Hydroinformatics-and ICT solution for water-related problems
Past experiences and ongoing projects

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Outline

- Forecasts
- Hydroinformatics
- ICT based research
  - Modelling for decision support
  - Projects
  - MSc studies
The forecasts of the past – the unimaginable future

Prediction is very difficult, especially if it is about the future.

N. Bohr, Physics Nobel Price, 1922

“I have traveled the length and breadth of this country and talked with the best people, and I can assure you that data processing is a fad that won’t last out the year.”

— The editor in charge of business books for Prentice Hall, 1957

Digital twins

https://dlmultimedia.esa.int/download/public/videos/2021/10/038/orig-2110_038_AR_EN.mp4

Source: https://www.arup.com/services/digital/digital-twin
Water

- Pressures on water resources
- Consequences of climate change
- Need for conservation and sustainability of water resources
- Need for better information and predictions - to understand and to manage water resources

Water

- Need for better information and predictions - to understand and to manage water resources
  - water-related decisions are difficult to test on large-scale experiments, hence the importance of computer-based modelling
  - control of water resources must be based on optimal solutions
  - management of water needs a lot of data and information from various sources

→ need for Computer-based modelling, Information and Communication Technology (ICT) tools
Hydroinformatics

- modelling, information and communication technology, computer sciences applied to problems of aquatic environment with the purpose of proper management
- Flow of information

Data → Models → Knowledge → Decisions

Earth observation, monitoring → Numerical Weather Prediction Models → Data modelling, integration with hydrologic and hydraulic models → Access to modelling results → Decision support

Hydroinformatics research

Data
- Data from:
  - Sensor networks
  - Remote sensing
  - Historical records
  - Diverse data models
  - Standardization
  - From data poor to data rich environments

Models
- Application specific expertise!
- Generic modelling issues:
  - Calibration
  - Sensitivity and Uncertainty analysis
  - Coupling of models
  - Model building (data-driven models)
- Multiple model runs that require more computational power (HPC, Clouds)

DSSs
- Multiple objectives of water systems:
  - Optimisation
  - Multi Criteria Analyses
- Many stakeholders:
  - Collaborative modelling and decision making
  - Web and mobile phone applications
  - Citizens' observatories
- Mix of social and technical data
Examples of using modelling in water-related issues

• Projects
• MSc studies

Data and Decision support

• Decision makers are effective if they
  • seek safe and reliable information
  • acknowledge incompleteness of information
  • depend on a variety of information streams
  • respect opinions of stakeholders
  • assess the consequences of possible decisions with models
  • use principles of systems analysis and optimisation
    • generate alternatives – assess them – choose the best one

• There are no tools that make decisions, they only support them
Project IWAVE (2012-2014 IAEA funded)

- Water-related data collected and managed by different agencies
- Proposal: Web-based Spatial Data Infrastructure (SDI) for data sharing
- Agencies maintain control over their datasets and determine conditions for sharing

Project IWAVE HISP component

Water related agencies in the Philippines

- NWRB – National Water Resources Board
- MGB – Mines and Geology Bureau
- LWUA – Local Water Utilities Association
- PAGASA – Philippines Met office
Project IWAVE-HISP Technologies and results

Promoting the use of web-based services to share and process large amounts of key environmental information in the Black Sea Catchment.

Project EnviroGRIDS (2009-2013 EU funded)

Promoting the use of web-based services to share and process large amounts of key environmental information in the Black Sea Catchment.
Modelling for Decision support

Flood Example

- Expert and citizens
  - Predictions & Adaptation measures
    - Expert & Decision makers

Project ProACC (2012-2014 DUPC Funded)

- Study area: Mekong delta
- Objective:
  - determine climate change - vulnerabilities management and risk modelling for the coastal area in the Mekong Delta
Project ProACC: Modelling flood hazard in Mekong delta

1D model of Mekong delta (Mike 11 model)

Peak flood

the largest inundated area (in time)

Flood vulnerability in Mekong delta

2050 flood at peak flood

2050 the largest inundated area (in time)

Risk zones | Hazard ranking | Vulnerability index | Risk factor
---|---|---|---
Very Low | 0.0-0.04 | 0-0.2 | 0-0.008
Low | 0.04-0.1 | 0.2-0.4 | 0.008-0.04
Medium | 0.1-0.2 | 0.4-0.6 | 0.04-0.12
High | 0.2-0.4 | 0.6-0.8 | 0.12-0.32
Very high | 0.4-1.0 | 0.8-1.0 | 0.32-1.0
Phones and decision support

How is the phone used for water and environment?

