

Integrated Decision Support Tools for water resources management

Jacob Høst-Madsen
COO, DHI



- Technology aspects



- What are the challenges?



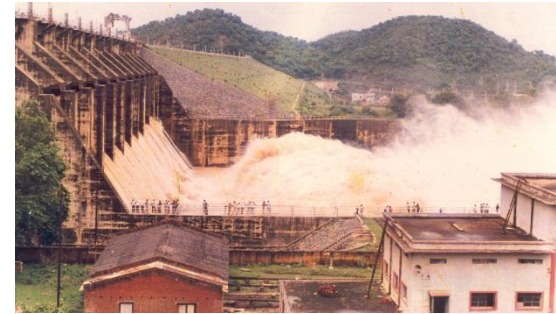
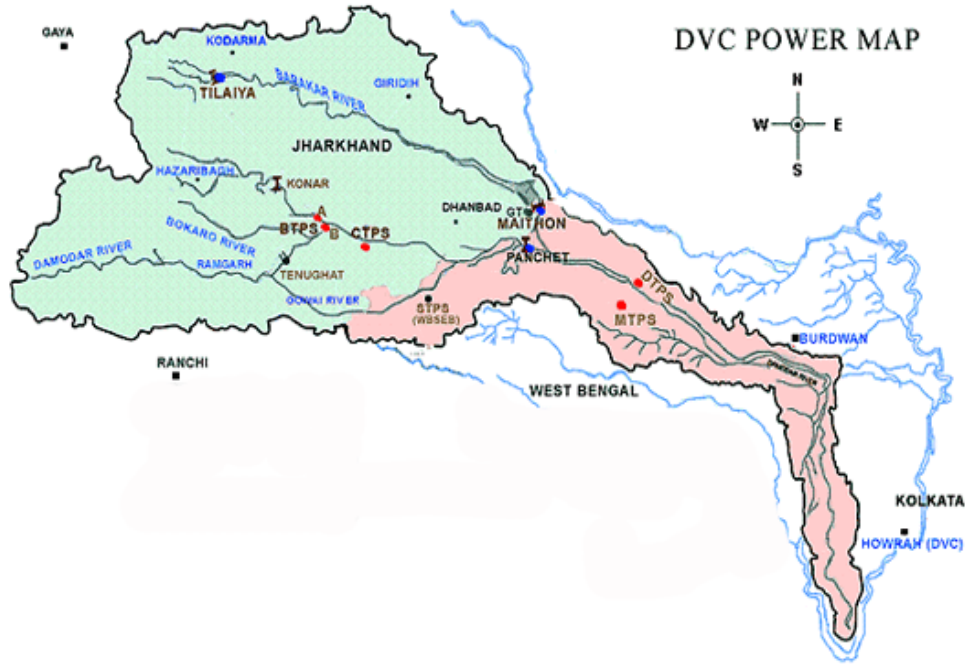
- Examples to learn from



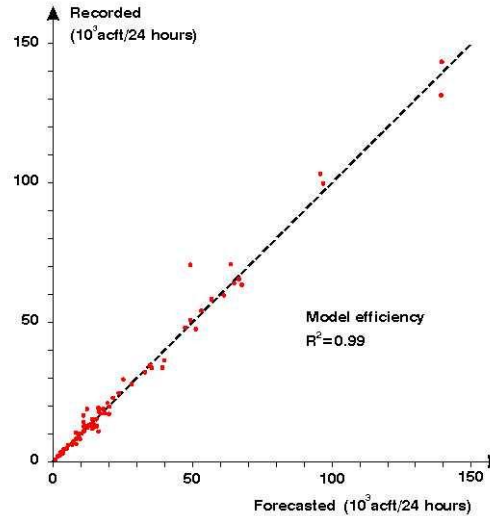
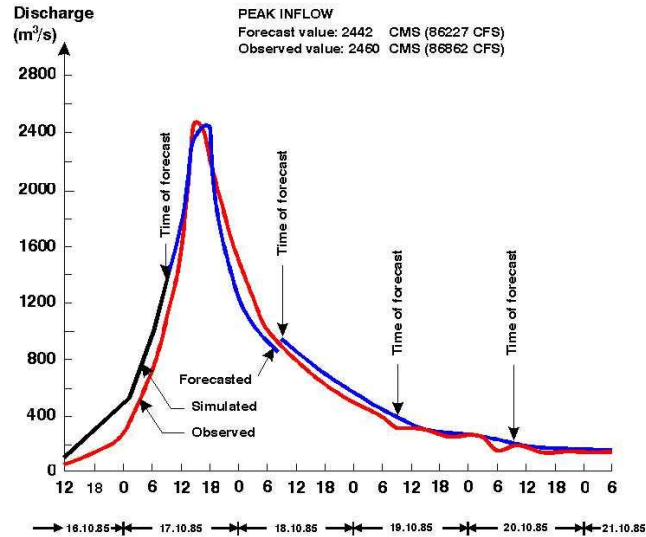
- Recommendations



Damodar valley, India, 1985



Damodar valley, India, 1985



Forecasted and recorded Inflow Hydrographs for Maithon Reservoir during the Flood Event of 16-19 October, 1985.

Flood Forecasting & Warning Centre

Bangladesh Water Development Board (BWDB)

Updated On: 23 Apr 2014
Beta version! Information may vary with actual



- Home
- About Us
- Data
- Forecast & Warning
- Map
- Reports
- Hydrograph
- Important Links
- Definitions

Madarban
Water Level : 4.78
Danger Level : 15.25

Chiringa
Water Level : 2.06
Danger Level : 5.75

Dohazari
Water Level : 1.25
Danger Level : 7.00

Lama
Water Level : 6.64
Danger Level : 12.25

Narayanhat

- Severe
- Danger
- Warning
- Normal
- South Eastern Hill
- Ganges
- Meghna
- Brahmaputra

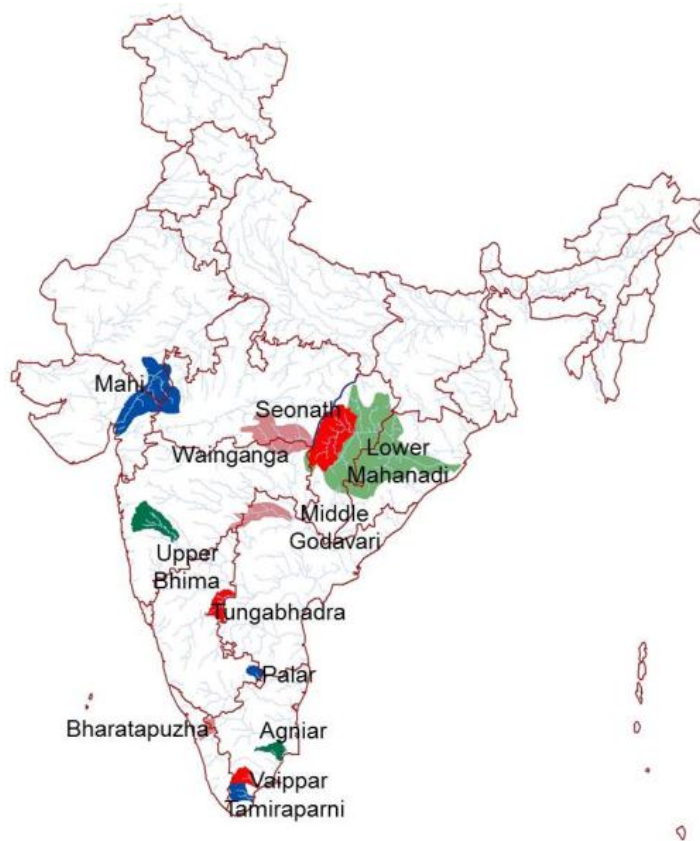
- River Based Map
- Division Based Map
- District Based Map
- Google Map



