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

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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

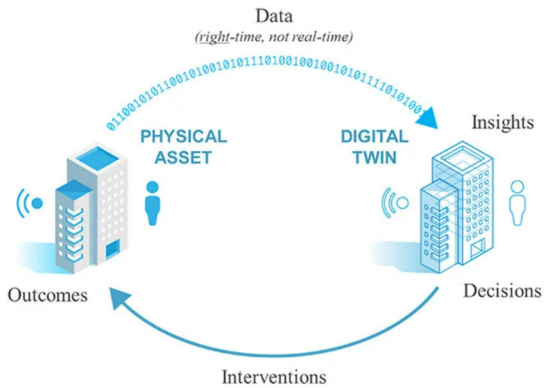
"**I have traveled the length and breadth of this country and talked with the best people, and I can assure you that data processing is a fad that won't last out the year.**"

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

The forecasts of the past – the unimaginable future

- 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

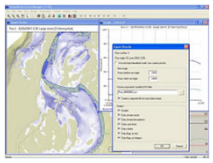
Hydroinformatics

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

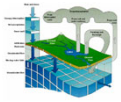
Data → Models → Knowledge → Decisions

Earth observation, monitoring

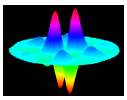
Numerical Weather Prediction Models



Data modelling, integration with hydrologic and hydraulic models



Access to modelling results



Decision support

Hydroinformatics research

> "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

Data → Models → DSSs

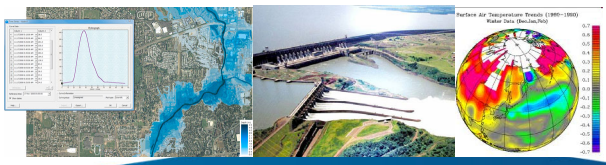
- Data from:
  - Sensor networks
  - Remote sensing
  - Historical records
- Diverse data models
- Standardization
- From data poor to data rich environments

- 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)

- 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



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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

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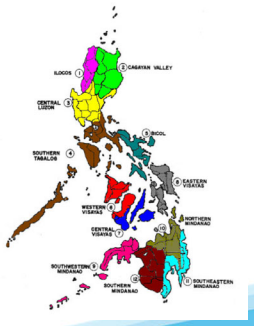
Project IWAVE (2012-2014 IAEA funded)

IWAVE- IAEA funded capacity building project

IHE component

Hydrological Information Sharing (HISP)



- 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

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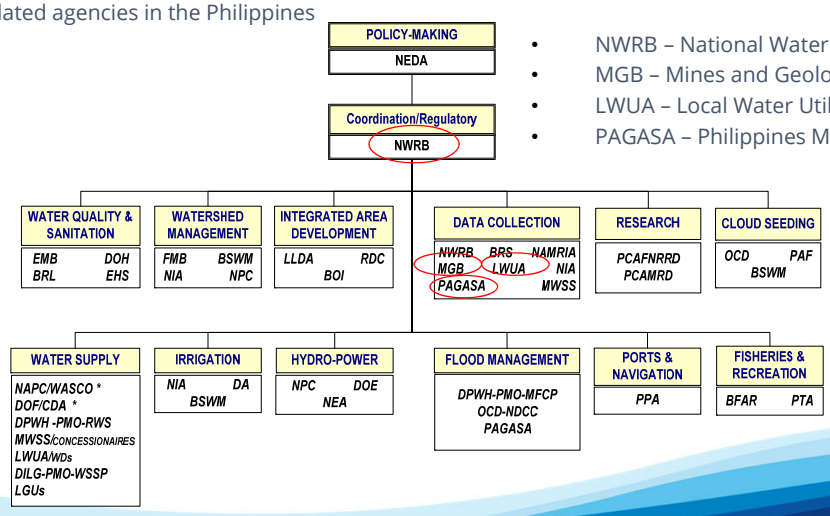
Project IWAVE HISP component

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

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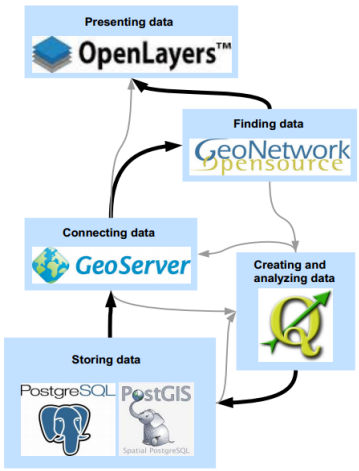
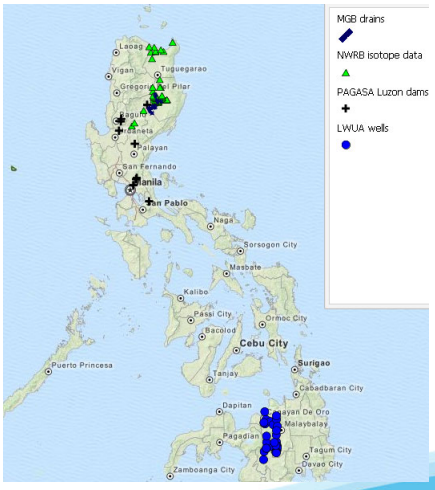
Project IWAVE-HISP Technologies and results





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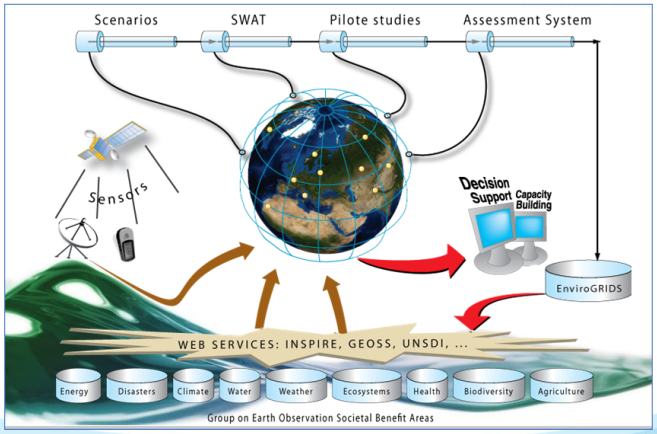
Project EnviroGRIDS (2009-2013 EU funded)

