Blue Green Dream

EC project on Integration of Natural Water Retention Measures in river basin management
The 2nd Danube Region Workshop, 23-24 June 2014
Bucharest, Romania

Part I
Benefits of NWRM for water resources management

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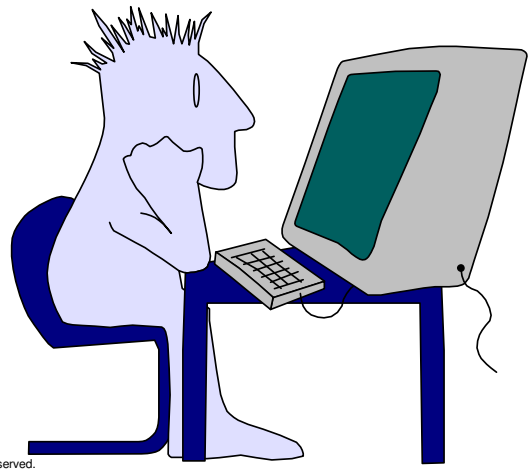
Blue Green Dream

About me

- **Professor of Urban Water Systems, Imperial College London**
- **Head of the Urban Water Research Group**
- **Editor-in-Chief, URBAN WATER JOURNAL**
- **Editor-in-Chief, URBAN WATER Book Series**
- **Special Advisor to UNESCO on Urban Water**
- **Coordinator of the EU projects: Blue Green Dream and RainGain (WP3)**

NWRM… What is it all about ?



NWRM as defined in WISE

Natural water retention measures are measures that aim to safeguard and enhance the water storage potential of landscape, soil, and aquifers, by restoring ecosystems, natural features and characteristics of water courses and using natural processes. They support Green Infrastructure by contributing to integrated goals dealing with nature and biodiversity conservation and restoration, landscaping, etc. They are adaptation measures that use nature to regulate the flow and transport of water so as to smooth peaks and moderate extreme events (floods, droughts, desertification, salination). They reduce vulnerability of water resources to CC and other anthropogenic pressures.They are relevant both in rural and urban areas. Examples of NWMR include:

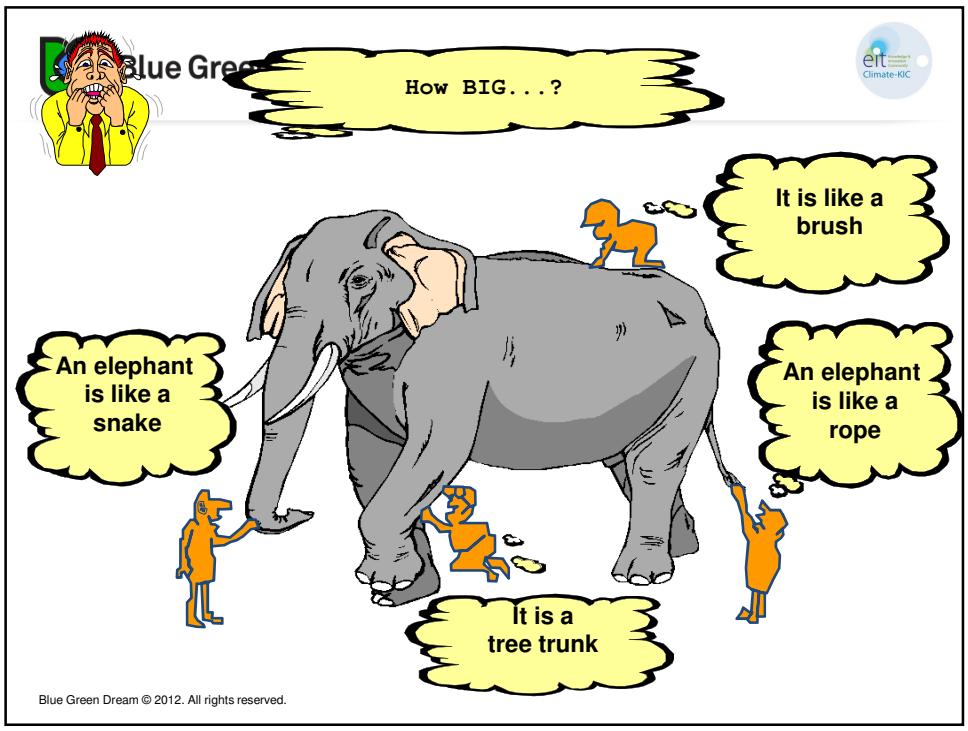
Sustainable Forestry Practices: e.g. CCF, riparian forests, afforestation

Sustainable Agriculture Practices: e.g. buffer strips, crop practices, grasslands, terracing, green cover

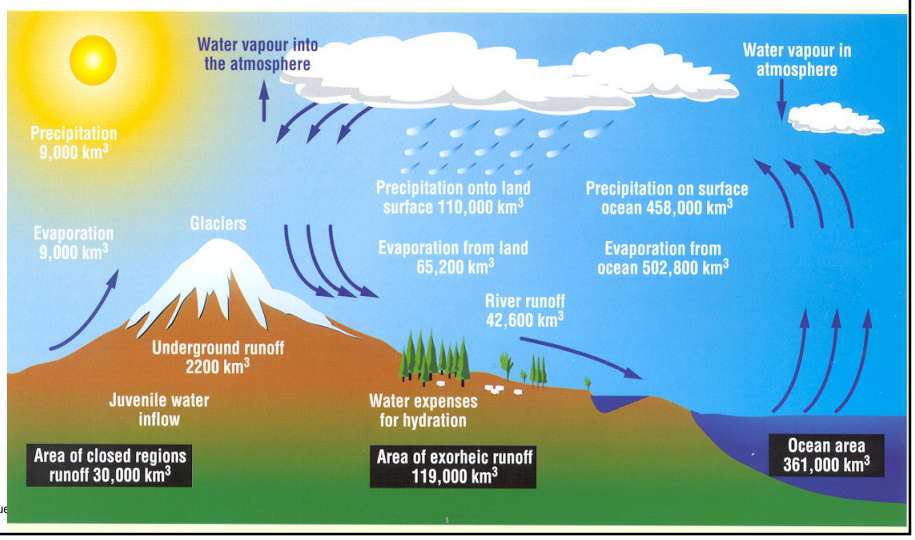
Urban Measures: e.g. Sustainable Drainage Systems (filter strips, swales), Green Roofs ….)

Measures for increasing storage in catchment and alongside rivers: wetlands, floodplains, lake, basins and ponds, re-meandering, natural bank stabilization

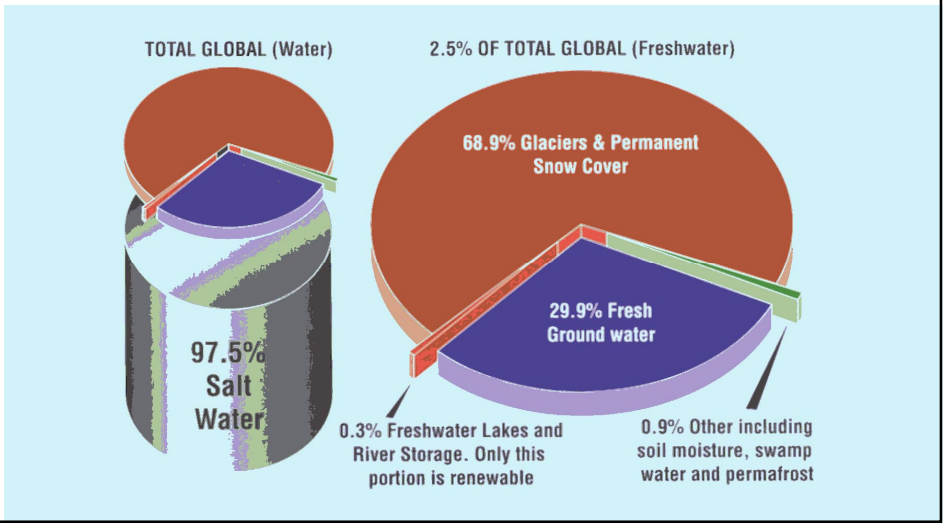
Other Measures for increasing Groundwater Recharge