• Collect rainfall data
• Show water quality
• Collect land use
• Measure water level
• Measure water velocities
Phone technologies used in IHE studies

Projects
- 2008-2012 - **Lenvis** - Localised environmental and health information services for all: User-centric collaborative decision support network for water and air quality management
- 2008-2012 - **MoMoX** – Mobile Monitoring Experiment
- 2012-2016 - **WeSenseIT** - Engaging citizens for innovative flood risk management solutions (Citizen Observatory of Water)
- 2014-2018 - **MaMaSe** - Mau Mara Serengeti Sustainable Water Initiative
- 2016-2019 - **SCENT** - Smart Toolbox for Engaging Citizens into a People-Centric Observation Web

Involving citizens as sensors for environment

Traditional methods
- Complex instrumentation
- High cost

Crowdsourcing
- Simple
- Data abundant
- Low cost
- Awareness
Project: LENVIS$^{4}$all (2008-2012 EU funded)

LENVIS4all (2008-2012)
localised environmental information services for all:
user-centric collaborative decision support network for water and air quality management

Integrated Web-Mobile Phone applications

Web site

Brabantse Delta:
Monitored water quality of lakes used for swimming

Dommel:
Modelled river water quality affected by urban waste water and agricultural runoff

IAHR Africa Online Summer School, 2-12 October 2022
I. Popescu @IHE Delft
Project ICeWater (2012 - 2015 EU Funded)

Objectives:
- Increased energy and water efficiencies.
- Using latest sensor technologies (pressure, flow, energy, leakage).
- Connected via wireless technologies.
- To monitoring, management and decision support system components.
- Using and overall system architecture based on web services.

Project ICeWater – case study of Milan city in Italy and IHE’s DSS component

Water Distribution Systems

Hydraulic simulation of the Water Distribution System (Epanet)

Optimisation of Pump Schedules in the Water Distribution System (Epanet combined with Genetic Algorithms)
SCENT project (2016-2019)

• Modelling for decision support
• Flood modelling is data demanding

Predictions & Adaptation measures
Expert & Decision makers

Citizen observatories – SCENT project

http://scent-project.eu/

• Citizens become the ‘eyes’ of the policy makers

• Tools:
  • Campaign manager
  • Explore
  • Measure
  • Collaborate
SCENT project case studies

Rural/Wetland area
Danube delta, Romania

Urban area
Kifissos catchment, Greece

Case study: Danube delta, Romania

Measured Q (m³/s)

Stage (m.a.s.l)

Upstream boundary

Downstream boundary
SCENT project
Case study: Model of the Sontea – Fortuna area in the Danube delta, Romania

Downstream boundary
Upstream boundary

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I. Popescu @IHE Delft

SCENT project
Danube delta – Data collection campaign during dry period

Legend:
- Tulcea
- 32 observations (Score: 78.6)
- 33 observations (Score: 90.7)

Legend:
- Boat position
- Possible depth measurement points
- Possible velocity measurement locations

Canal width

IAHR.org
SCENT project
Sontea Fortuna area collected data

Example of water level collected data

Example of velocity collected data

Analysis of collected data in Sontea Fortuna area in DD
SCENT project
Case study: Kifissos catchment, Greece

Use of side-view phone photos to determine Xsections in Kifissos river

<table>
<thead>
<tr>
<th>Station (m)</th>
<th>Height (m)</th>
<th>Station (m)</th>
<th>Height (m)</th>
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![Diagram of river sections and photos](image)

Height (m) vs Station (m) graphs for K14, K20, and K25, showing drone-based DSM, drone-based DTM, side-view, and original cross-section data.
Water related citizen science efforts in Africa