Level Status

- Normal Level
- Danger Level
- Warning Level
- Severe Level
- Stations
- Rivers

DSS Planning



Nine Participating States

- Andhra Pradesh
- Tamil Nadu
- Karnataka
- Kerala
- Maharashtra
- Madhya Pradesh
- Orissa
- Gujarat
- Chhattisgarh

Six Central Agencies

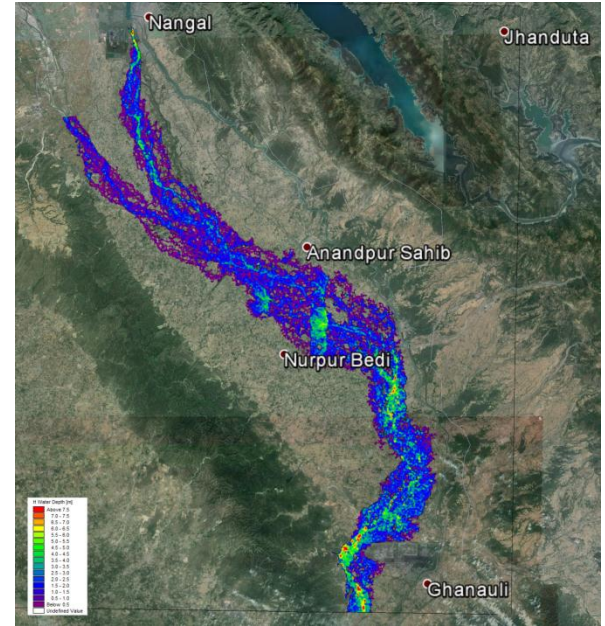
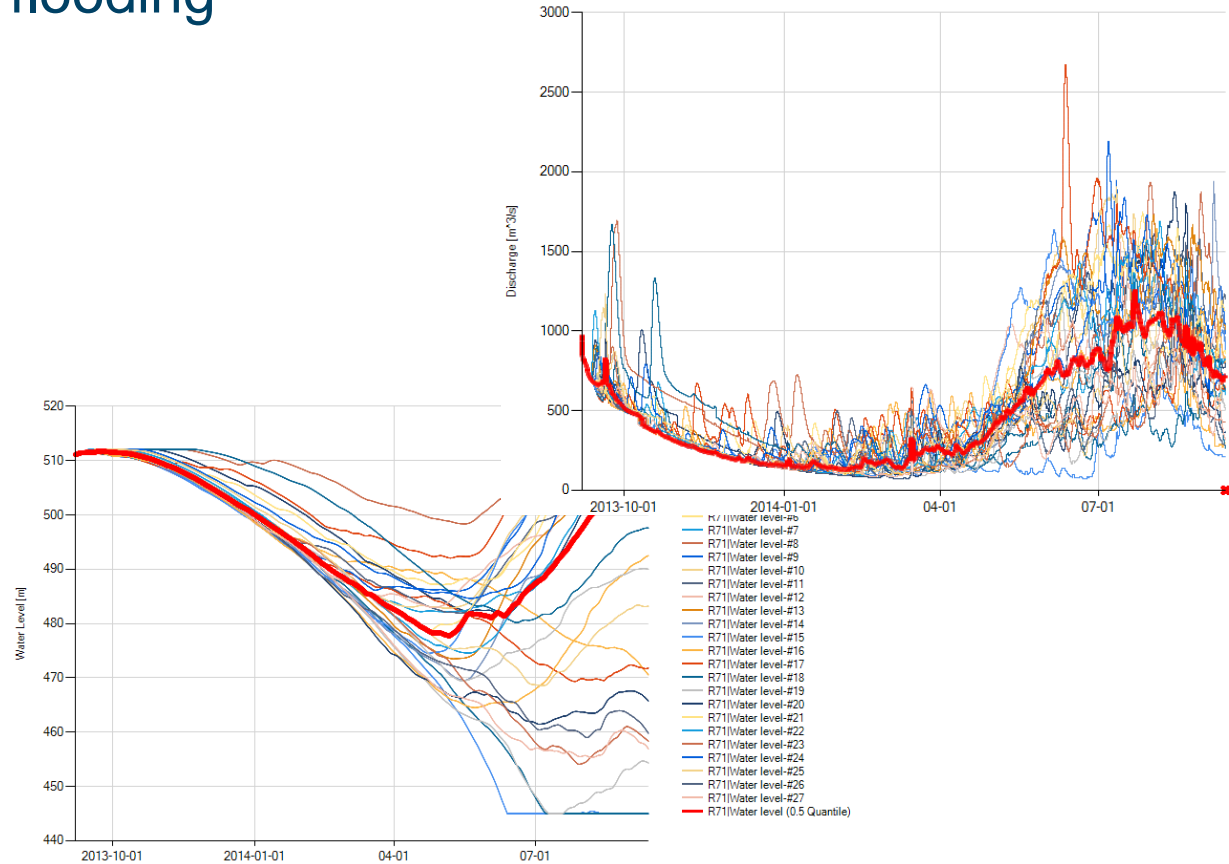
- National Institute of Hydrology
- Central Water Commission
- Central Ground Water Board
- Central Water and Power Research Station
- India Meteorological Department
- Central Pollution Control Board

Case studies selected in each state

Real-time installations



Ensemble Inflows, Reservoir storage levels, Downstream flooding



Technology aspects

Integrated decision support tools for water resources management

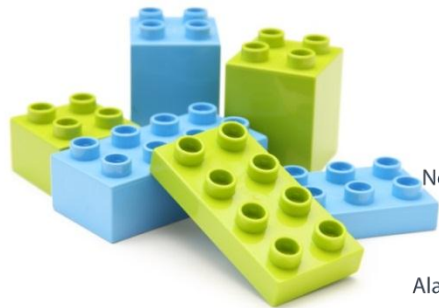
...get the full benefit of real-time **monitoring** and early warning systems

...optimise **operations** and planning



...manage, organise and analyse large amounts of **data**

...make wise and robust water management **decisions**



Notifications @

Alarms !

Data acquisition

OPC/SCADA link

Data assimilation

Jobs and automation

Uncertainty

Optimisation

Ensembles

System and database



Roles

Data brokering

Time series

GIS

Documents

Web publishing

Spreadsheets

Scripts

Indicators

Meta data Audit log

Audit log

Models and Scenarios

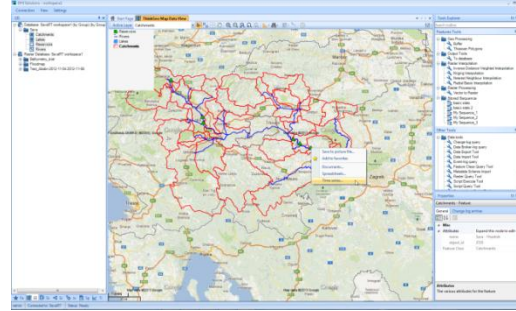
Multi-Criteria-Analysis

Cost-Benefit-Analysis

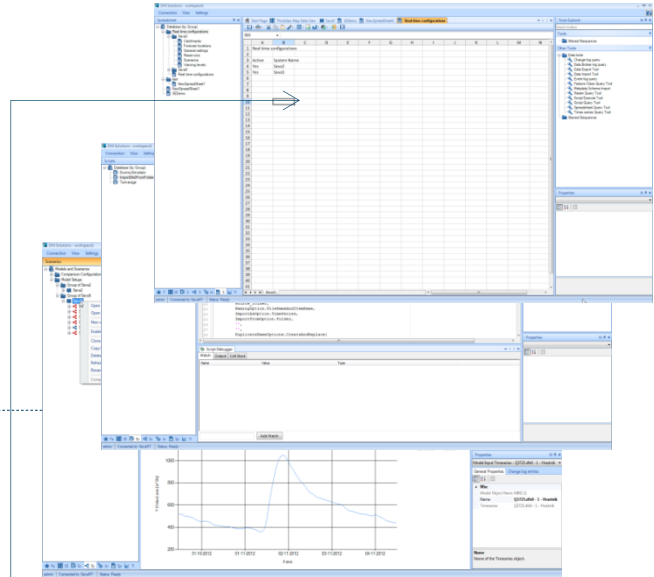




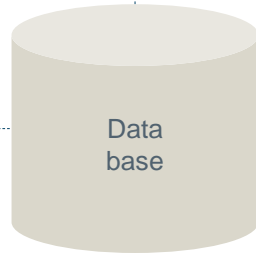
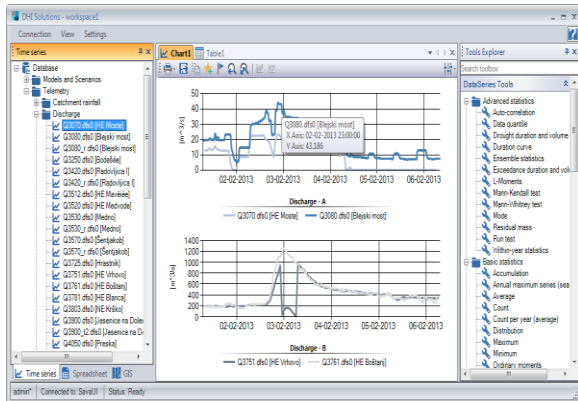
Maps
(GIS)