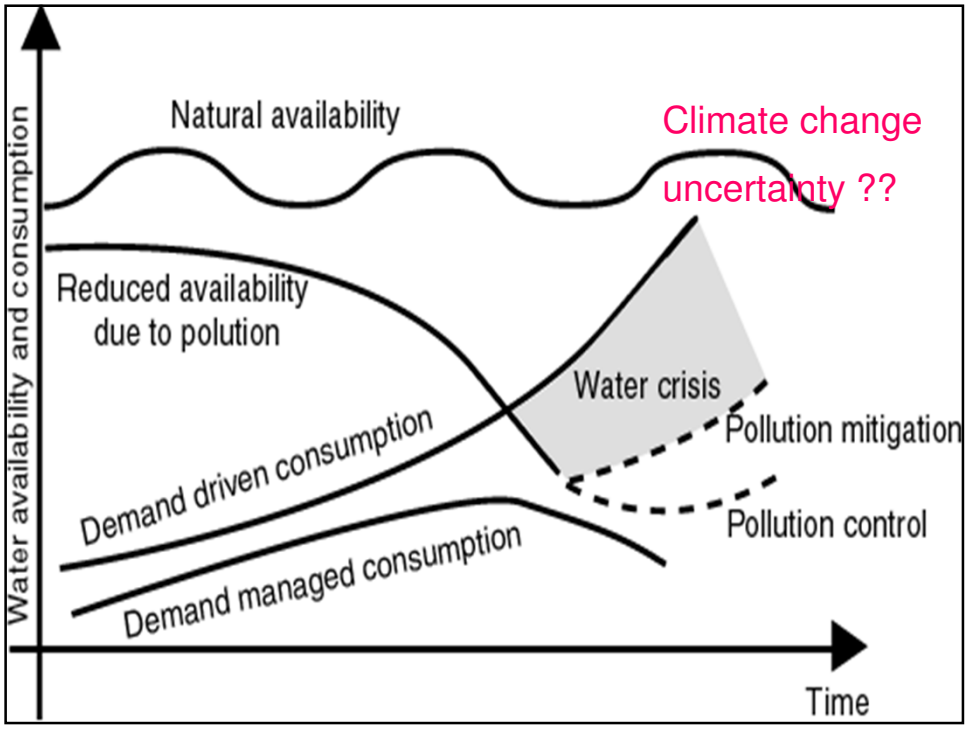


Global water balance



Global Water Availability





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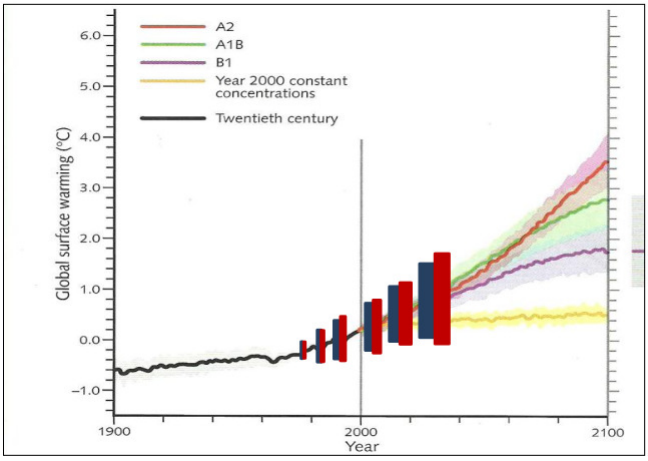
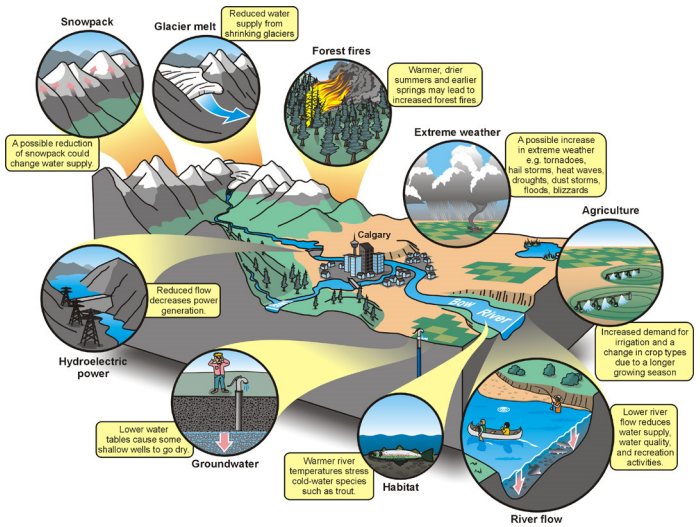
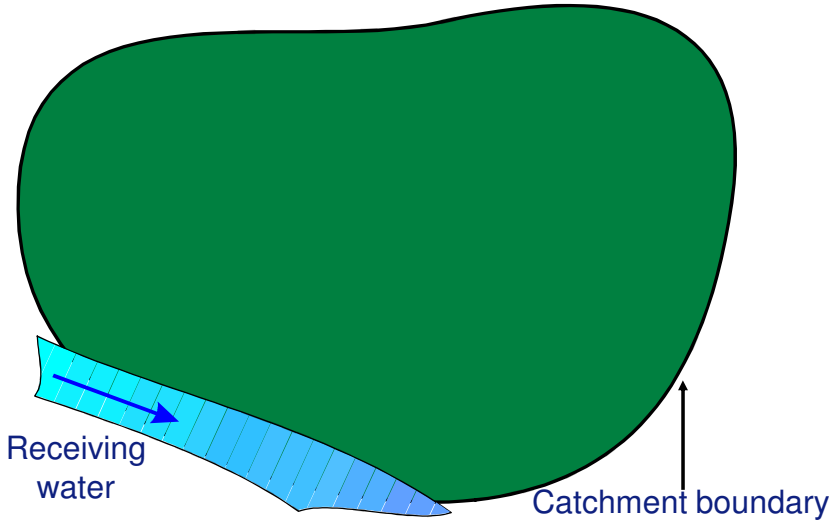


Temperature increase impacts on the state of the environment



Courtesy Prof. Asimakopoulos

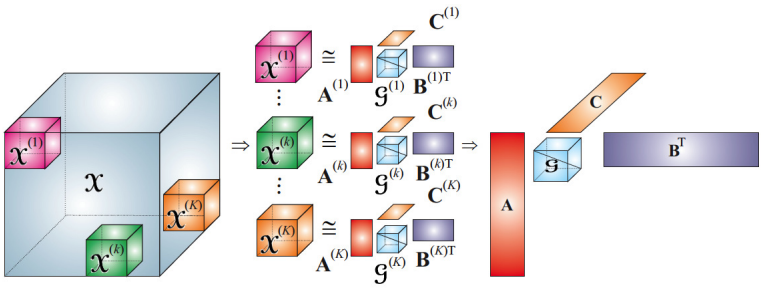
Urban drainage catchment



Confused with complexity

"The centipede was happy quite,
Until a toad in fun Said: "Pray, which leg goes after whic
This worked his mind to such a pitch,
He lay distracted in a ditch, Considering how to run."
Ogden Nash

Complexity – Tensor approach



Efficient computation of the CP and Tucker decompositions, whereby tensor decompositions are computed in parallel for sampled blocks, these are then merged to obtain the global components A, B, C and a core tensor.

Courtesy of Prof Danilo Mandic

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$$\underset{(I\times N)}{\mathbf{X}} \cong \underset{(I\times R)}{\mathbf{T}}\ \underset{(R\times N)}{\mathbf{P}^{\mathrm{T}}} = \sum_{r=1}^{R} \boldsymbol{t}_r \boldsymbol{p}_r^{T}$$

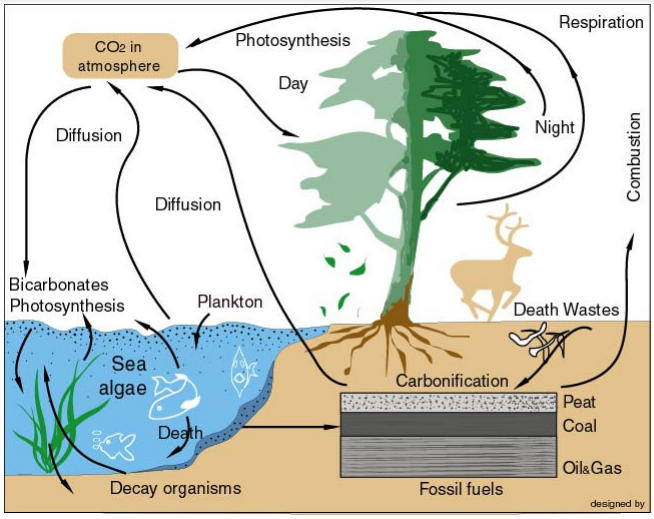
$$\underset{(I\times M)}{\mathbf{Y}} \cong \underset{(I\times R)}{\mathbf{U}}\ \underset{(R\times M)}{\mathbf{Q}^{\mathrm{T}}} = \sum_{r=1}^{R} \boldsymbol{u}_r \boldsymbol{q}_r^{T}$$

The basic PLS model performs joint sequential low-rank approximation of the matrix of predictors X and the matrix of responses Y, so as to share (up to the scaling ambiguity) the latent components — columns of the score matrices T and U. The matrices P and Q are the loading matrices for predictors and responses, and E and F are the corresponding residual matrices.

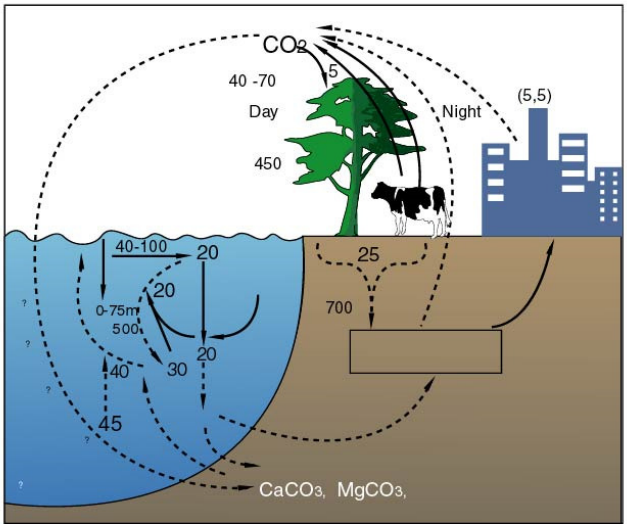
Courtesy of Prof Danilo Mandic

The Natural Carbon Cycle

58b

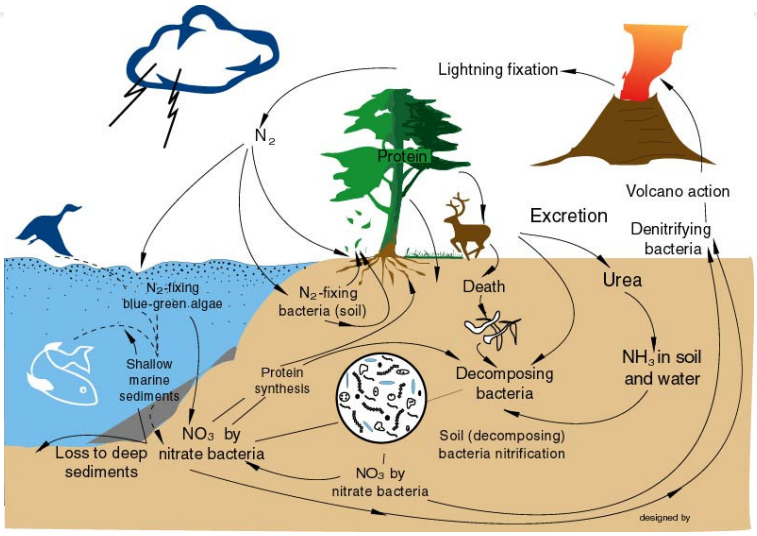


The Effect of Human Activities on Global Carbon Balance (tons)