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



enviroGRIDS

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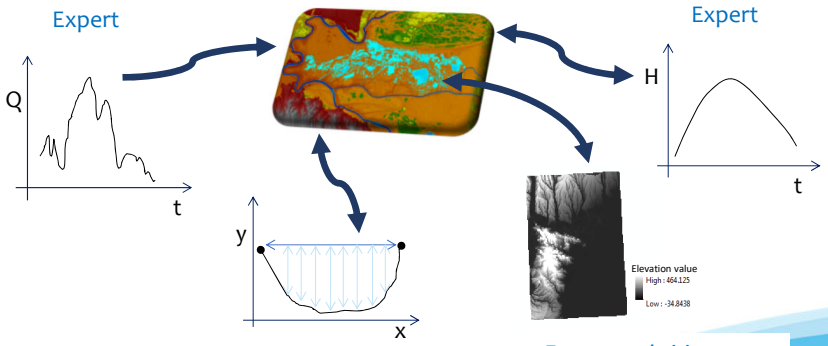
Modelling for Decision support

Flood Example

Predictions & Adaptation measures
Expert&Decision makers



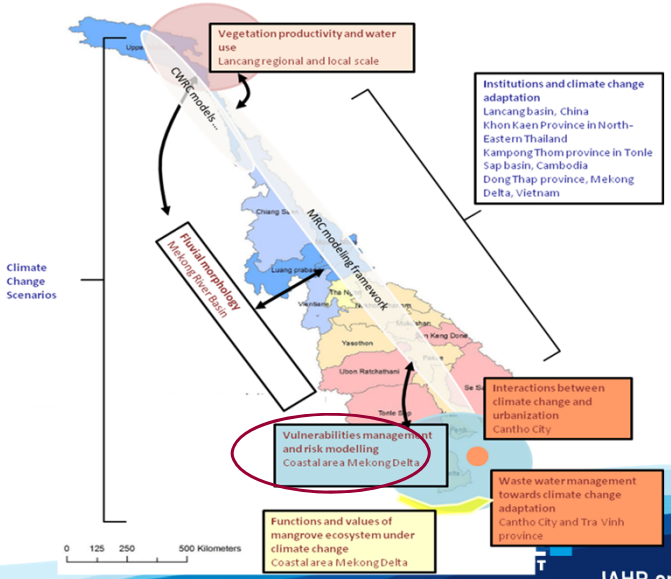
Expert and citizens

Expert and citizens

Project ProACC (2012-2014 DUPC Funded)

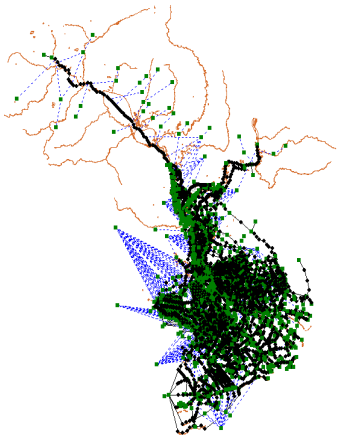
- Study area: Mekong delta
- Objective:

- determine climate change – vulnerabilities management and risk modelling for the coastal area in the Mekong Delta

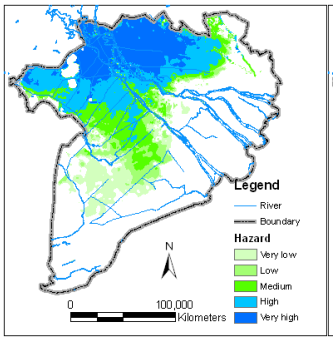


Project ProACC: Modelling flood hazard in Mekong delta

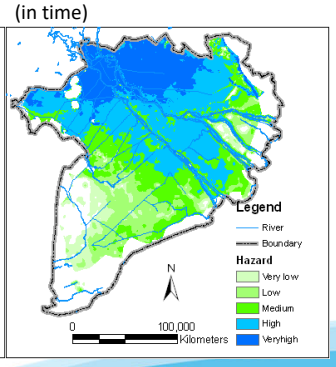
1D model of Mekong delta (Mike 11 model)



Peak flood

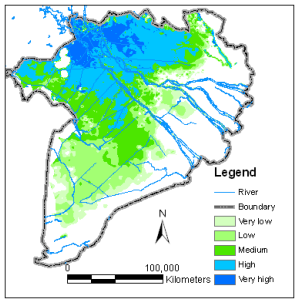


the largest inundated area (in time)

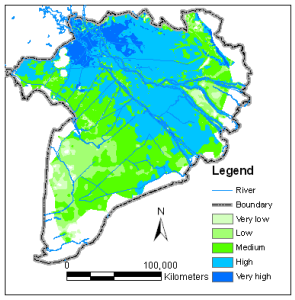


Project ProACC: Flood vulnerability in Mekong delta

2050 flood at peak flood

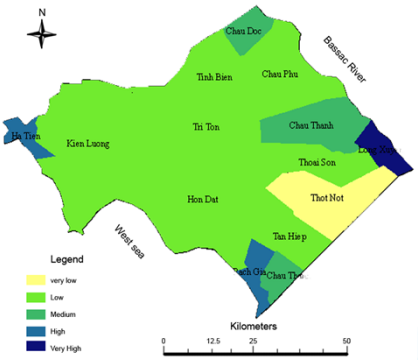


2050 the largest inundated area (in time)

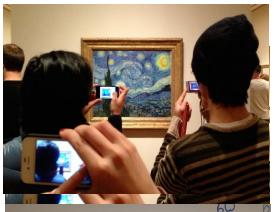
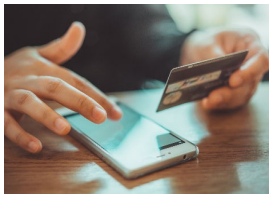


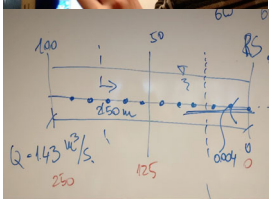
Risk zones	Hazard ranking	Vulnerability index	Risk factor
Very Low	0.0-0.04	0-0.2	0-0.008
Low	0.04-0.1	0.2-0.4	0.008-0.04
Medium	0.1-0.2	0.4-0.6	0.04-0.12
High	0.2-0.4	0.6-0.8	0.12-0.32
Very high	0.4-1.0	0.8-1.0	0.32-1.0