Spreadsheets



Time series



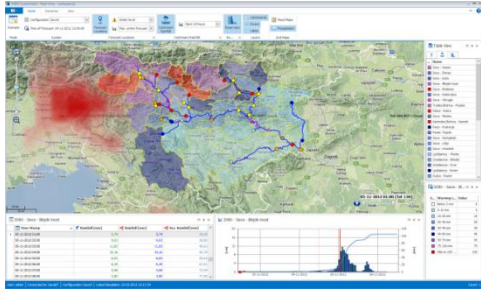
Data
base

Open architecture (API)

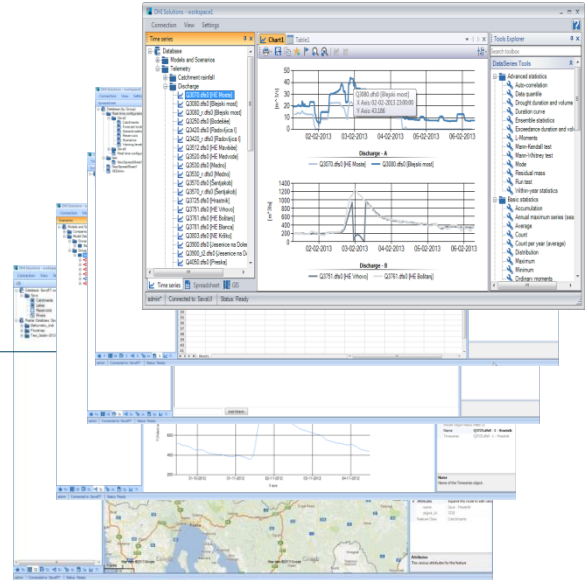
Add User tools

Different users – Different views

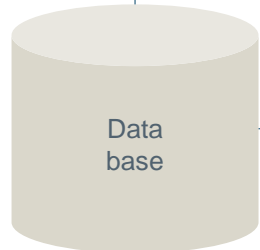
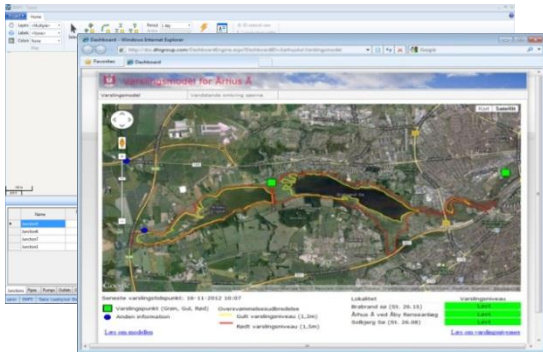
Operator view (product)

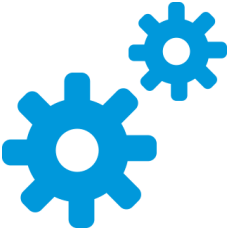


Scientific view (components)



Tailor made view (client solution)





Challenges

HP3: What are the challenges?



Climate Change
Water scarcity
Floods and droughts
Groundwater
Food production
Energy
Urbanization and Mega-cities
The Environment
Effective operations

Institutional development
Technology transfer
Capacity development
Knowledge sharing

Access to information
Effective real-time operations
Early warning systems
IWRM DSS

Legislation
Acceptance
Stakeholders
Transparency
Participation
Accountability



Development of a Water Resource Monitoring Information System (WRMIS) for the Lake Victoria Basin

Client: Lake Victoria Basin Commission

Period: Oct 2012 – Oct 2014

Viewing stations & points of interest

Where and what

The screenshot displays the WRIS (Water Resources Information System) software interface. The main window shows a map of Kisumu, Kenya, with various stations and points of interest marked. The interface includes a menu bar (Project, Stations, Analysis, Data, View), a toolbar with navigation and appearance tools, and a legend on the left side. The legend lists the following items:

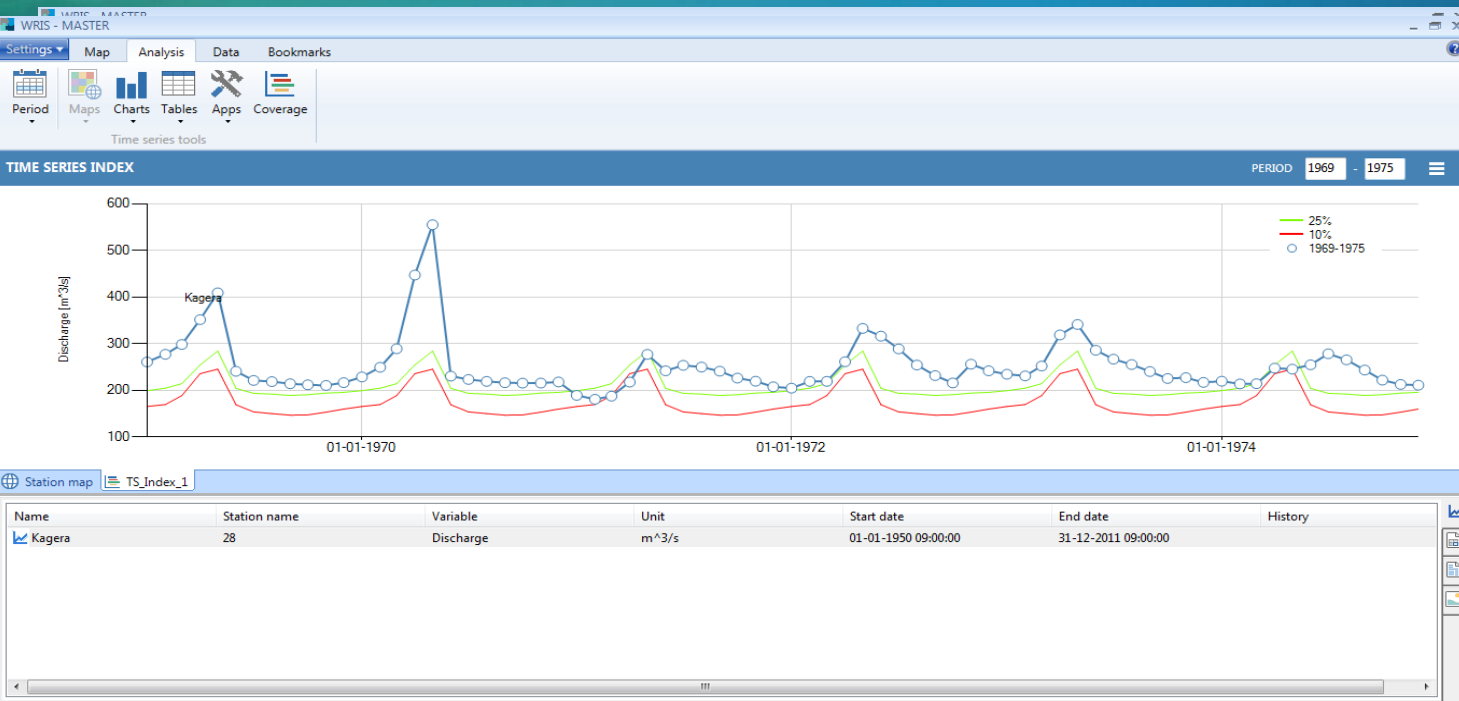
- WBL
- WQ_LakeStations
- QoSms_LVEMP
- PStns_LVEMP

The map shows the city of Kisumu, Lake Victoria, and the Kisumu Airport. The map data is attributed to Google, 2013. The interface also includes a scale bar (500 m, 2000 ft) and a north arrow.