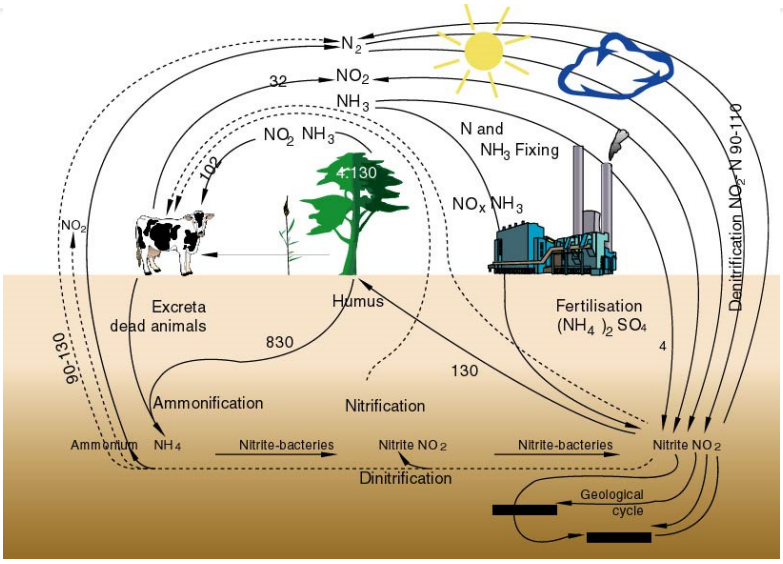
The Nitrogen Cycle

59a



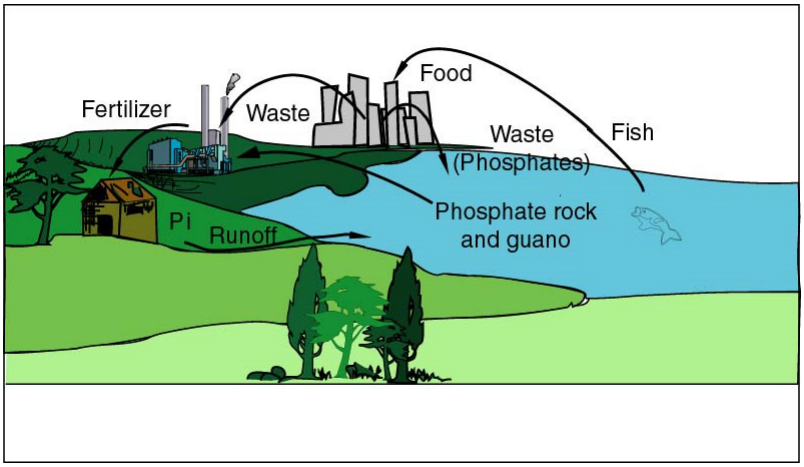
The Ammonium Cycle

59b



The Phosphorus Cycle

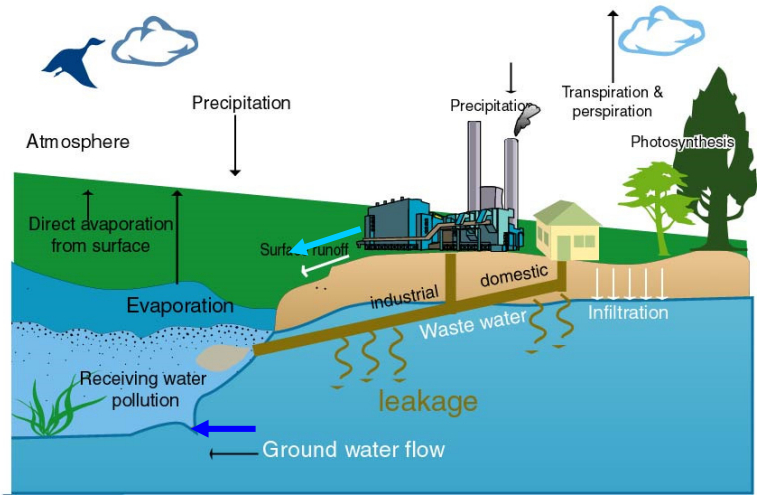
60



UNEP

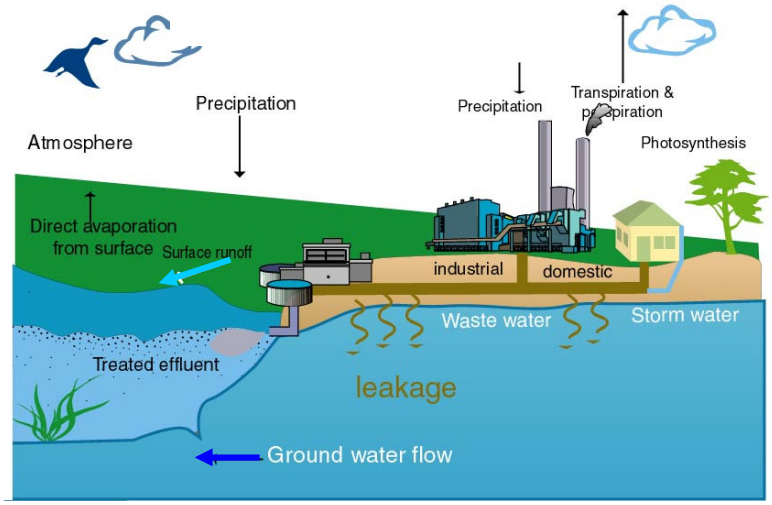
Water Cycle in Urban Ecosystem; Direct Disposal - No Treatment

61c



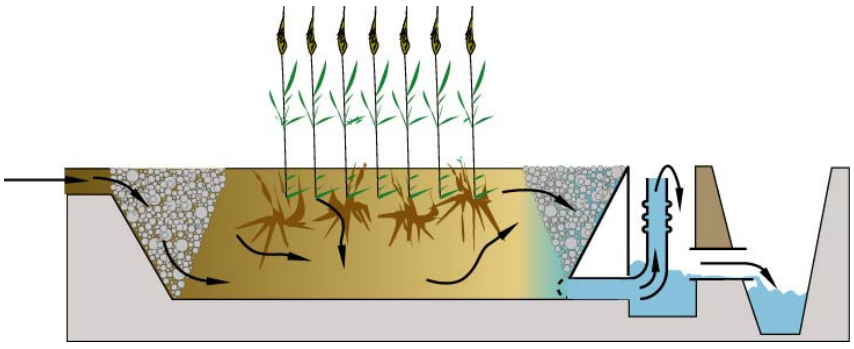
Water Cycle in Urban Ecosystem Combined System with Treatment