Flood vulnerability map in 2050 of Luang Quadrangle



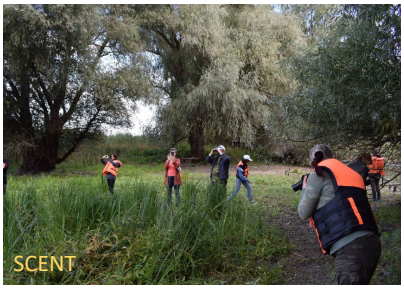
Phones and decision support

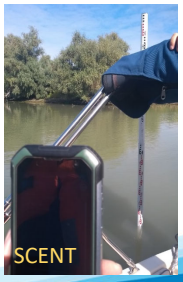






How is the phone used for water and environment?

- Collect rainfall data
- Show water quality
- Collect land use
- Measure water level
- Measure water velocities





Phone technologies used in IHE studies

MSc studies
PhD studies
Projects

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- 2015 -**ICeWater** - ICT Solutions for Efficient Water Resources Management

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

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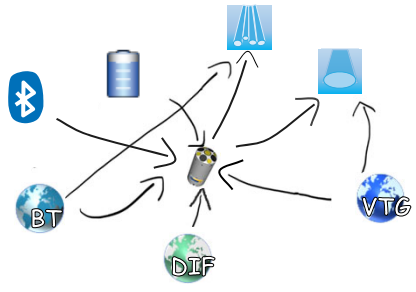
Involving citizens as sensors for environment



Traditional methods
- Complex instrumentation
- High cost

Crowdsourcing
- Simple
- Data abundant
- Low cost
- Awareness

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Project: LENVIS^{4all} (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

HydroLogic
UNESCO-IHE Institute for Water Education
gmv INNOVATING SOLUTIONS
ARIA TECHNOLOGIES
IDROMOD
INSTITUTO SUPERIOR TÉCNICO
esaprojekt
UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA
COMUNE DI BARI
Provincie Noord-Brabant

Project: LENVIS^{4all} -Case studies in NL

Integrated Web-Mobile Phone applications

Web site

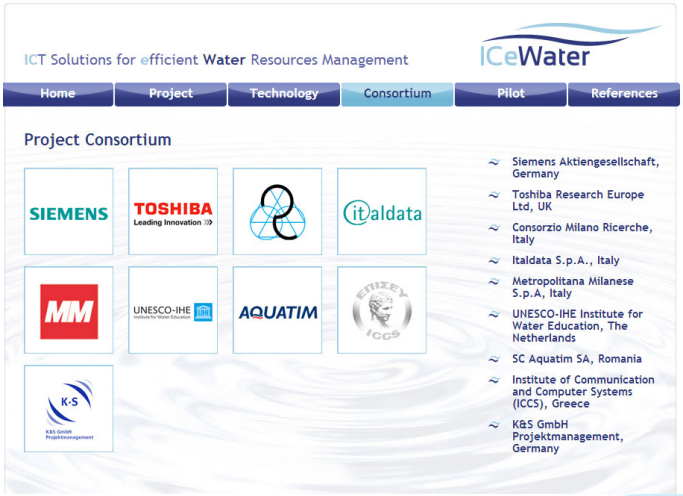
Brabantse Delta:

Monitored water quality of lakes used for swimming

Dommel:

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

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.

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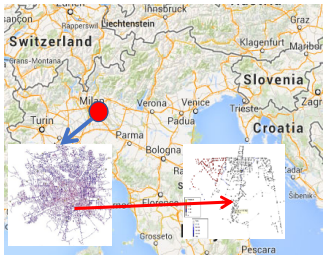
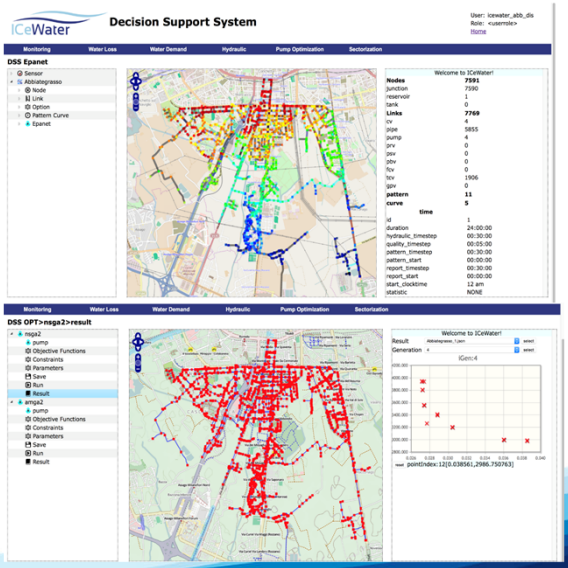
Project ICeWater – case study of Milan city in Italy and IHE's DSS component

Water Distribution Systems





Hydraulic simulation of the Water Distribution System (Epanet)

Optimsation of Pump Schedules in the Water Distribution System (Epanet combined with Genetic Algorithms)

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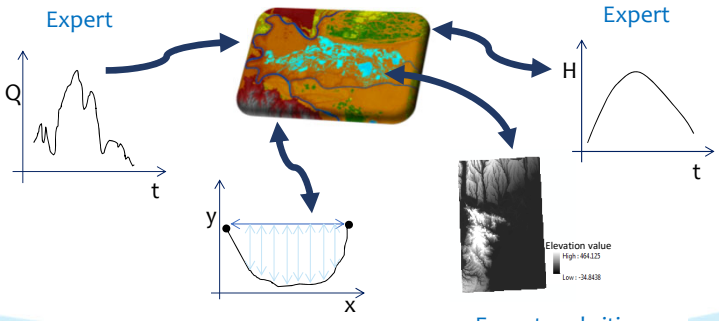
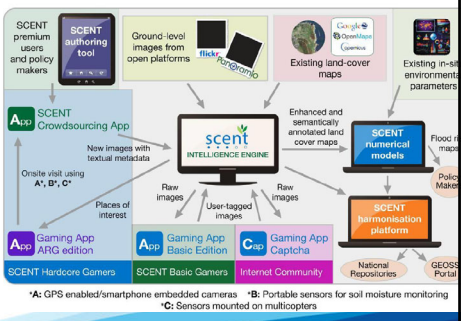
SCENT project (2016-2019)