• CODATA & WDS Task group on Citizen science survey
• Aim: SDG 6 and SDG 11
• Survey questions
  • Data gathering: direct observation, expert opinions, interviews, ...
  • Tools used: smart phone, books, computer, test kits (water quality)
  • Funding source
  • Outcomes: education, advance research, etc

Total Sample size = 154; Total Responses = 51; Percentage = 33.1%
Eiffel (2021-2023 EU H2020)

- **Eiffel**: REVEALING THE ROLE OF GEOSS AS THE DEFAULT DIGITAL PORTAL FOR BUILDING CLIMATE CHANGE ADAPTATION & MITIGATION APPLICATIONS
- **IHE Delft**: Climate change adaptation to droughts, the case study of Aa of Werijks in The Netherlands

Source: eiffel4climate.eu/

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Eiffel (2021-2023 EU H2020)

- **IHE Delft**: Water and Land-Use Management

  - Decision Support System to assess the impact of potential measures focusing on water management, land use and soil carbon changes within a river basin.

  - Regional and cross-border scale
    - Netherlands-Belgium, Aa river basin
    - Noord-Brabant Province

Current Drought stress (A) & 2050 High Drought Stress (B) in the Dutch part of the Catchment (Data Source: Climate Impact Atlas)
Water ForCE (2021-2023 EU H2020)

- Water Scenarios for Copernicus explorations
- Aim: The overarching objective of the Water-ForCE project is to develop the a Roadmap for Copernicus Inland Water Services

Examples of using modelling in water-related issues

- Projects
- MSc studies
MSc: Flood risk evaluation in coastal areas of Bangladesh

Work of Feroz Islam (2016)

Results Discussion (Flood map for 3 worst case scenarios)
MSc: Flood risk evaluation in coastal areas of Bangladesh

Results Discussion (Flood map for 3 worst case scenarios)  Work of Feroz Islam (2016)

Settlements by the canal have higher risk of flooding

Work of Feroz Islam (2016)
MSc: Optimisation of Filling of a New Reservoir

Work of Khalid Hasaballah (2012)

• Problem: How to fill a new reservoir such that downstream reservoir is minimum impacted in energy production

• Objective
  • Model-Based Optimization of Downstream Impact During Filling of a New Reservoir

• Case Study: Mandaya and Roseires Reservoirs on the Blue Nile River

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MSc: Optimisation of Filling of a New Reservoir

Work of Khalid Hasaballah (2012)

• Problem:
  • The first 2 years of filling the Mandaya Reservoir leads to reduction of hydropower production within the Sudanese dams

• Research question:
  • What is the optimal (compromise) filling strategy of the upstream Mandaya Reservoir for:
    • Maximum power generated at Mandaya Reservoir during the filling period?
    • Minimum impact on power generation at Roseires Reservoir downstream

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MSc: Optimisation of Filling of a New Reservoir

Work of Khalid Hasaballah (2012)

- Sudan
- Ethiopia
- Roseires reservoir
- Mandaya reservoir (plan)

(in 2011 superseded by Grand Renaissance Dam project)
MSc: Optimisation of Filling of a New Reservoir

- Solution approach and results
  - The computational tools are coupled models of MIKE BASIN with MATLAB
  - Used the Multi-Objective Optimization (MOO) by randomized search (NSGA-II algorithm) with 2 objective functions:
    - Maximization of Roseires power generation (first 2 years)
    - Maximization of Mandaya power generation (first 5 years)
    - 36 decision variables (monthly control flows from Mandaya distributed over the first 3 years)

![Work of Khalid Hasaballah (2012)](image)

A. Highest weight to Mandaya
B. Highest weight to Roseires
C. Equal weight to both objective functions

MSc: Smartphone and web app for community-based disaster management

![Work of Vittorio Nespeca, 2017](image)

Accra, Ghana
MSc: Smartphone and web app for community-based disaster management

Work of Vittorio Nespeca, 2017

Accra, Ghana

Emergency Aid Dashboard
Some thoughts to conclude

Always be prepared to learn something new

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