Name	Station name	Variable	Unit	Start date	End date
------	--------------	----------	------	------------	----------

Viewing data

Tables & graphs of data stored in database



Climate
Streamflow
Water level
GW level
Concentration
Abstraction
WW discharge
Permits
Counts
Fish catches
Indicators
GIS information

Making analyses

E.g. important statistics

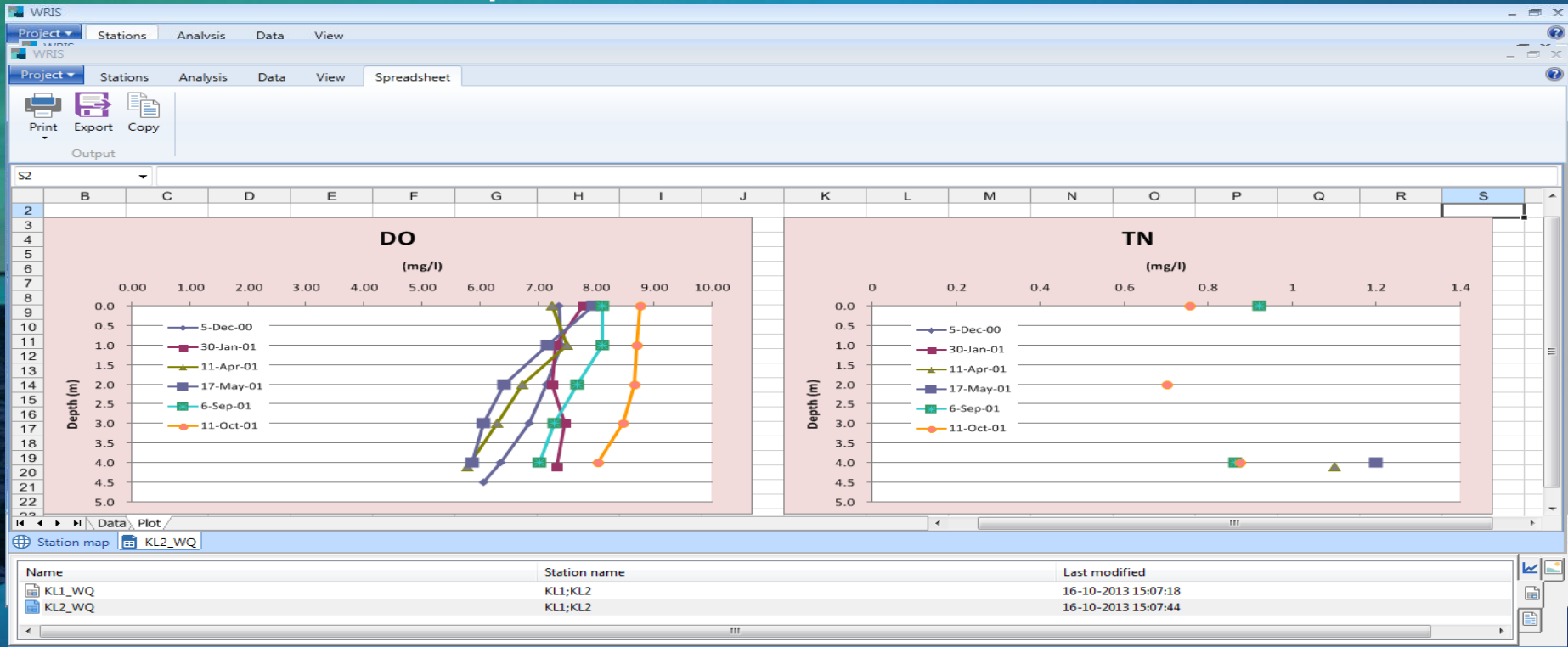
The image displays the WRIS - MASTER software interface. The main window shows a map of East Africa (Uganda, Rwanda, and Democratic Republic of the Congo) with various stations marked. A legend on the left identifies station types: Uganda Stations, WQ_LakeStations, Rainfall Stations, River Gauging Stations, and Rivers. Below the map is a table listing station details:

Name	Station name	Variable	Unit	Start date
P_GF_UG_8933043_Jin...	8933043	Rainfall	mm	01-01-1950 12
LVic_ObsWL	2	Water Level	m	01-01-1950 00

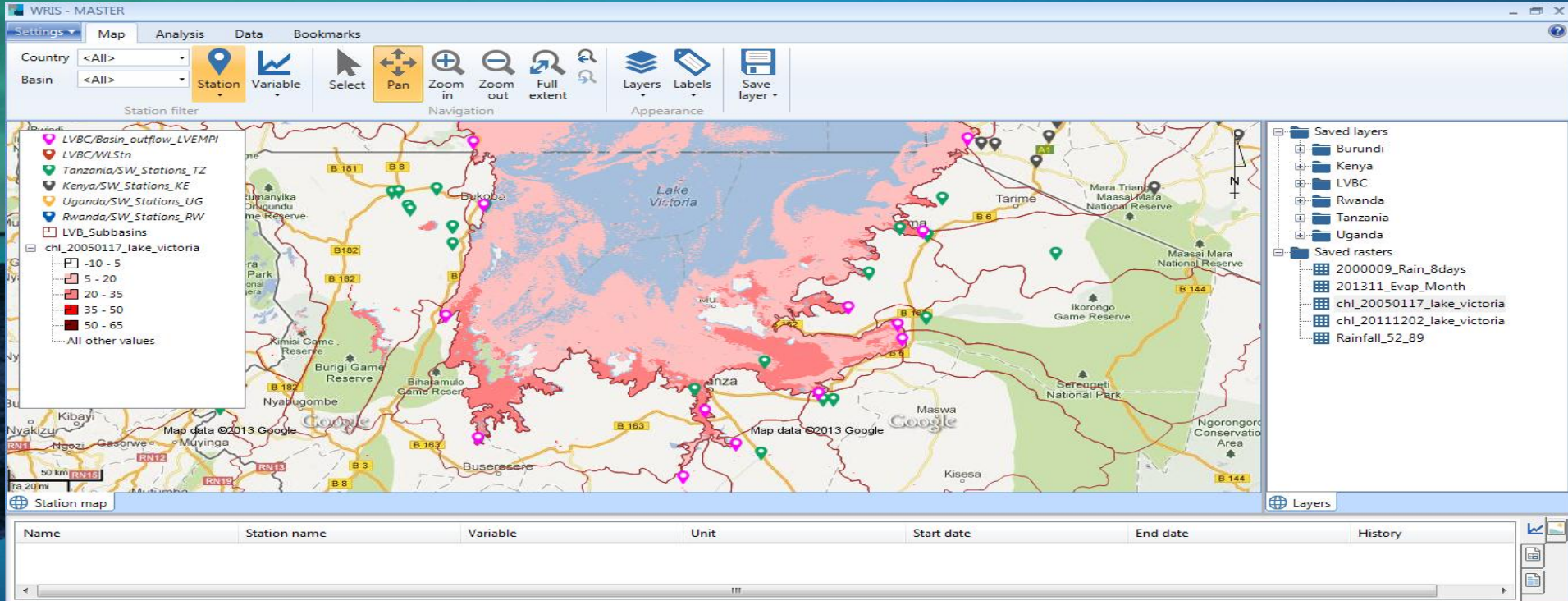
An Excel spreadsheet titled 'Jinja.xlsx - Microsoft Excel' is overlaid on the right. It displays 'Chart 4' for 'Station: Jinja'. The chart includes three sub-plots: 'Observed water level' (line graph from 1950 to 2008), 'Duration curve' (line graph of water level vs. exceedance probability), and 'Quantiles' (line graph of water level vs. month). A table of quantiles is provided below the charts:

Quantil	0.05	0.2	0.5	0.8	0.95
January	1152.20	1152.51	1152.34	1152.36	1152.26
February	1152.26	1152.27	1152.40	1152.42	1152.44
March	1152.25	1152.24	1152.26	1152.26	1152.64
April	1152.49	1152.70	1152.74	1152.73	1152.74
May	1152.44	1152.47	1152.48	1152.70	1152.70
June	1152.87	1152.87	1152.89	1152.41	1152.42
July	1152.49	1152.50	1152.51	1152.30	1152.34
August	1152.00	1152.01	1152.42	1152.44	1152.45
September	1152.46	1152.47	1152.47	1152.48	1152.40
October	1152.26	1152.29	1152.40	1152.42	1152.44
November	1152.20	1152.22	1152.28	1152.29	1152.41
December	1152.24	1152.26	1152.28	1152.34	1152.35

Viewing data that are stored in spread sheets

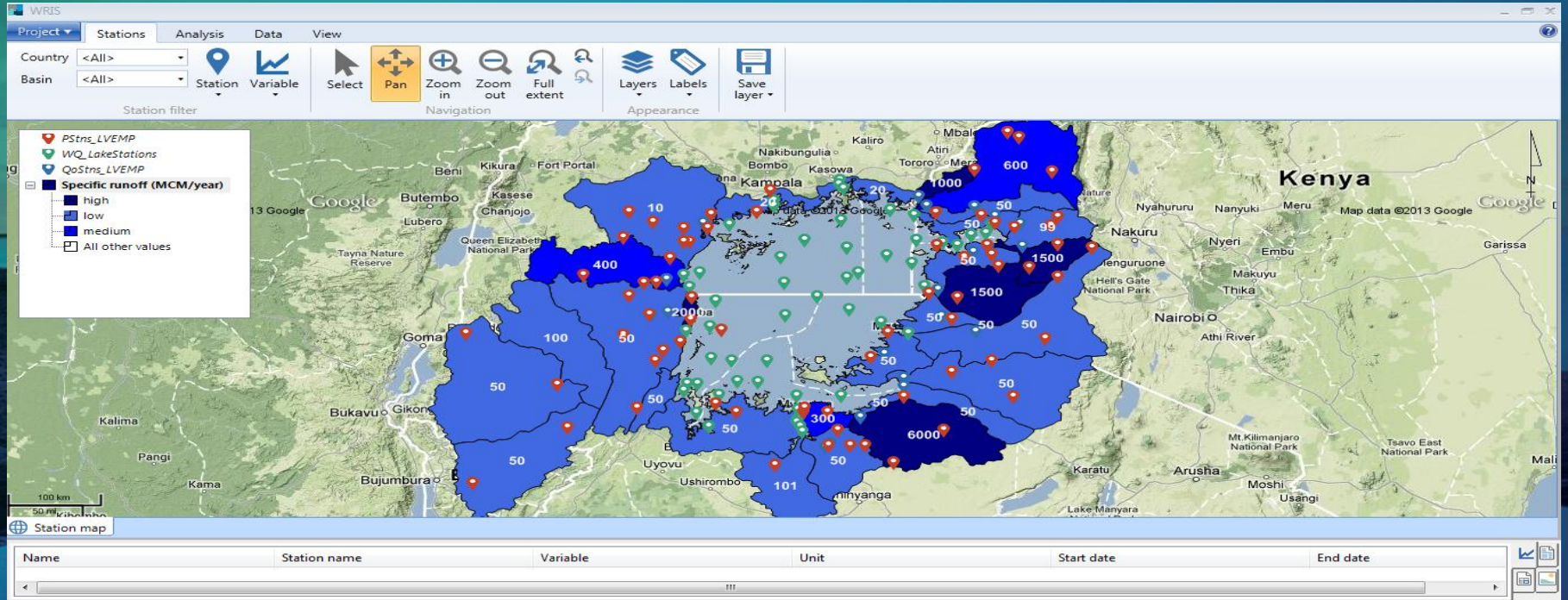


Importing data, e.g. from remote sensing sources



Making analyses

E.g. important indicators



Viewing GIS Information

The screenshot displays the WRIS - MASTER GIS application interface. The main map shows East Africa, including parts of Rwanda, Burundi, Kenya, and Tanzania. The map is overlaid with various protected areas, color-coded according to the legend on the left. The legend includes categories such as Conservation Area, Forest Reserve, Game Reserve, National Park, National Reserve, Nature Reserve, Parc National, Wetlands of International Importance (Ramsar), Wildlife Management Area, Wildlife Reserve, Wildlife Sanctuary, World Heritage Convention, and All other values. The interface also features a toolbar with navigation and appearance tools, a station filter, and a layers panel on the right. The layers panel shows a hierarchy of saved layers, including Burundi, Kenya, LVBC, and various rasters like Rainfall_1979 and Rainfall_52_89. At the bottom, a data table is visible, showing columns for Name, Station name, Variable, Unit, Start date, End date, and History. The status bar at the bottom indicates the user is logged in as 'admin' and is connected to the 'Intro_2_DB' database.

Name	Station name	Variable	Unit	Start date	End date	History

admin Connected to: Intro_2_DB Status: Ready

Publishing Information

Library of reports, analysis results

The screenshot displays a GIS application interface with a map of Lake Victoria and its surrounding regions. A PDF viewer window is open, showing two line graphs of temperature profiles. The first graph, titled 'FIG. 1. Temperature profiles observed between Mar-May 2002 at 30 min interval at UP 6. In stage 3 stratification of Talling (1966)', plots temperature (°C) against Julian Day 2002 for depths of 12m, 18m, 24m, 30m, 36m, 42m, 48m, 54m, and 60m. The second graph, titled 'FIG. 2. Temperature profiles observed Nov 2002 at UPS at 30 min interval in the early stratified period (stage 1)', plots temperature (°C) against Julian Day 2001 for the same depths. A 'DOCID31-Lake Victoria Environme.pdf properties' dialog box is open, showing the author 'Muyodi and Prof. R.E. Hecky' and keywords 'Water Quality Lake Victoria'. The background map shows various locations including Kampala, Masaka, and Kisumu. A file explorer on the right shows a folder structure for 'VRIS Docs' with sub-folders for 'Burundi', 'Kenya', 'LVBC', 'Not Published', 'Published', 'Figures', 'Web Sites', 'Rwanda', 'Tanzania', and 'Uganda'. A table at the bottom of the interface has the following columns: Name, Station name, Variable, Unit, Start date, End date, and History.

Name	Station name	Variable	Unit	Start date	End date	History
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Training, Capacity Building and Support



Training classes



On-the-job training

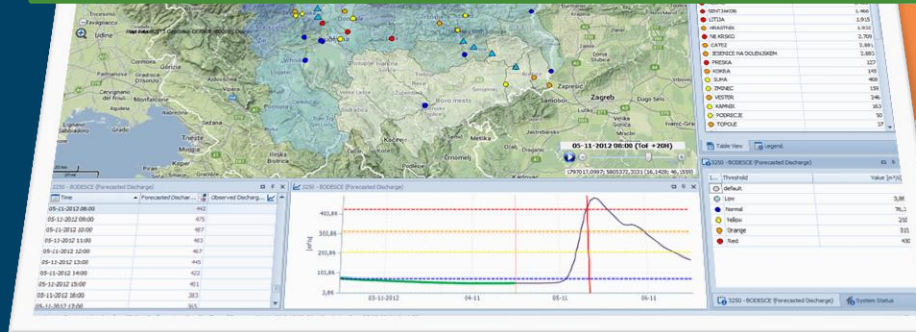


Help when needed

A tailormade solution



- Fitness to the purpose/applicability in Indian condition.
- User friendly (including accessibility to training facilities).
- Sustainability (including ongoing support and updating).
- Open sources, code flexibility for customizing, interfacing and further development.
- Cost.

