biotech/genomics/energy tech/ green tech, ag tech...

“Disrupt” stakeholder value chains

- Virtual social networks/ Digital Platforms...
- Sharing economy...
- Crowdsourcing, gamification, competitions (e.g. hackathons, appathons...)...
- Mobile money, fintech, cryptocurrency...
- Maker movement/DIY/Tech Incubators...
- Virtual learning/re-skilling...

http://www.appolutelydigital.com/dt/
Information & Analysis Trends

What’s Out?
- Paper Records/Publications
- Desktop Databases
- Static, Infrequent data
- Data Secrecy
- Unclear data pricing
- Sectoral approaches
- Fragmented activities
- Desktop Modeling – “Retail”
- Supply-side inputs
- “Come to my website & see my bit of data…”

What’s In?
- Digital Data/Portals/Apps/e-books…
- “Analysis Ready” Cloud Data Services/APIs
- Real-time data services & visualizations
- Open, Public-Domain, Available
- Free open basic data services
- Multi-sectoral/ spatial approaches
- Shared vision partnerships; Interoperability
- Cloud Analytics – “Wholesale” AI Platforms
- Demand-driven to support decisions
- Integrative, Collaborative Data Services & Customized Platforms/Dashboards/Apps
“Bottom-up” Monitoring Systems

Crowdsourcing Monitoring
Emerging Citizen Science

Ethiopia: Tana and Beles Integrated Water Resources Management Project

Thanks JB for some of the photos!

Sediment Concentration Analyses

<table>
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<th>2011</th>
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<td>&gt;12777</td>
<td>&gt;15000</td>
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<td>1216</td>
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Secchi Jug for turbidity
360° Cameras for photos/videos
360° Cameras for photos/videos
Field/Virtual Surveys

- Online Spatial Surveys
- Mobile ODK – KoboToolBox, Survey123...
- Interactive Dashboards
Collect Field Data – 3D iOS Models in the Field

Lidar sensor on new iPhone 12 Pro and iPad Pro.

Field personnel can scan area of interest and create a 3D model in minutes.

3D model can be shared with office-based personnel directly from iOS device.
“Top-down” Earth Observation & Other Global Analytics Services

**Climate**
- Precipitation & Forecasts
- Temperature
- Storms

**Hydrology**
- Levels, Flow & Inundation & Forecasts
- Soil Moisture
- Evapo-transpiration

**Other**
- Land Cover
- NDVI, EVI, GRACE, etc.
- Social, Economic, Environmental, etc.
Gravity Recovery and Climate Experiment (GRACE)
Heliborne Geophysical Surveys of Aquifers

Source: http://skytem.com/water-mapping/
Drones/UAVs
**“Top-Down” Data Acquisition System**

- Satellite & Aerial Earth Observation

**Cloud Services**

- Big Data
- Data Science
- Machine Learning & other AI
- ChatBots Crowdsourcing
- Platforms APIs

**Data Rescue**
- GIS and other datasets

**Data Management**
- Analytics/Models

**Stakeholder Alerts**
- Dashboards/Portals/Apps/e-books/AR/VR

**Operational Control Rooms**

**“Bottom-up” Data Acquisition System → IoT**

- Manual Monitoring Crowdsourcing
- Automated Monitoring

**Country boundary**

- Major river
- Capital city
- Lake/Sea

- GDP (million $/sq.km.)

Data source: NOAA, 2006
Multiple sectors, multiple institutions, linked by water and natural resources…

Need for Integrated Water Resources Management

...Need for a shared multi-sectoral vision supported by modern information, institutions, and investments…
Precipitation → Evapotranspiration

Streamflow

Soil Moisture

Groundwater

GRACE
High-Resolution Satellite Imagery

Mashreq > Climate > NASA GPM/IMERG Precipitation Accumulation

Choose a country...

Leaflet | Powered by Esri | Tiles © Esri — Esri, DeLorme, NAVTEQ. This IMERG dataset is provided by the NASA/Goddard Space Flight Center's GPM Team and Precipitation Processing System (PPS), which develop and compute IMERG as a contribution to GPM, and archive...
Watersheds, Topography
Population

Along the selected region shape, the total population in 2018 is 1,744,145, with a population density of 34,274 per km².
Population Trends

Your custom shape
The selected region has an area of 50.89 km².