- Modelling for decision support
- Flood modelling is data demanding

Predictions & Adaptation measures
Expert&Decision makers





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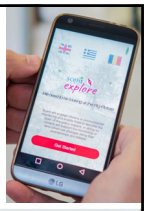
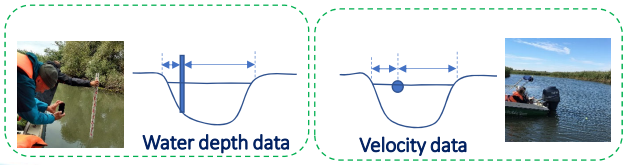
Citizen observatories – SCENT project

http://scent-project.eu/



- Citizens become the 'eyes' of the policy makers

- Tools:
  - Campaign manager
  - Explore
  - Measure
  - Collaborate



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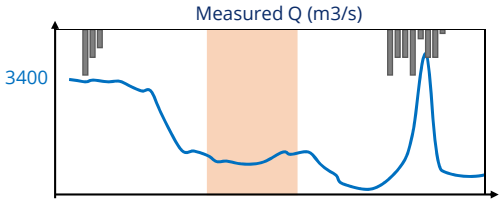
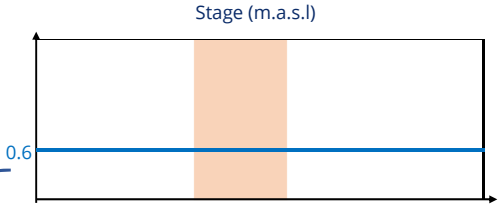
SCENT project case studies

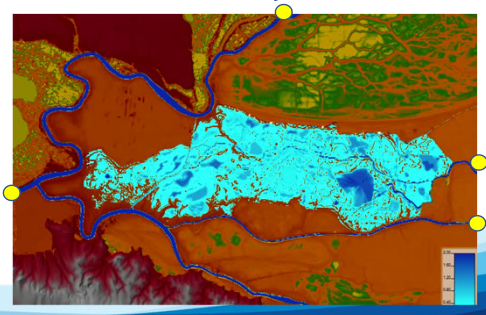
Rural/Wetland area
Danube delta, Romania

Urban area
Kifissos catchment, Grece

SCENT project
Case study: Danube delta, Romania







Upstream boundary

Downstream boundary

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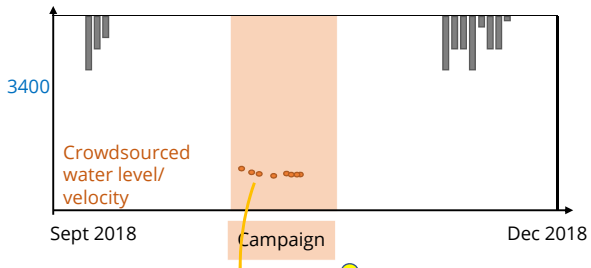
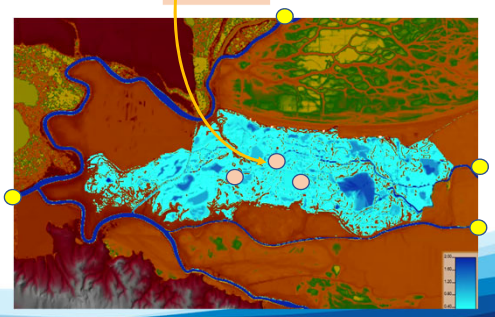
SCENT project

Case study: Model of the Sontea – Fortuna area in the Danube delta, Romania





Upstream boundary

Downstream boundary

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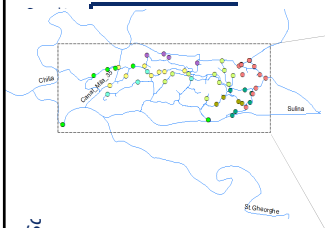
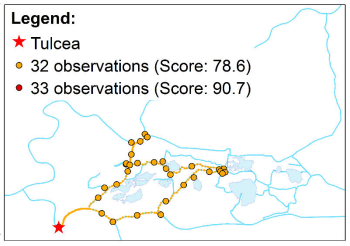
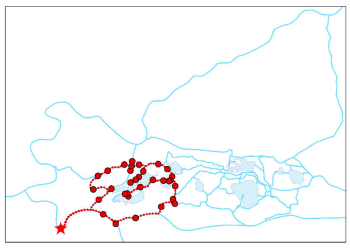
SCENT project

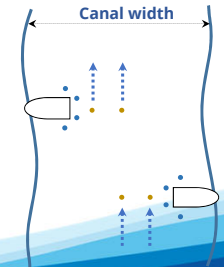
scent explore scent collaborate scent measure scent campaign manager

Danube delta – Data collection campaign during dry period









Boat position

Possible depth measurement points

Possible velocity measurement locations

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SCENT project

Sontea Fortuna area collected data

scent explore · scent collaborate · scent measure · scent campaign manager

Example of water level collected data

Example of velocity collected data

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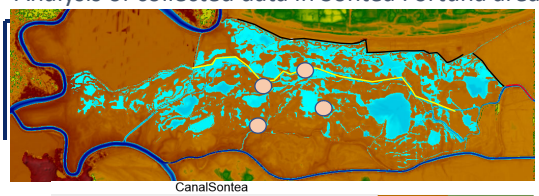
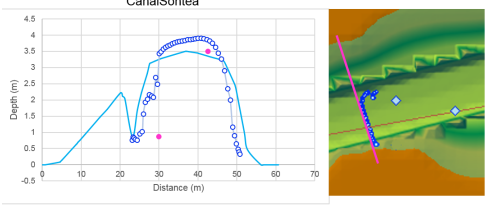
SCENT project