61d

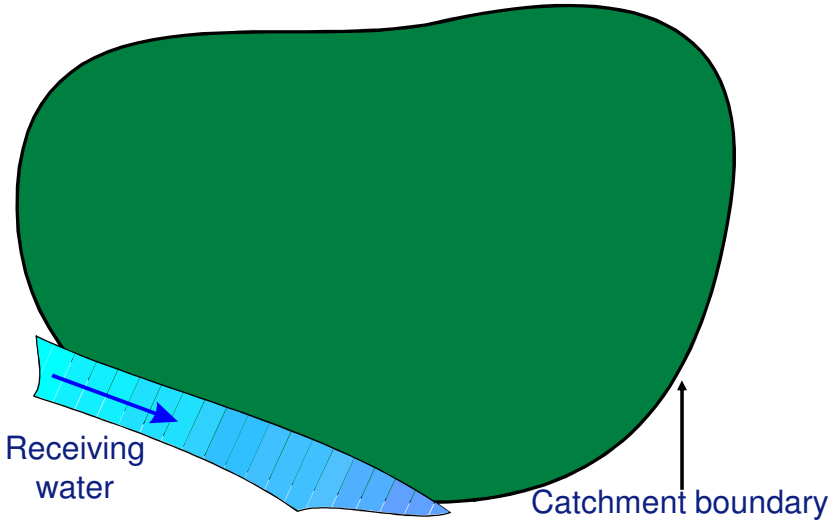


Constructed Wetland

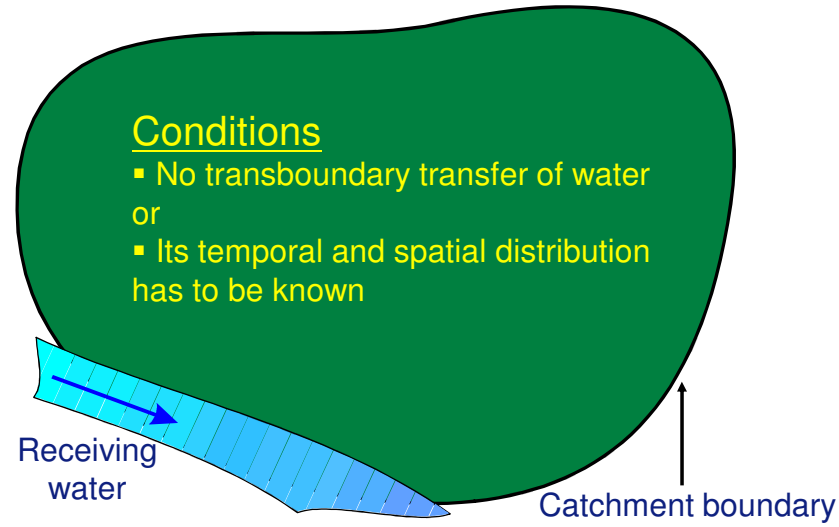
90b



Urban drainage catchment



Urban drainage catchment



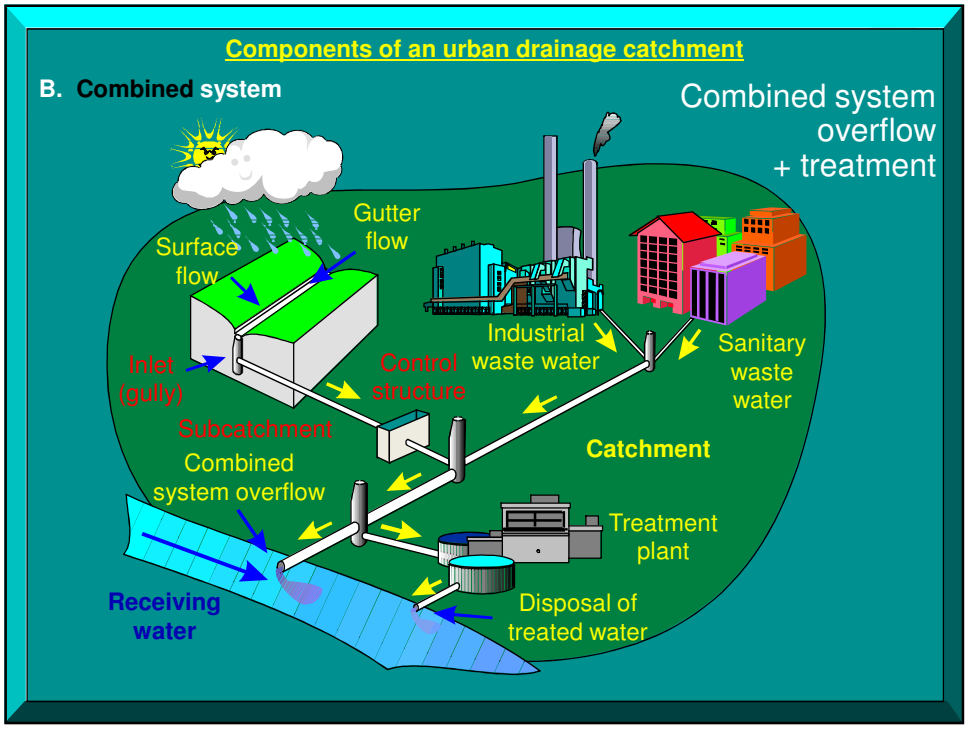
Urban flooding

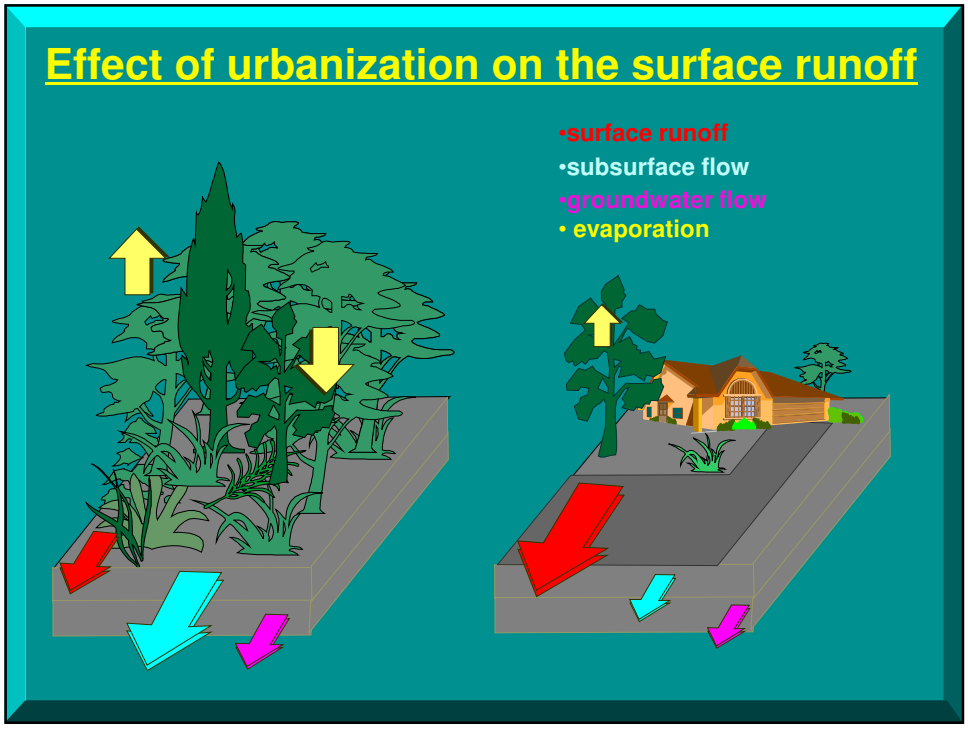
Types of urban flooding :

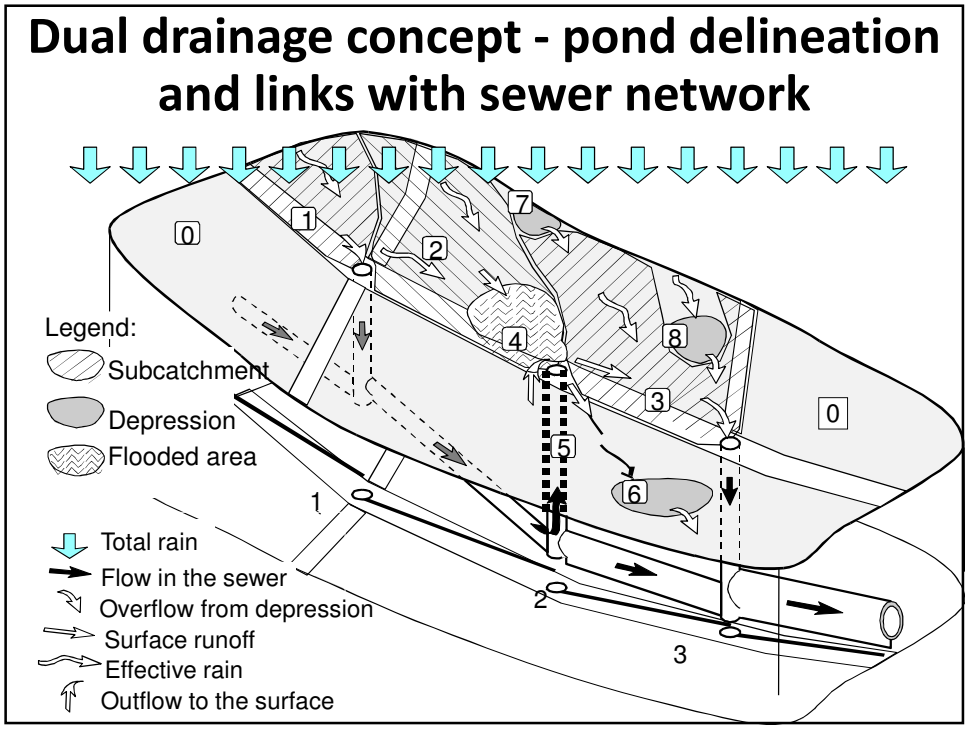
- Fluvial -> Originating from rivers
- Coastal -> primarily tidal surges and waves
- Ground water flooding, slow and lasting
- Pluvial (surface) flooding
- Coincidental flooding

Receiving water

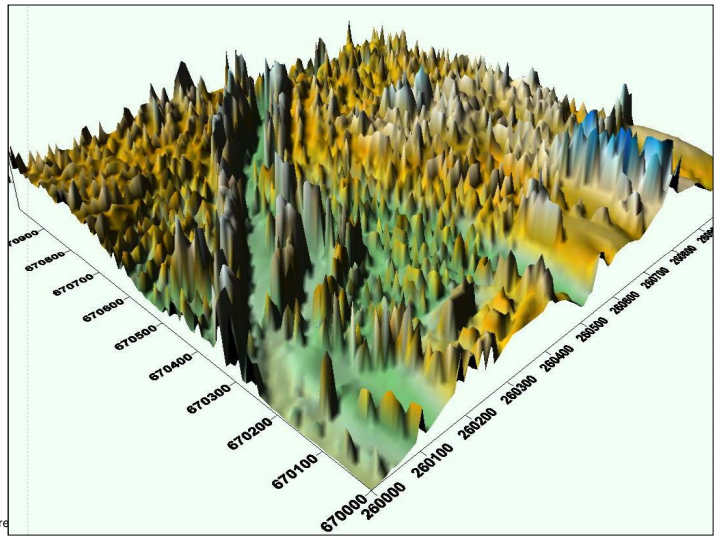
Catchment boundary



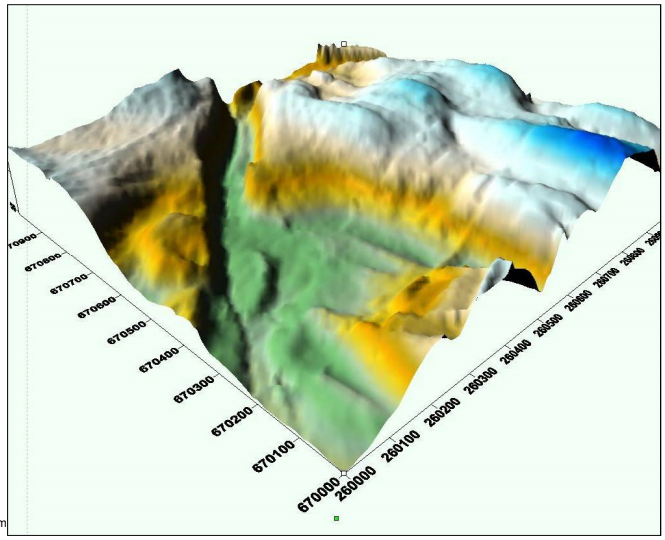

Effect of urbanization on the surface runoff
•surface runoff
•subsurface flow
•groundwater flow
• evaporation