Population

<table>
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<th>Year</th>
<th>Population</th>
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<td>2000</td>
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<td>2005</td>
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<tr>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>2020</td>
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</table>

Total Population in 2000: 3.723m people
Population Density in 2000: 71.158 per km²
Recent Precipitation

Image
- < 0.2 mm/hr
- 0.2-0.3 mm/hr
- 0.3-0.5 mm/hr
- 0.5-1.0 mm/hr
- 1.0-2.0 mm/hr
- 2.0-3.0 mm/hr
- 3.0-5.0 mm/hr
- 5.0-10.0 mm/hr
- 10.0-20.0 mm/hr
- 20.0-50.0 mm/hr
- 50.0-100.0 mm/hr
- > 100.0 mm/hr
Rainfall Daily

Daily Rainfall mean value: 1.829 mm/day
Vegetation (NDVI)

Area analysis

Your custom shape

The selected region has an area of 2.93 km².

NDVI

Variable: NDVI; calculation: average

Vegetation Health mean value: 0.173
Soil Moisture

The selected region has an area of 2.53 km².

Soil Moisture (0 - 10 cm underground)

Variable: soilmoisture10; calculation a...

Soil moisture mean value: 0.188 l/kg

Performing Analysis...
Evapo-Transpiration
Sub-surface Soil Moisture
Satellite Altimetry

Near Real Time products with datum based on a single satellite overpass (1 day)
Groundwater Assessment Platform

GAP Maps allows you to view and print maps related to geogenic groundwater contamination. By creating a free login, you can also upload your own data to view, share or model. By default, your data are private, however you can choose to share them with individual users, with a community of users or publicly. You can also grid your point data or model them using logistic regression to produce a prediction map.

Use the buttons on the left and right sides of the screen to access and navigate GAP's maps and functionality:

- **Layer list** - active and available layers
- **My Layers** - upload and manage layers
- **Statistical Analysis** - grid or model your data
- **Community** - interact with groups of users
- **Print** - print a PDF map

Select a base map
Get data at a point
Zoom in or out (or use mouse wheel)

Terms of Use © Eawag

Go to the Help to learn how to use a particular section by clicking the question mark or the * symbol.
Live Telemetry
The stations established by the Central Water Commission, the Central Groundwater Board and the State agencies throughout the country measure important hydrological and meteorological parameters and provide data on a real time basis for immediate action and planning.
Projected Change in Monthly Precipitation of Watershed #21 for 2080-2099 (Compared to 1986-2005)

Climate Change Knowledge Portal

For Development Practitioners and Policy Makers

WORLD BANK GROUP

Projected Change in Monthly Precipitation for Watershed #21

MONTHLY PRECIPITATION (MM)

-40  -30  -20  -10  -2  0  10  20  30  40

HISTORICAL OBSERVED MONTHLY PRECIPITATION FOR WATERSHED #21
Mashreq Water Initiative

Disruptive Tech in Groundwater

Table of Contents

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- Introduction
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  - Groundwater Use
  - Mashreq Region
  - Disruptive Tech
- Groundwater Management
  - Information
  - Institutions
  - Investments
- Applications of Disruptive Tech in GW Management
  - Information
Visualizing and Decision Support

Online web services (including spatial data using OGC standards) and open data APIs are ushering a revolution of interactive dashboards to visualize data and analytics related to groundwater.

The UN (including UNESWA) has been working with IGRAC and others to develop a UNESCO-IHP Groundwater Portal. The GGIS is an interactive portal for sharing data and information on groundwater resources around the world. It gives access to map layers, documents, and well and monitoring data. It also contains several thematic map viewers. There are also a number of sites that provide information globally on water points and their status but the information is often patchy.

The World Bank has also been helping improving awareness about relevant free, public-domain water related data through its initiatives such as the Water Data Portal, HydroInformatics Data Platform, and Water In Agriculture Data Platform. For the Mashreq Region, a Mashreq Water Data Platform has been developed.

The groundwater component of the Transboundary Waters Assessment Programme (TWAP) provides aggregated information for the main transboundary aquifers and Small Island Developing States (SIDS). The data that has been made available in the TWAP Groundwater Information System (link is external) includes core indicators, encompassing the hydrogeological, environmental, socio-economic and governance dimensions of the systems.
MASHREQ WATER INITIATIVE - DISRUPTIVE TECH IN GROUNDWATER

Apps, Augmented Reality/Virtual Reality, or hybrid methods such as Tangible Landscape.
Virtual Missions

Pre-Mission
- Satellite Imagery
- Cloud Analytics/Mapping
- Flythroughs
- Online/In-Situ Surveys/Interviews
- Digital Twins

Virtual Mission
- Polls, Collaborative Work
- Reflect in Agenda, Presentations
- Platform, Translation, Breakouts

Post-Mission
- Interactive Documents
- Recordings
- Prepare for next Virtual Mission
Presentation: Remote Supervision Tools for Dam Safety

Collect Field Data - Photogrammetry Models (Construction I)

Photogrammetry model from Drone photos

Photogrammetry model from Cell Phone photos

(3D holograms visualized in the office using a HoloLens and Ada Platform)
Visualization of 3D Models – Underground Visualization

INSFRASTRUCTURE, IMU SURVEY DATA, RESERVOIR MODELS, BOREHOLE DATA, GEOPHYSICS, INSTRUMENTATION, ETC.
Development Scenario Visualization on Landscapes
From Aurelie Rossignol and the Bank VR Team: https://wbgvr.org/Albia
Illustrative Interactive Dashboards

Example for Dam Operation

Decisions to be Supported: When to release? How much to release?