Analysis of collected data in Sontea Fortuna area in DD

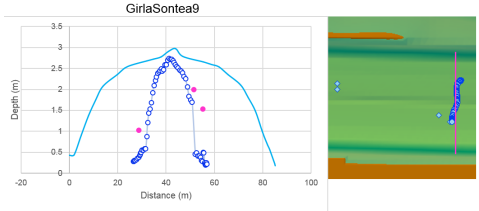


Legend
- Crowdsourced data
- Measured (ADCP) data
- Model profile
- Model terrain

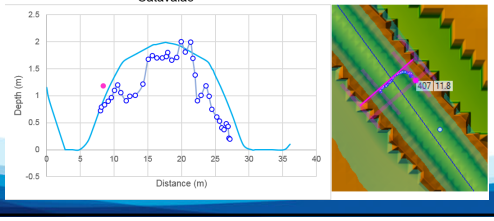
CanalSontea



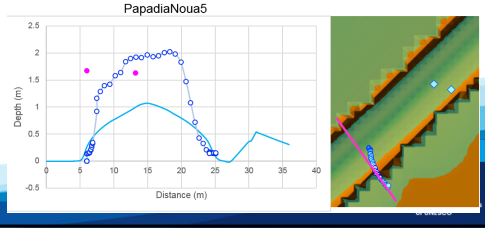
GirlaSontea9



Catavala3



PapadiaNoua5



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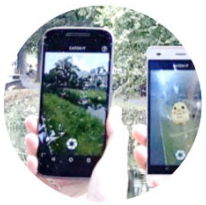
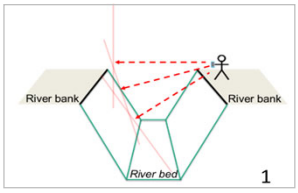
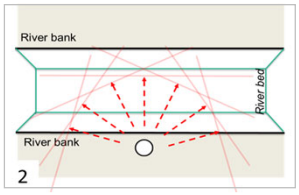
SCENT project

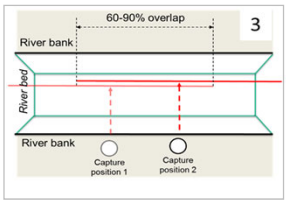
Case study: Kifissos catchment, Greece

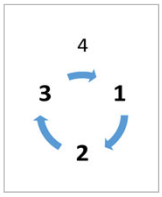
Use of side-view phone photos to determine Xsections in Kifissos river

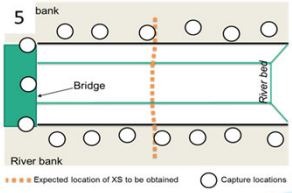












SCENT project

Case study: Kifissos catchment, Greece

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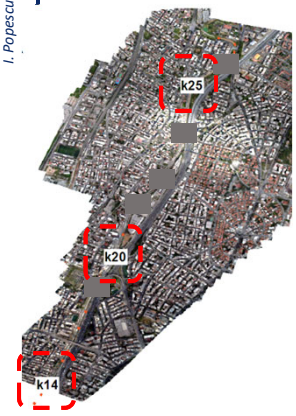
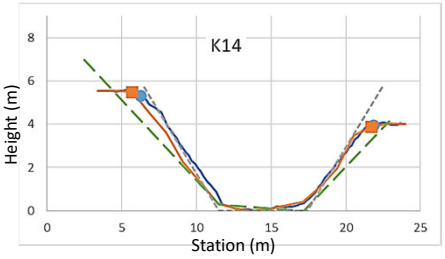
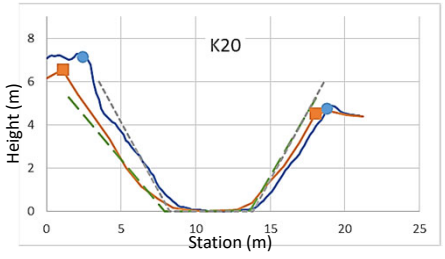
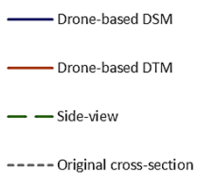
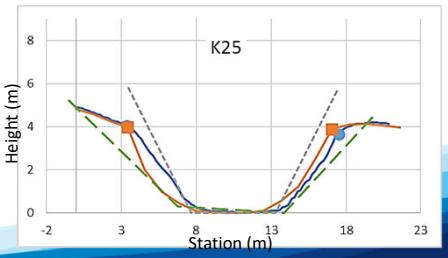
Use of side-view phone photos to determine Xsections in Kifissos river











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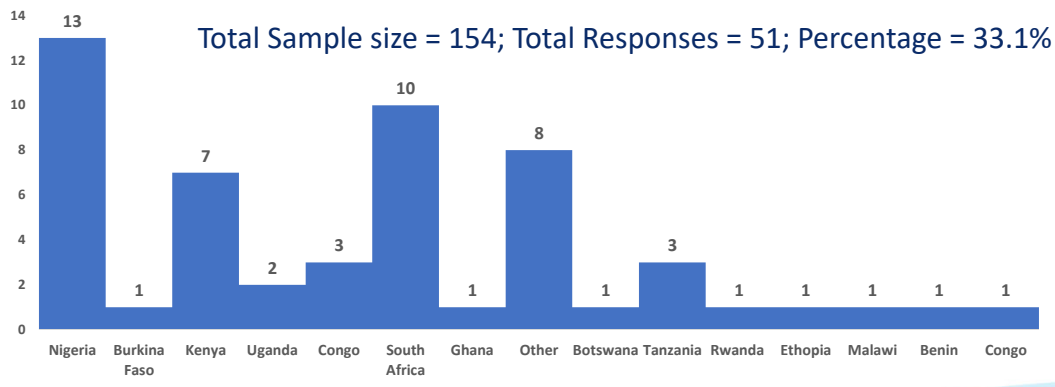
Water related citizen science efforts in Africa