Dual drainage concept - pond delineation and links with sewer network
Legend:
Subcatchment
Depression
Flooded area
Total rain
Flow in the sewer
Overflow from depression
Surface runoff
Effective rain
Outflow to the surface
0
1
2
3
4
5
6
7
8

DEM not filtered (3D view)

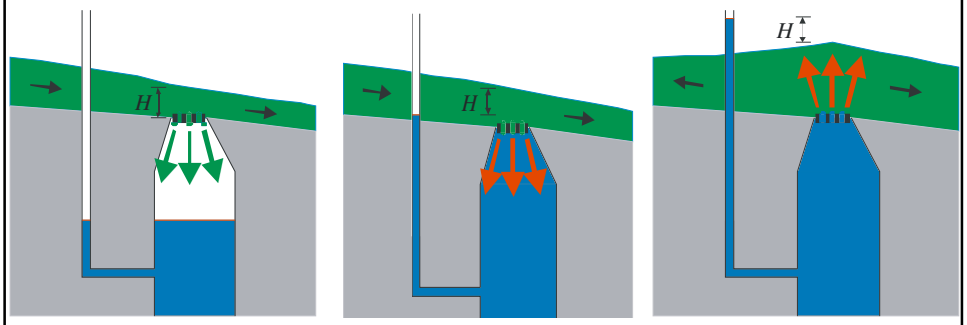


DTM (3D view)

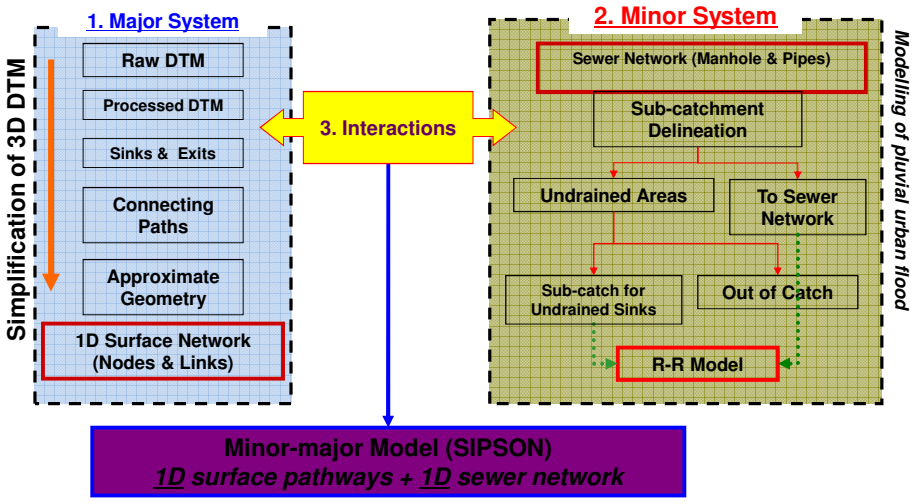


Dual drainage concept – model description

1. "Equivalent inlet" (manhole + inlets)
2. Flow directions alternate during an event

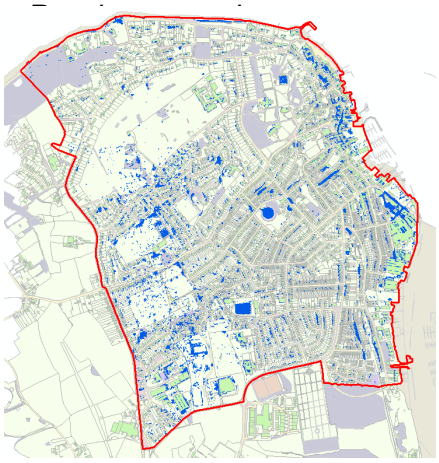


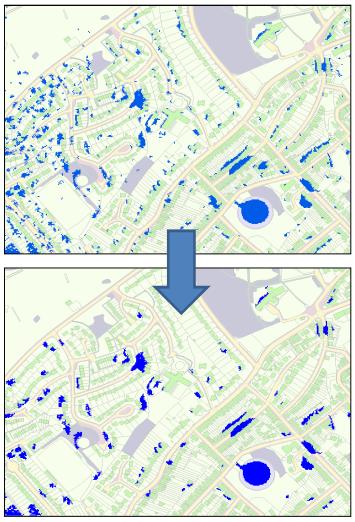
Dual drainage concept – model development



Pond delineation - analysis

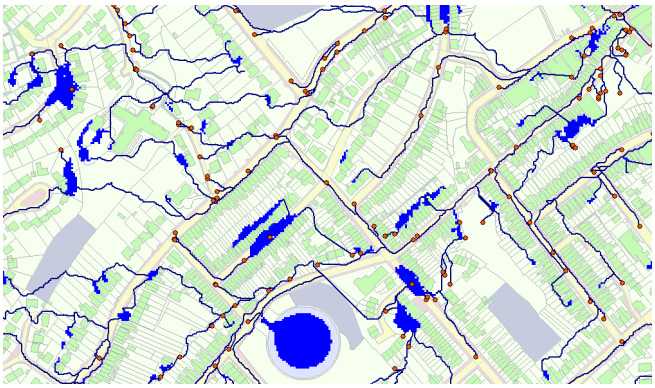
1.



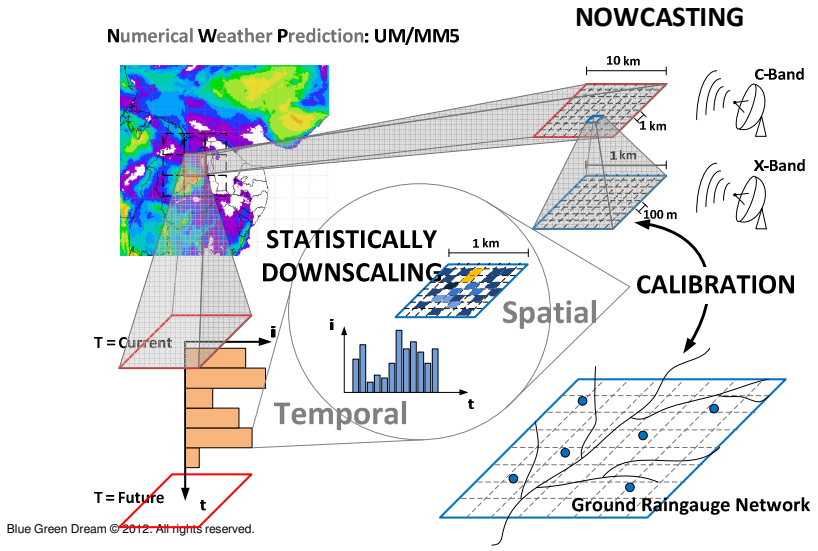


Flow pathways delineation

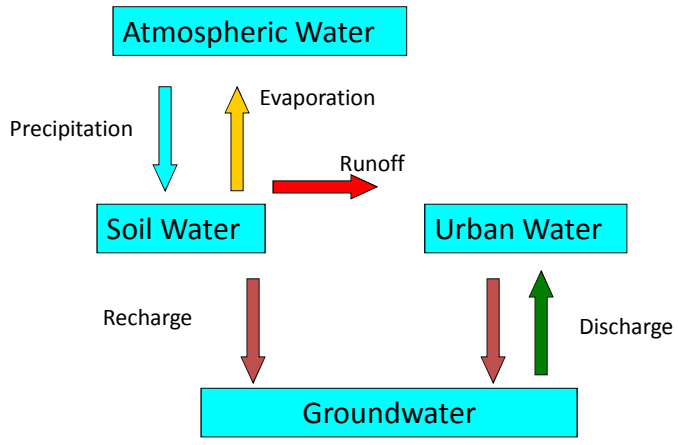
- Pond to pond and manhole to manhole
- Pond to manhole and manhole to pond



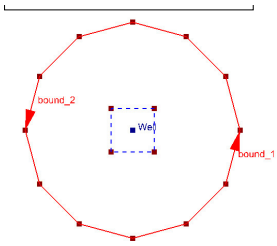
Ongoing research: Urban Pluvial Flood prediction based on short term rainfall prediction