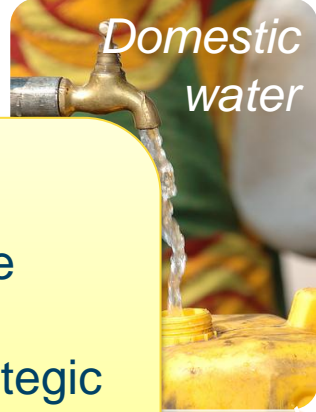


RESOURCE
MANAGEMENT



Flood Forecasting and Warning System, Chaophraya, Thailand

Sample challenges in Thailand



From single to multi-objective water management at operational, seasonal and strategic level

Department of Water Resources
Minister of Science and Technology
Hydro and Agro Informatics Institute
Minister of Emergency
The People of Thailand
Royal Irrigation Department
Electrical Generating Authority of Thailand



Early warning and forecast systems



Chao Phraya, Thailand

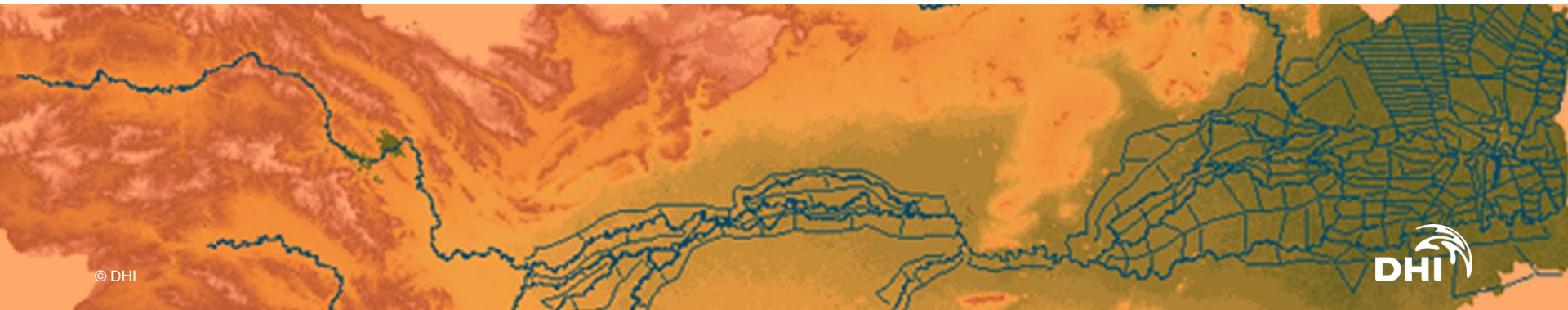
The Chao Phraya River Basin.
160,000 km².

One Decision Support System to
protect against devastating
flooding.



HAII highly appreciates DHI for their excellent job, especially on the close collaboration and hands on experience that made us become a good partner.”

Dr. Piyamarn Sisomphon, Project Leader, Hydro and Agro Informatics Institute



Chao Phraya Flood Forecasting and Management DSS system

Customised Project Web page Designed by end client

โครงการพัฒนาระบบแบบจำลองและระบบช่วยการตัดสินใจ
เพื่อวิเคราะห์การไหลและพยากรณ์น้ำท่วมในลุ่มน้ำเจ้าพระยา

One- and two-dimensional flood modelling applied
(Example: downstream flood plains).

สถาบันสารสนเทศทรัพยากรน้ำและการเกษตร (องค์การมหาชน)
Hydro and Agro Informatics Institute

โครงการพัฒนาระบบแบบจำลองและระบบช่วยการตัดสินใจ
เพื่อวิเคราะห์การไหลและพยากรณ์น้ำท่วมในลุ่มน้ำเจ้าพระยา

หน้าหลัก | เกี่ยวกับโครงการ | ข้อมูลปัจจุบัน | ข้อมูลคาดการณ์ | สมดุลน้ำ | การบริหารจัดการอุทกภัย | ติดต่อเรา

หน้าหลัก >> ข้อมูลคาดการณ์ >> Sideflow

ปริมาณน้ำท่าจากลุ่มน้ำสาขา (Sideflow)

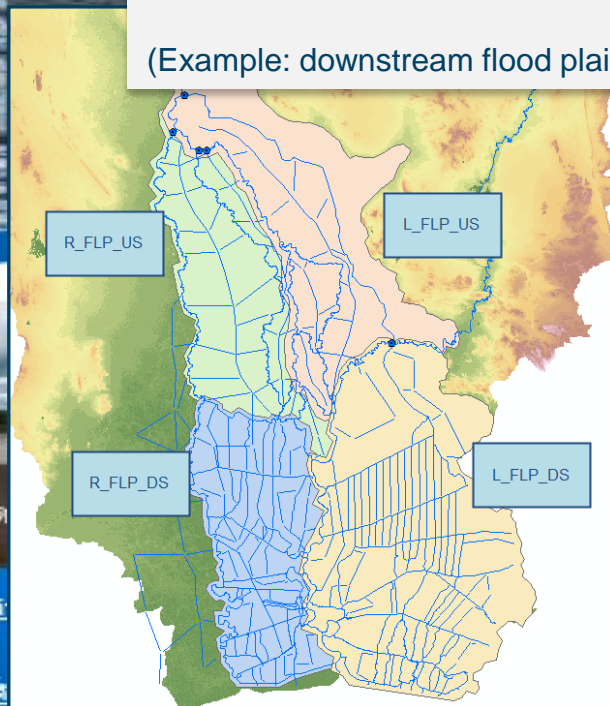
Block1: Block1-All
Block5: Block5-All
Block9: Block9-All
Block2: Block2-All
Block6: Block6-All
Block10: Block10-All
Block3: Block3-All
Block7: Block7-All
Block11: Block11-All
Block4: Block4-All
Block8: Block8-All

Block1-All

Runoff (m³/s)
Date

Real-time data view

- Runoff_BLOCK1-CHANGMAI, 4528.000 - 1 - CPV_RR.res11
- Runoff_BLOCK1-UPPER, 4316.000 - 2 - CPV_RR.res11
- Runoff_BLOCK1-MIDDLE, 6587.000 - 3 - CPV_RR.res11
- Runoff_BLOCK1-BHUMBOL, 7917.000 - 4 - CPV_RR.res11
- Rainfall_BLOCK1-CHANGMAI, - 42 - CPV_RR.res11
- Rainfall_BLOCK1-UPPER, - 43 - CPV_RR.res11
- Rainfall_BLOCK1-MIDDLE, - 44 - CPV_RR.res11
- Rainfall_BLOCK1-BHUMBOL, - 45 - CPV_RR.res11



บริหารจัดการอุทกภัย

แผนที่น้ำท่วม

บันทึกเขื่อนตลิ่งน้อย

Home Publish View

Real-time Mode Configuration Catchment Precipitation Stations Water Level

Area District Area Dike Floodweak Road Stations Sub Polder Tunnel Floodweak Road Rainfall Radar