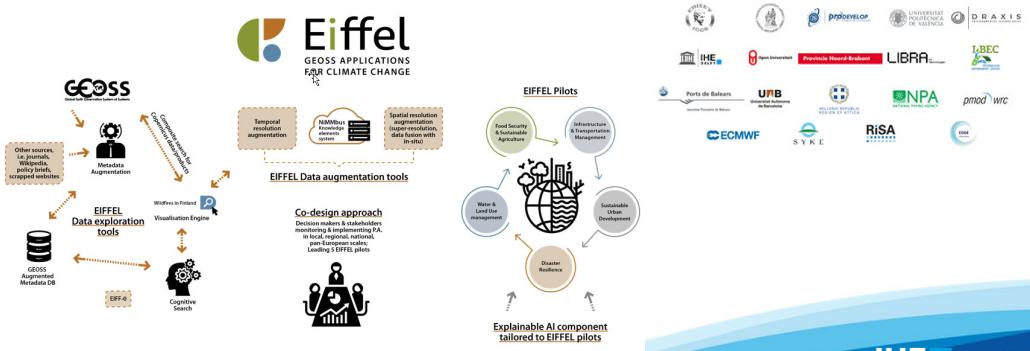
- CODATA & WDS Task group on Cirtizen science survey
- Aim: SDG 6 and SDG 11
- Survey questions
  - Data gathering: direct observation, expert opinions, interviews, …
  - Tools used: smart phone, books, computer, test kits (water quality)
  - Funding source
  - Outcomes: education, advance research,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

Water related citizen science efforts in Africa



Eiffel (2021-2023 EU H2020)

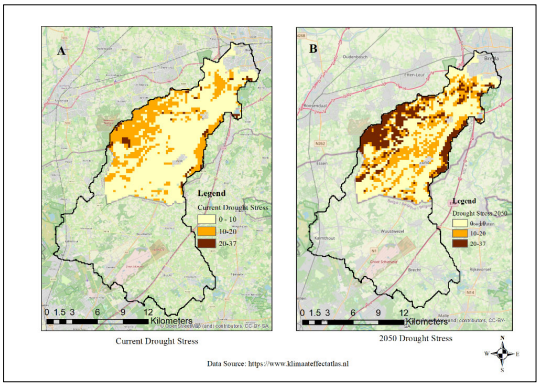
- Eiffel: REVEALING THE ROLE OF GEOSS AS THE DEFAULT DIGITAL PORTAL FOR BUILDING CLIMATE CHANGE ADAPTATION & MITIGATION APPLICATIONS
- IHE Delft: Climate change adaptation to droughts, the case study of Aa of Werijs in The Netherlands



Source: eiffel4climate.eu/

Eiffel (2021-2023 EU H2020)

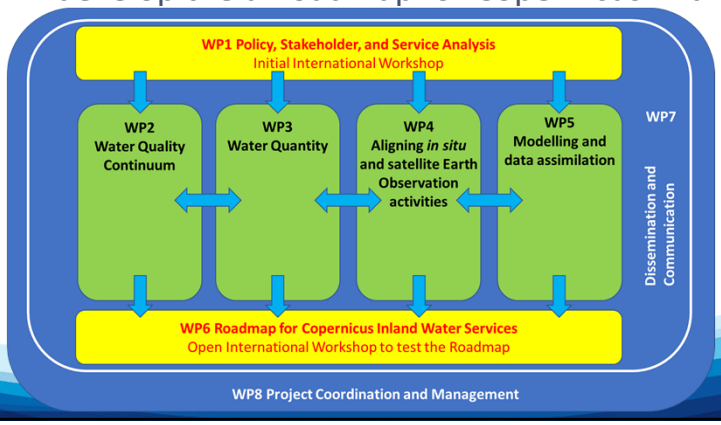
- IHE Delft: Water and Land-Use Management
  - Decision Support System to assess the impact of potential measures focusing on water management, land use and soil carbon changes within a river basin.
  - Regional and cross-border scale
    - Netherlands-Belgium, Aa river basin
    - Noord-Brabant Province



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



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Examples of using modelling in water-related issues

- Projects
- MSc studies

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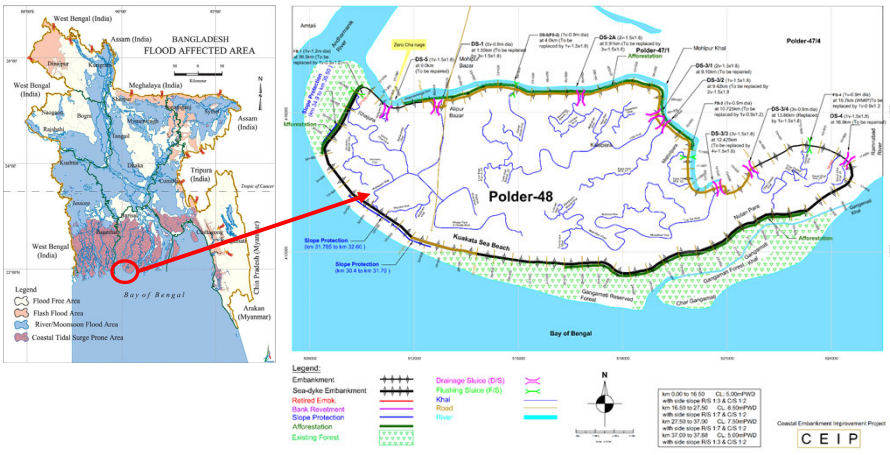
MSc: Flood risk evaluation in coastal areas of Bangladesh

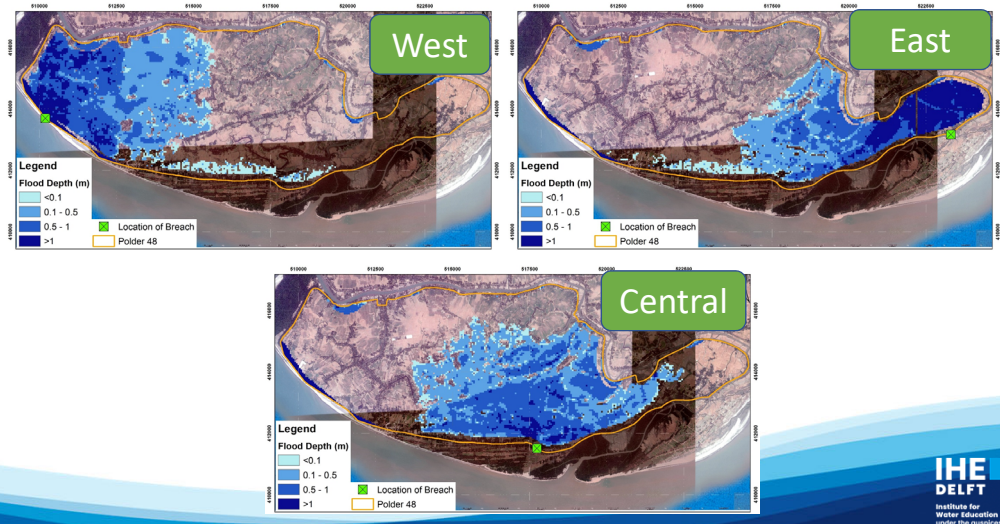
Work of Feroz Islam (2016)