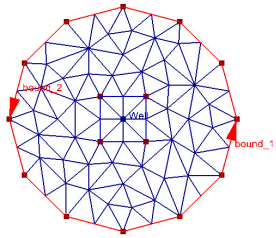


Ground Water Balance in Urban Regions

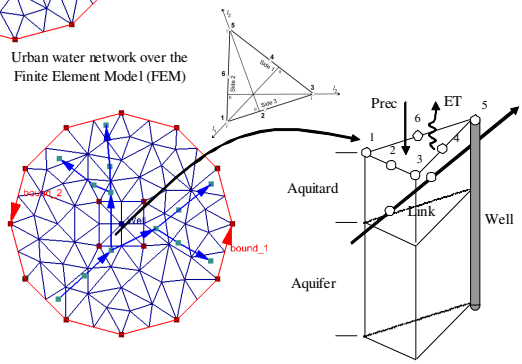


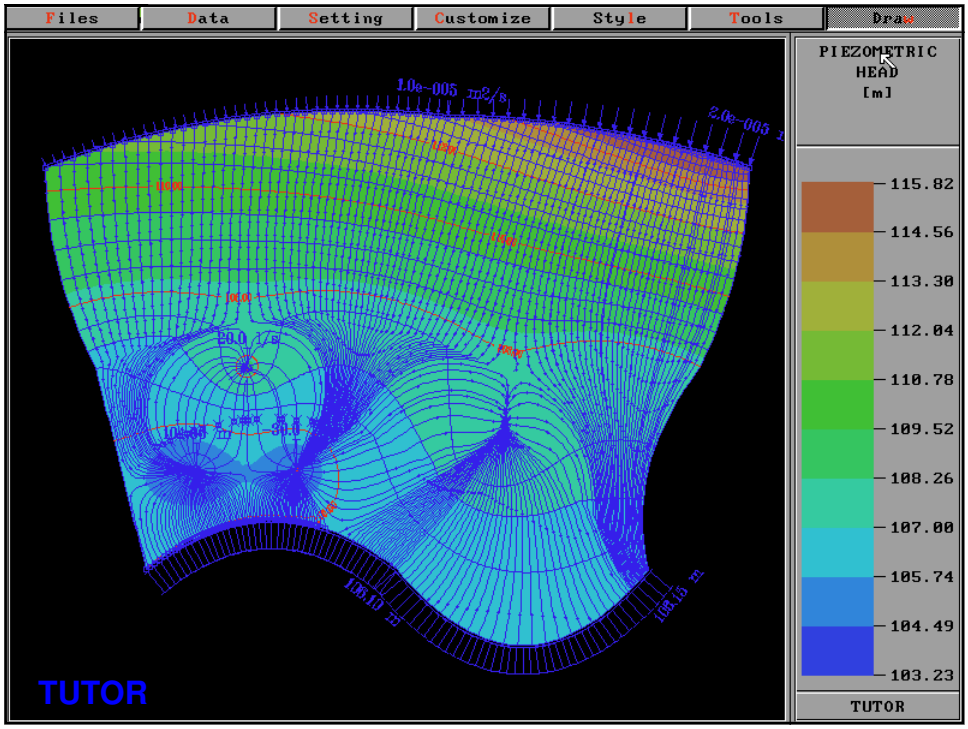
UGROW - Algorithms: UFIND

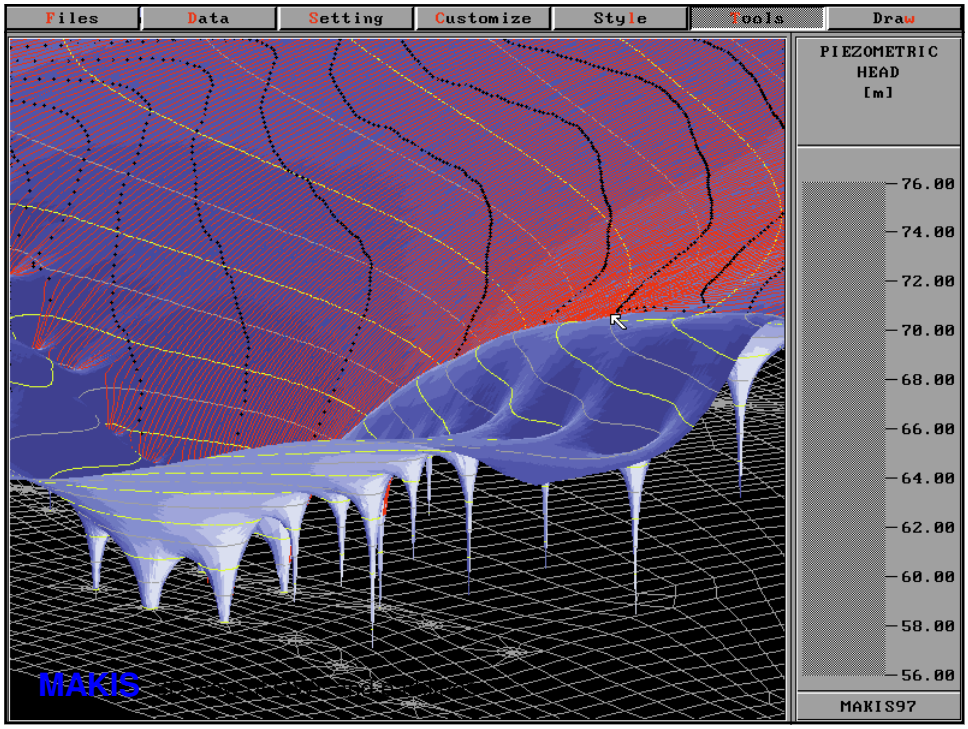




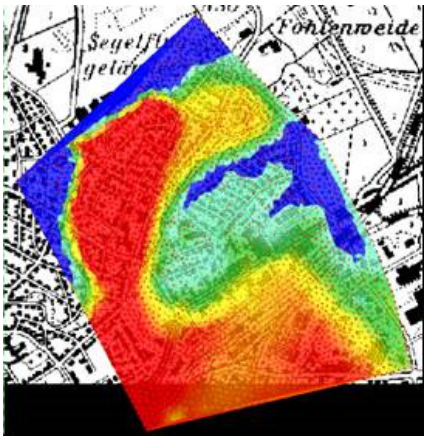
Urban water network over the Finite Element Model (FEM)

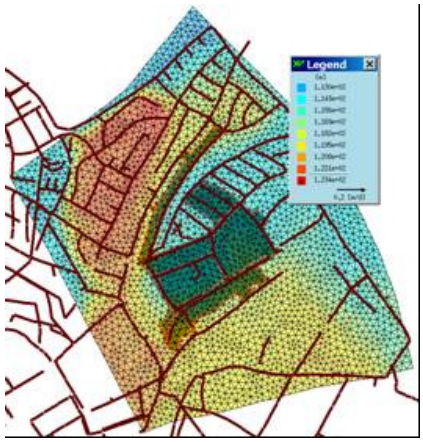






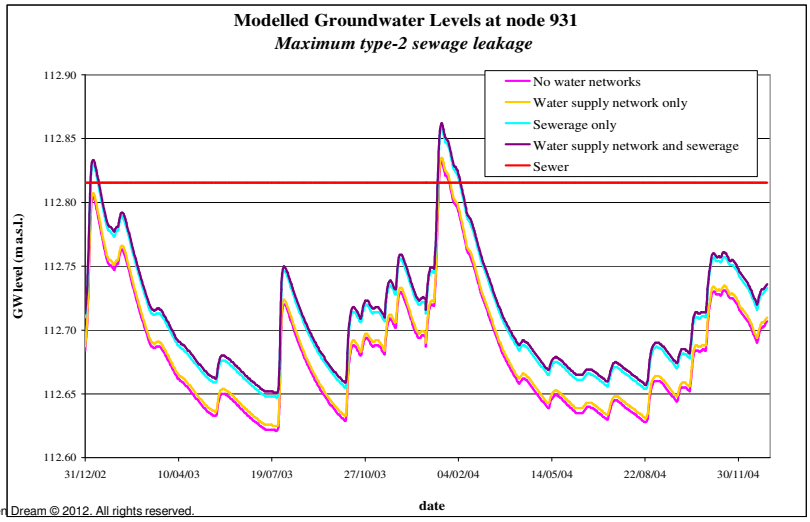
CASE STUDY 1: RASTATT
Digital Terrain Model



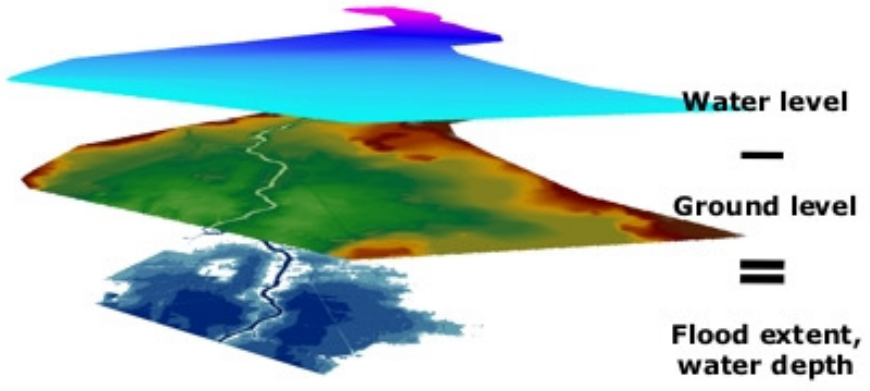


UGROW **FEFLOW**

CASE STUDY 1: RASTATT
Effect of sewers on groundwater levels: worst case



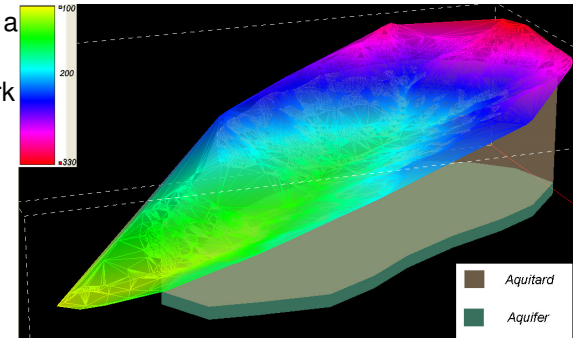
CASE STUDY 2
Interactions of surface water and groundwater flooding



UGROW (Urban Groundwater)

Systems which can be simulated using UGROW:

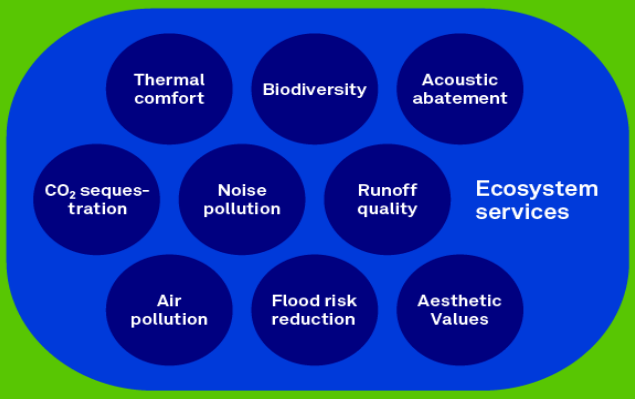
1. Aquifer within urban a
2. Vadose zone
3. Water supply network
4. Sewer network
5. Streams
6. Abstraction wells



Blue Green Dream

Definition of ecosystem services

Integrate the existing knowledge and modelling tools and develop next generation BG IMS



- Extraction knowledge
- Sensitivity analysis
- Unified performance indicators
- Modelling of interactions
- Quantification of performance and benefits
- Assistance to planners
- Inputs to the BG IMS