**Climate**
- Rainfall in upstream watershed (GPM, in-situ gauges/radar, CHIRPS, ...) – current & historical
- Weather forecasts (short-term, seasonal); Storm tracks
- Snowmelt estimates (if relevant)

**Flows**
- Current and historical flows (from in-situ observations, satellite estimates where possible)
- Dam inflow forecasts (e.g. from GEOGLOWS Global Streamflow Forecasting, local forecasts)

**System Levels**
- Current and historical levels of this dam’s reservoir as well as other storages in system (e.g. from satellite, in-situ gauges)

**Downstream**
- Irrigation status (crops, crop stage from earth observation and in-situ)
- Soil and sub-surface soil moisture, groundwater (from earth observation and in-situ)

**Other Data & Analytics**
- Inundation forecasts
- Systems water infrastructure needs
- Systems model to explore implications of alternative dam operations
- Hi-resolution Satellite data
- Crowdsourced data

Need to draw upon global and other accessible data and analytic services to make interactive maps, graphs, and analytics for such decision support dashboards that are accessible on portals, apps, e-books, touchscreens, etc.
E-Packaging of Knowledge
(e.g. Interactive E-books/Storymaps)

Outreach
(e.g. virtual/online learning, hackathons, Expos)
Groundwater Management Challenges

**Information**
- Understanding and monitoring groundwater systems (e.g. aquifers, extraction, recharge, quality)
- Analytic insights into specific groundwater links to water cycle and inform longer-term planning and shorter-term operational decision support

**Institutions**
- Institutional arrangements to work across spatial and sectoral scales
- Capacity, policies, and instruments to effectively manage groundwater effectively and sustainably

**Investments**
- Planning and operation of extraction and recharge investments in a systems context
- Development and climate scenario-based investment planning considering technical, environmental, social, economic, financial, institutional, and other sustainability aspects
The Data Value Chain
Planning Water Infrastructure

Water Investments
(e.g. Dams, Irrigation Systems, Water Supply, ...)

Integrated Basin Plans
(information, institutional, and investments)

Resource Management
Issues/ Options/ Goals

Investment (New/ Rehab) & System Operation Issues/ Options/ Objectives

Planning Process
(Analytical and Stakeholder Inputs to assess impacts, trade-offs)

Models
(Water balance, Systems Simulation/Optimization, Multi-Criteria, climate resilience)

Surveys
(e.g. Groundwater, Topography, Soils, Socio-economic, Environmental, Water Infrastructure)

Brainstorming Options
(investments, system operations)

Decision Support

Knowledge

Information

Data

Historical Climate, Flow, and other temporal and spatial data
Flood Coping Actions
(stakeholder actions to minimize loss of life/livelihood)

Dissemination/Preparedness
(stakeholder channels – DSS, Bulletins, SMS, Radio, TV, Social Media, Portals, Apps, Podcasts, phone, emails,

Flood Early Warning & Recommendations

Products & Services
(Formats, Frequency, Messaging, Customization, Media)

Weather Forecasts
Hydrologic Forecasts
Flood Inundation Forecasts

Models
(Seasonal to nowcasting; statistical/hydrologic systems/hydrodynamic,...)

Surveys & Studies
(detailed Digital Elevation Model, Soils, Geomorphology, Water Infrastructure Status, Flood impacts)

“Top-Down” Data
(from remote sensing/earth observation products)

“Bottom-up” Data
(from field gauges, manual reporting, crowdsourcing)

Data

Historical Climate, Flow, and Flooded area Data

Knowledge

Information

Decision Support

Example: Deciding on Coping with Floods
In Summary

• Rapidly evolving technologies have the potential to “disrupt” traditional challenges in groundwater management

• Reimagine Information, Institutions/Policy and Investments with a broader spatial and sectoral perspective

• Great potential to leverage (and contribute to) global, regional, and national hydroinformatics data and analytics for local benefit

• Improve ecosystem of new open data services and collaboration across sectors and countries

• Improved access to “wholesale” data, analytics, knowledge learning platforms and engaging all stakeholders (incl. youth)
Disrupt or Be Disrupted!

Thanks!

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http://spatialagent.org/Mashreq/

Download the Spatial Agent App at: http://apps.worldbank.org

http://spatialagent.org/KIDS/