MSc: Flood risk evaluation in coastal areas of Bangladesh

Results Discussion (Flood map for 3 worst case scenarios)

Work of Feroz Islam (2016)



MSc: Flood risk evaluation in coastal areas of Bangladesh

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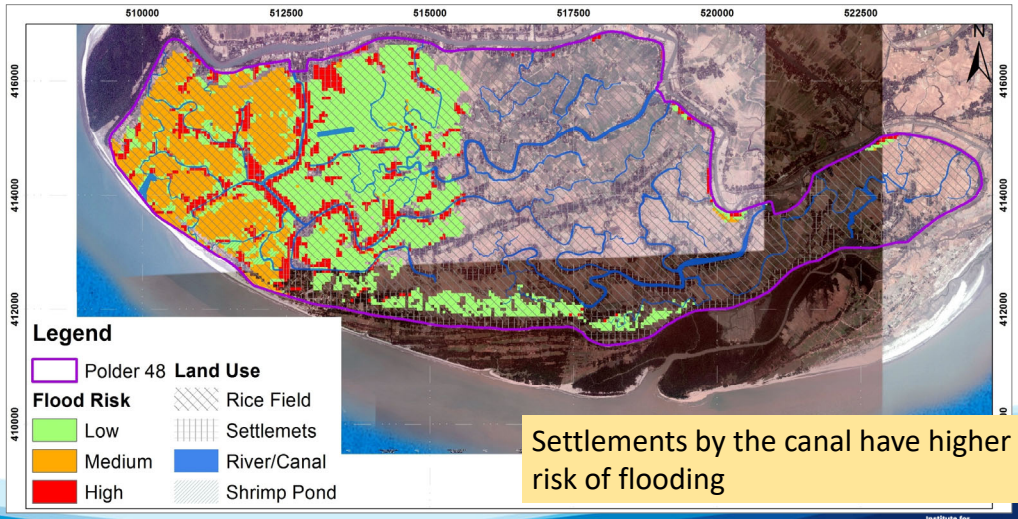

Settlements by the canal have higher risk of flooding

MSc: Flood risk evaluation in coastal areas of Bangladesh

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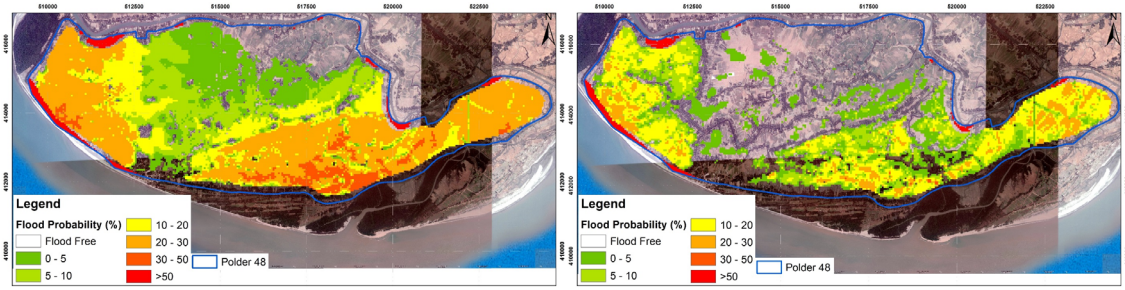
Results Discussion (Probabilistic flood map)

Work of Feroz Islam (2016)



<u>> 0m</u>

- Indicates areas with probability of inundation

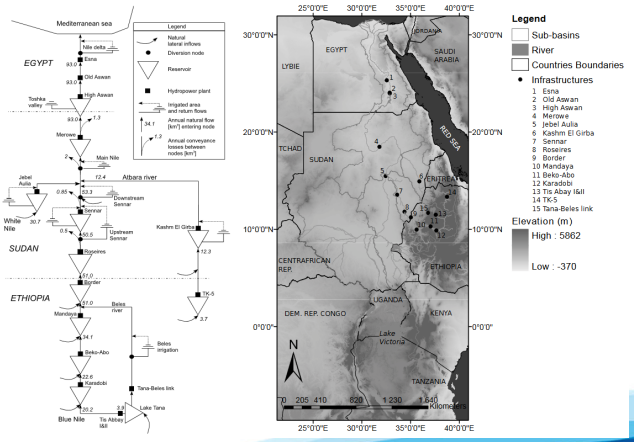
<u>> 0.5m</u>

- had the highest extent and damage.
- Indicates areas in need of attention for a flood resilient plan

MSc: Optimisation of Filling of a New Reservoir

Work of Khalid Hasaballah (2012)

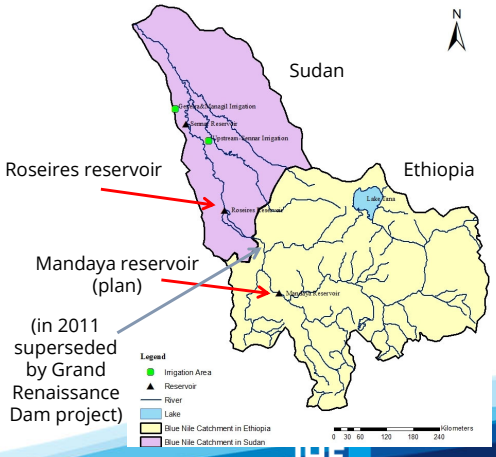
- Problem: How to fill a new reservoir such that downstream reservoir is minimum impacted in energy production
- Objective
  - Model-Based Optimization of Downstream Impact During Filling of a New Reservoir
- Case Study: Mandaya and Roseires Reservoirs on the Blue Nile River