Blue Green Dream

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"Complete" Infrastructure

- water supply
- wastewater disposal
- solid waste dumping
- urban stream

 Designed by CUW-UK

23

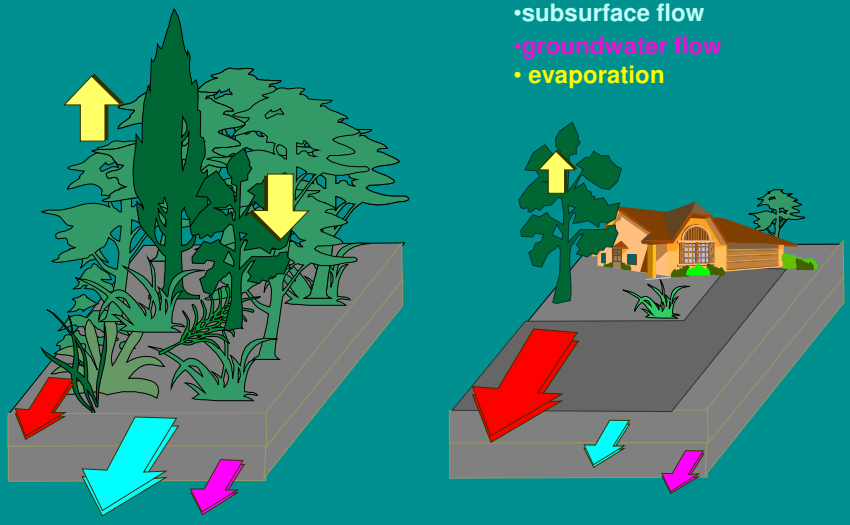
Solid waste "management"

UNEP

Designed by CUW-UK

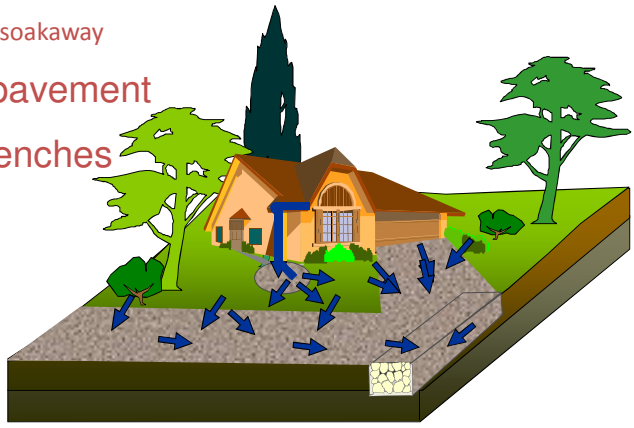
Effect of urbanization on the surface runoff

- surface runoff
- subsurface flow
- groundwater flow
- evaporation



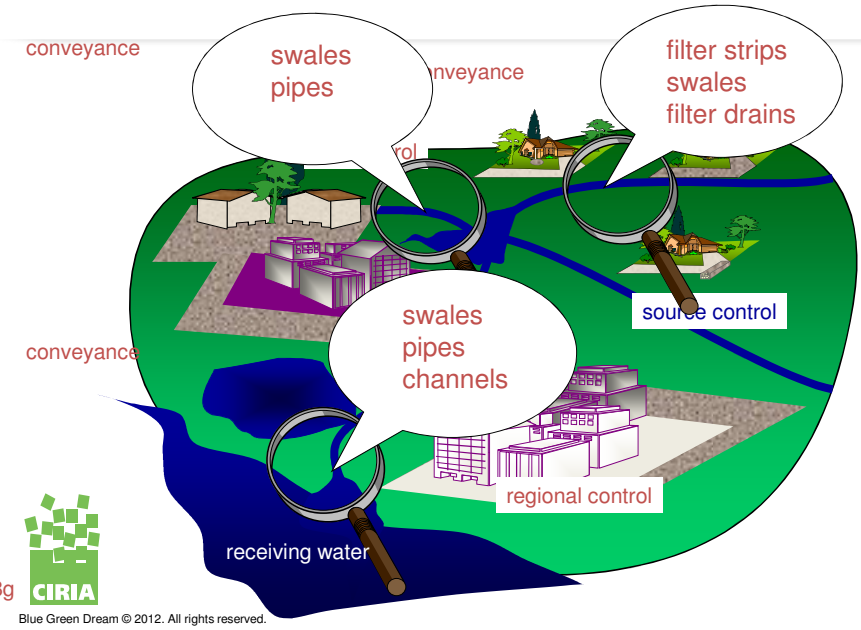
Source control

- Disconnect downpipes
  - Drain to lawns
  - Infiltration into soakaway
- Permeable pavement
- Infiltration trenches



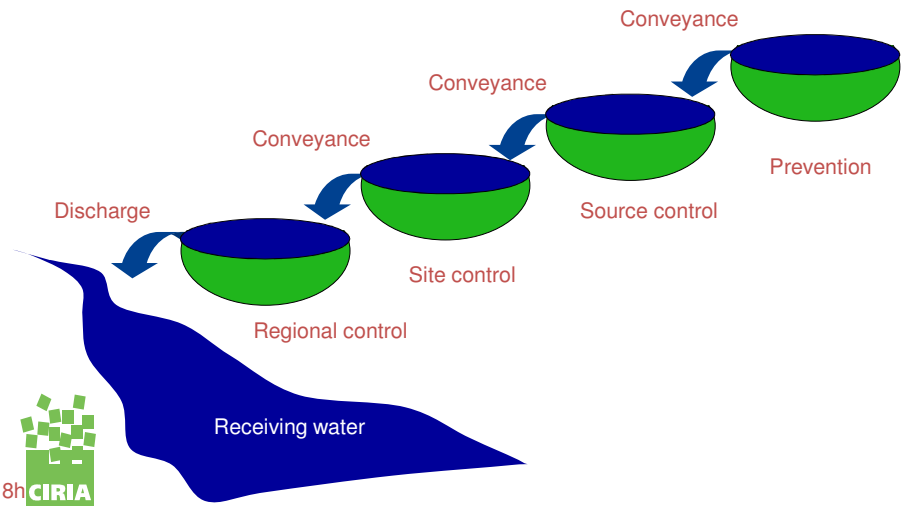
18c CIRIA

An integrated system



8g CIRIA

SUDS management train

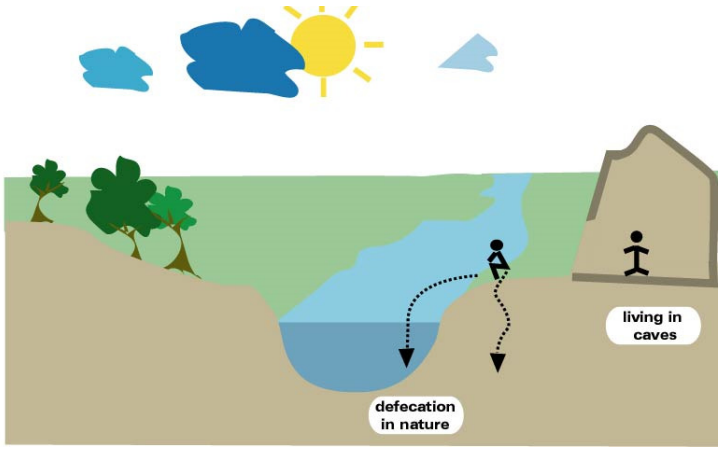


18h CIRIA

Phases in Unsustainable Urban Development

1. Early Civilisation - Living in Nature - Low Level of Pollution

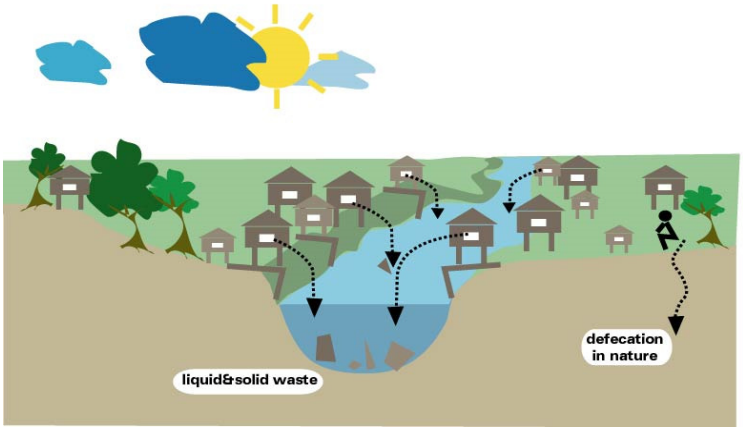
5



Phases in Unsustainable Urban Development

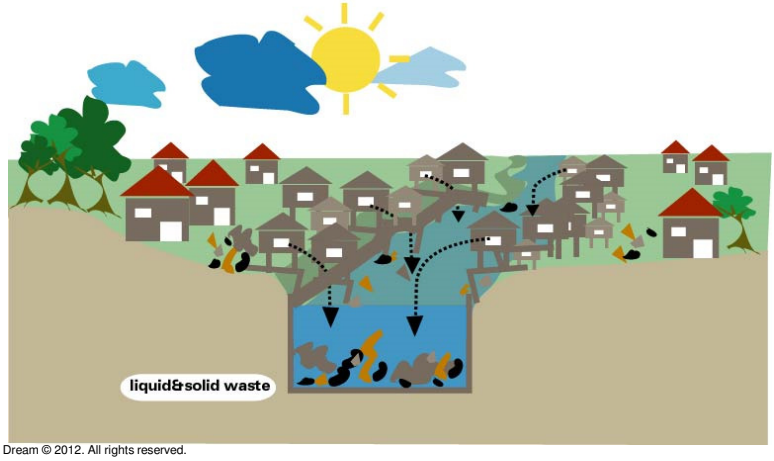
2. Uncontrolled Urbanisation (Occupation) of Flood Plains Streams as Recipients of Solid & Liquids Wastes Problems with Flooding