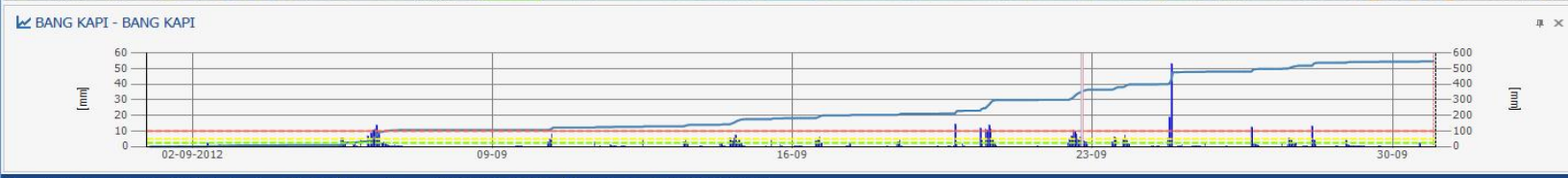
Layers and Grids



Name	Value [mm]
PHRA NAKHON	63.83
DUSTI	58.56
NONG CHOK	64.21
BANG KHEN	60.17
BANG KAPI	54.00
PATHUM WAN	64.21
PHRA KHANONG	64.21
MIN BURI	63.83
LAT KRABANG	52.59
PHAYA THAI	64.21
HUAI KHWANG	63.83
BANGKOK YAI	34.30
KHLONG SAN	63.83
BANGKOK NOI	58.56
BANG KHUN THIAN	38.50
PHASI CHAROEN	34.30
NONG KHAEM	64.21
TALING CHAN	49.52

BANG KAPI - BANG KAPI

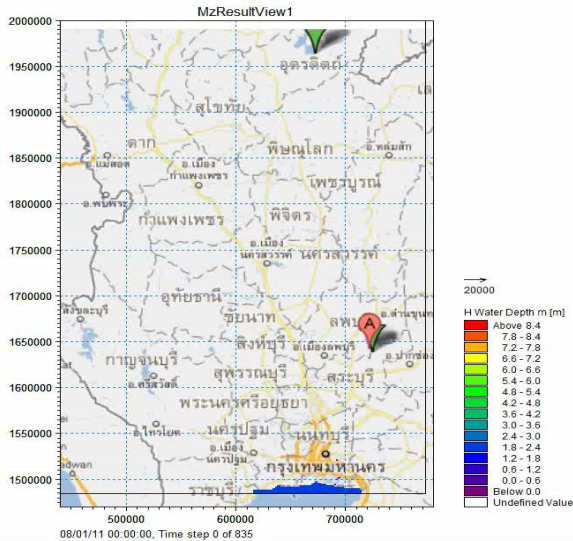
I...	Threshold	Value
<input type="radio"/>	Default	
<input checked="" type="radio"/>	Low	20
<input type="radio"/>	Medium	50
<input type="radio"/>	High	100



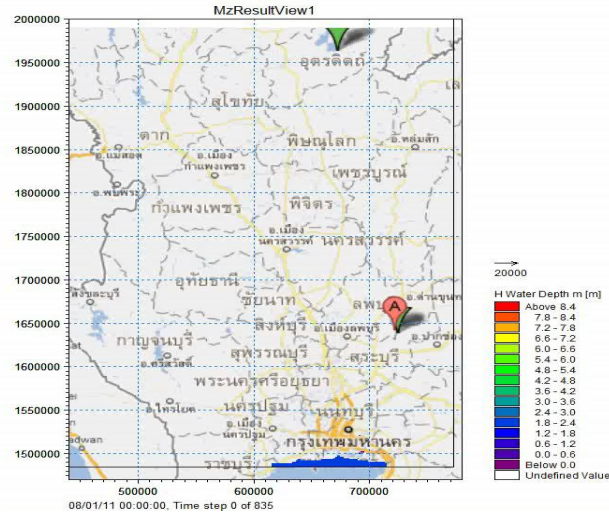
Windows taskbar with icons for Internet Explorer, Office, and other applications. System tray shows 100% CPU usage and date 10-09-2013.

What happens if a dike is constructed around Bangkok?

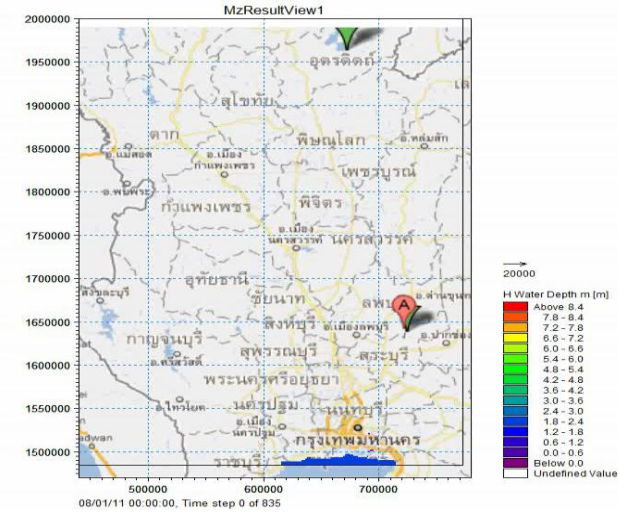
Current



3m dike



4m dike



Nile basin decision support system

Nile Basin Decision Support System



Accepted tools
Sharing of data and knowledge
Cross boundary cooperation

“The Nile Basin Decision Support System will provide the basis for agreement on and development of sustainable water resources projects in the Nile Basin”

Dr. Abdulkarim H. Seid, Head, Water Resources Management, Nile-Sec



Need for wise and robust water management decisions



Priority Concerns

Water resources development:

Focus on infrastructure (e.g. new dams)



Coping with floods:

focus on flood protection and impacts



Optimal water resources utilization:

Focus on optimal use (e.g. reservoir operation rules)



Rain-fed and irrigated agriculture:

focuses on crop-production and irrigation

Energy development (hydropower):

focus on development of hydropower potentials



Navigation:

Focus on impacts on river navigation

Coping with droughts:

Focus on drought management



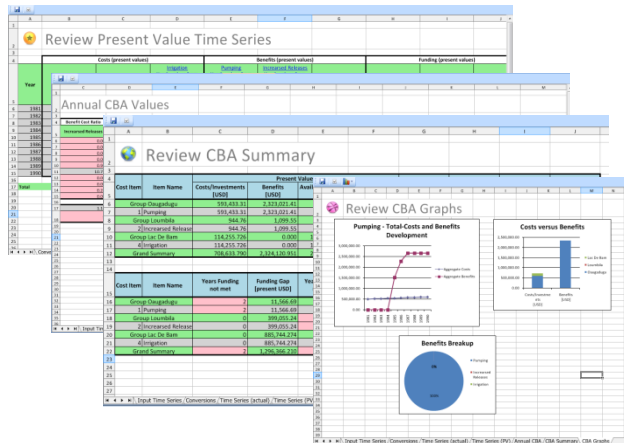
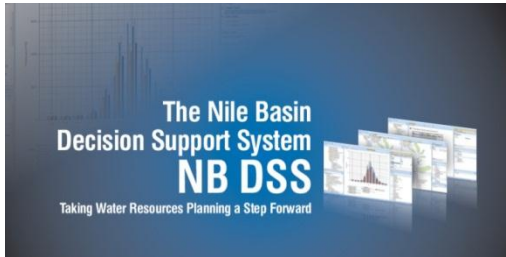
Watershed and Sediment Management:

Focus on land-use, soil erosion, sediment loads



Cross cutting issues :
Climate change and Water quality

Sharing water resources fairly



Nile Basin DSS

Time series

Spread-sheets

GIS

MCA/CBA

Scenarios

Dashboard (web publishing)