MSc: Optimisation of Filling of a New Reservoir

Work of Khalid Hasaballah (2012)

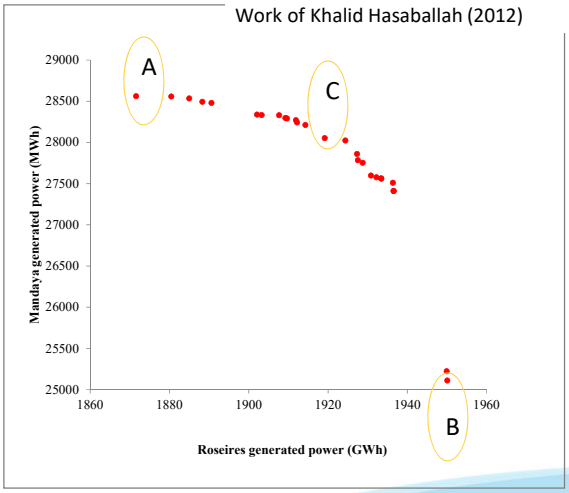
- Problem:
  - The first 2 years of filling the Mandaya Reservoir leads to reduction of hydropower production within the Sudanese dams
- Research question:
  - What is the optimal (compromise) filling strategy of the upstream Mandaya Reservoir for:
    - Maximum power generated at Mandaya Reservoir during the filling period?
    - Minimum impact on power generation at Roseires Reservoir downstream



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)

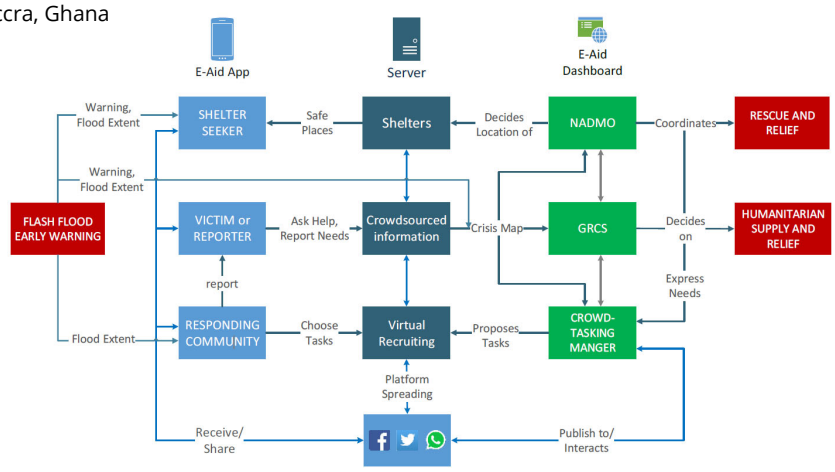


A. Highest weight to Mandaya
B. Highest weight to Roseires
C. Equal weight to both objective functions

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

Work of Vittorio Nespeca, 2017

Accra, Ghana



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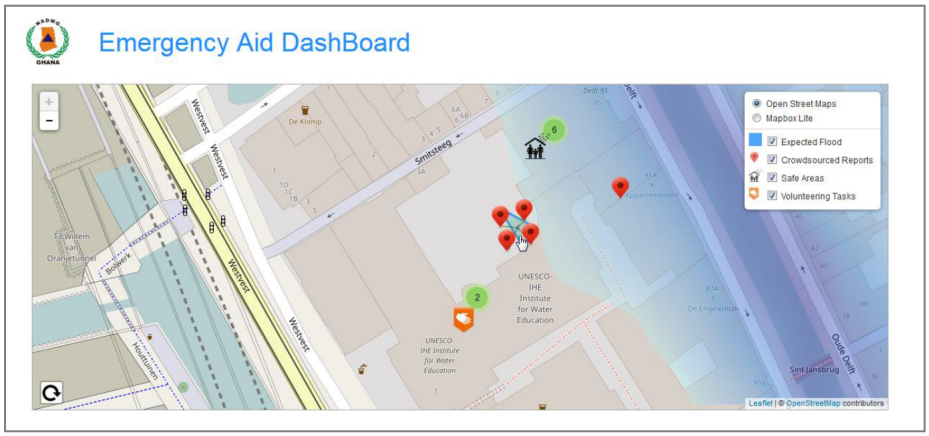

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MSc: Smartphone and web app for community-based disaster management

Work of Vittorio Nespeca, 2017

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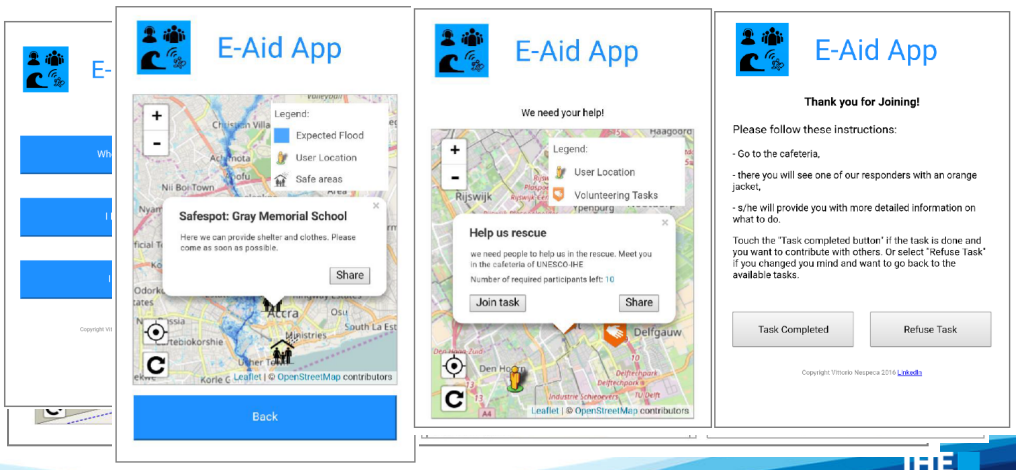

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Some thoughts to conclude

Always be prepared to learn something new

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thank you

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Hydroinformatics

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