Optimisation

Work spaces

Ensembles

Meta data

Scripting

Indicators

Data base

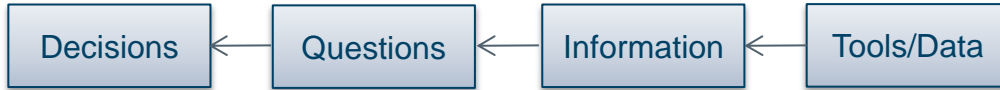


Client Focused Solutions and Collaborative development approach

Use Cases – Rooted in real problems in the basin

- Lk. Victoria, the Sudd wetlands, Blue Nile Hydro Power

Decision driven – Decisions and Actors drive the requirements

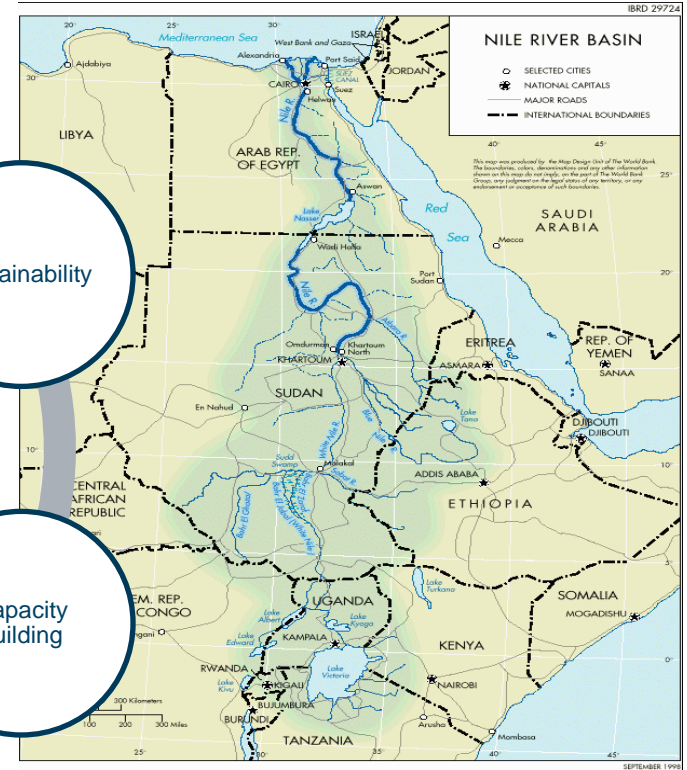


“The Actors”

Q: How significant are the hydrological linkages between the Sudd wetlands without adversely affecting eco-system services?



Key value



Computer Assisted River Management System (CARM), Australia

Innovation

Over 1,600km of river with two dams and thousands of water users. **One** river management system.

Precision releases to deliver the right flows at the right time



New South Wales, Australia

“ CARM is a world class development designed to maximise the efficiency of the Murrumbidgee River system.”

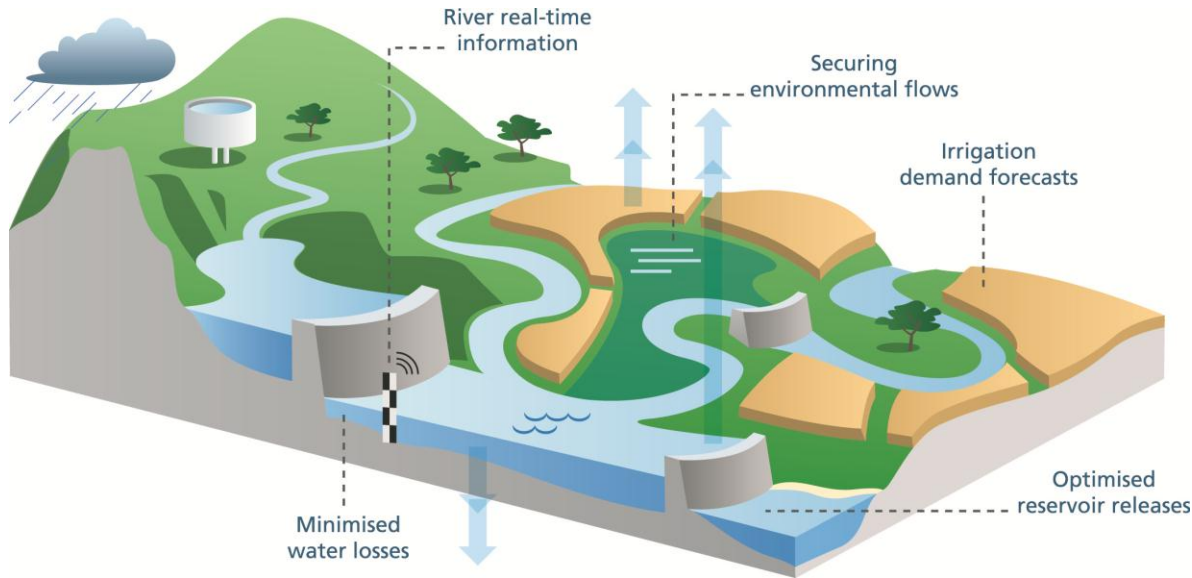
Brett Tucker, Chief Executive Officer, State Water Corporation, New South Wales, Australia



River operations



New South Wales, Australia



“The CARM project will make control of water flows more responsive and more precise.”
State Water Corporation

Recommendations

Recommendations

- Be clear on technical and institutional challenges (use also wheel).
- Focus on potential value creation.
- Be clear on roles and responsibilities.

- Clear up misunderstandings on: Open sources, code flexibility for customizing, interfacing and further development.
- Focus on benchmarks, proven performance etc. rather than Fortran code and isolated price.

Be clear on technical and institutional challenges (use also wheel)

...get the full benefit of real-time **monitoring** and early warning systems

...manage, organise and analyse large amounts of **data**

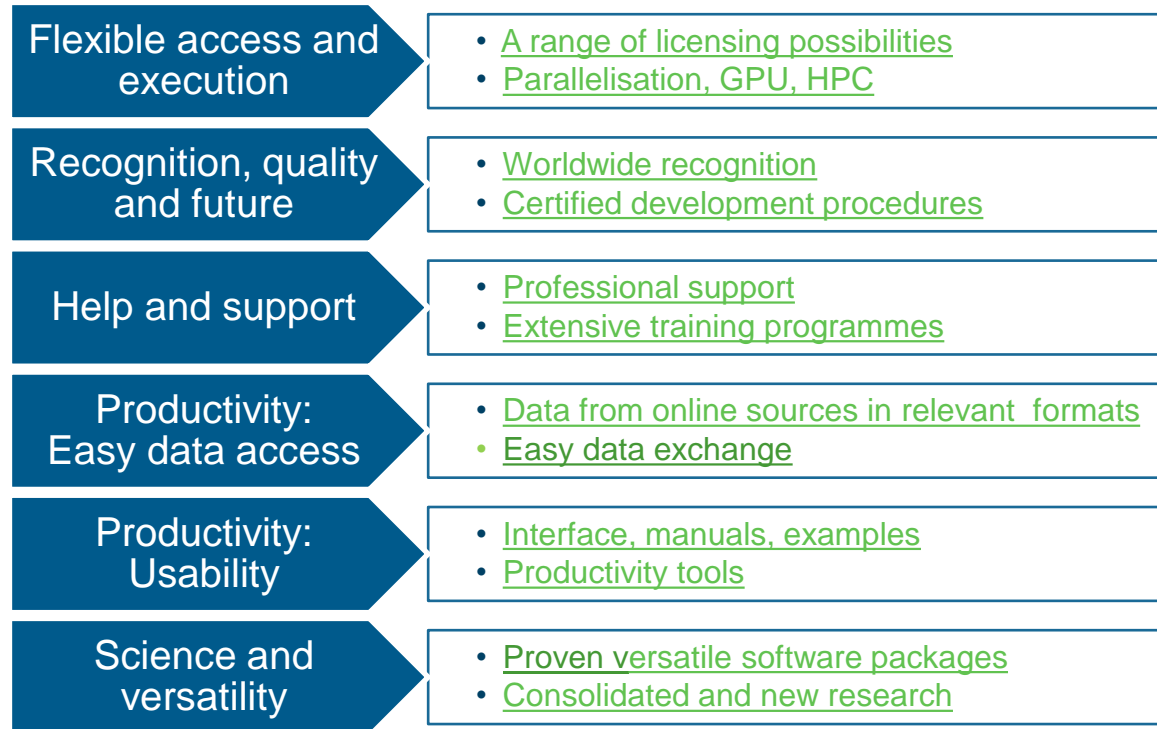


...optimise **operations** and planning

...make wise and robust water management **decisions**

Set high requirements and use benchmarks

Suggestion:



Thank you

jhm@dhigroup.com