4b



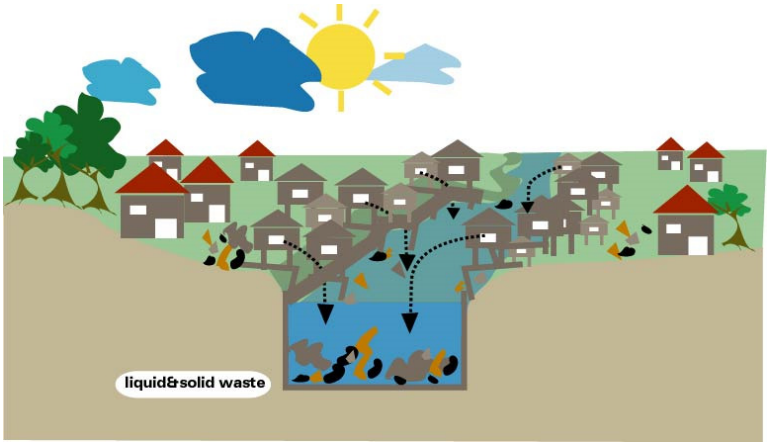
Phases in Unsustainable Urban Development

3. Channelization of Urban Streams Recipients of Solid & Liquid Wastes - Wastes & Storm water Problems with Flooding & Clogging



Phases in Unsustainable Urban Development

4. Channelization of Urban Streams Recipients of Solid & Liquid Wastes - Wastes & Storm water Problems with Flooding & Clogging



Phases in Unsustainable Urban Development

5. Uncontrolled Urbanisation in the Upper Parts of a Stream Building of Separate Sewers – Problem of Inlet Clogging

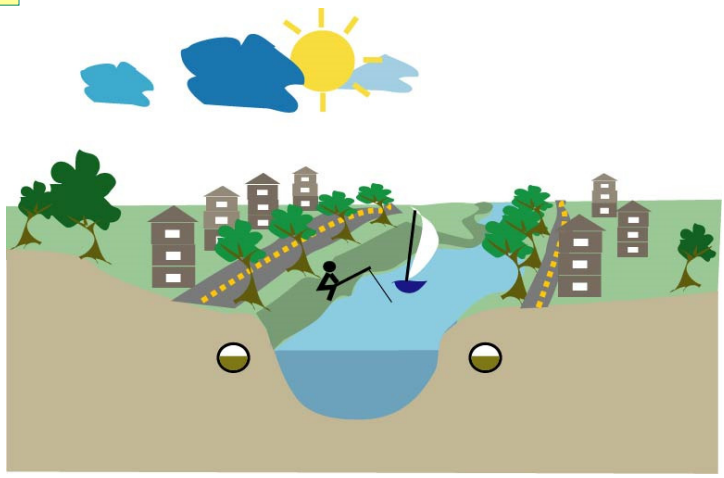
Denaturalisation of Urban Streams

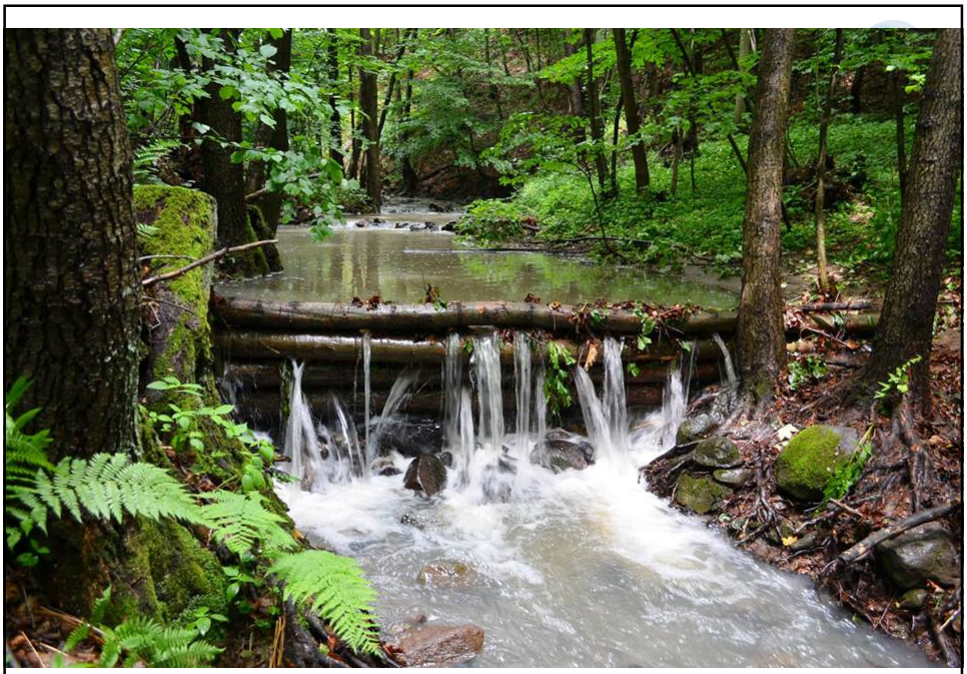
32

Denaturalisation of Urban Streams – Back to Nature

8b

Figure 1.6.b





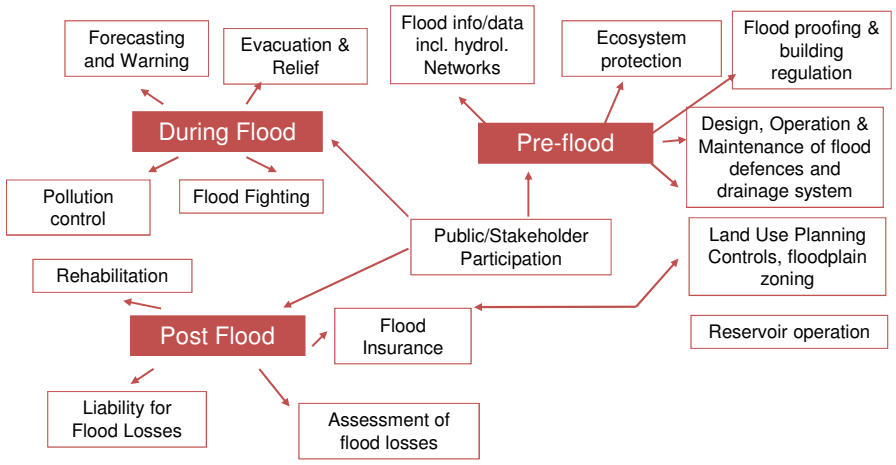
Simple “dams”

Blue Green D

Blue Green Dream

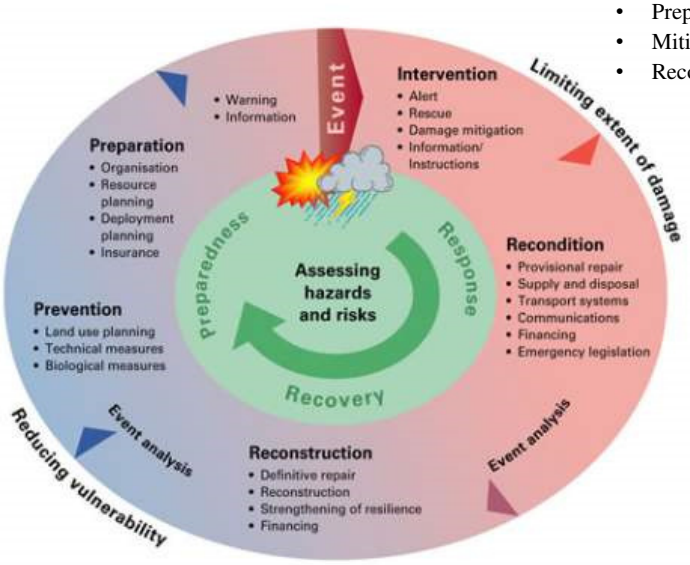
When the flood happens – assessing damage is not a trivial task

Overview of functions in IFM

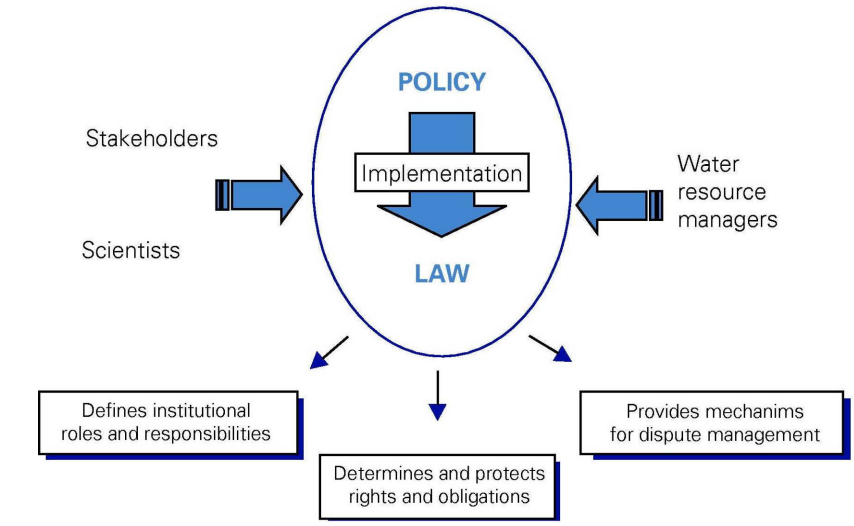


Flood Risk Management

- Preparedness
- Mitigation and Response
- Recovery and rehabilitation

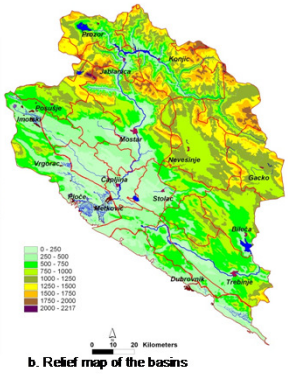


Roles of Law in Flood Management



Neretva & Trebišnjica catchments

a. Administrative division



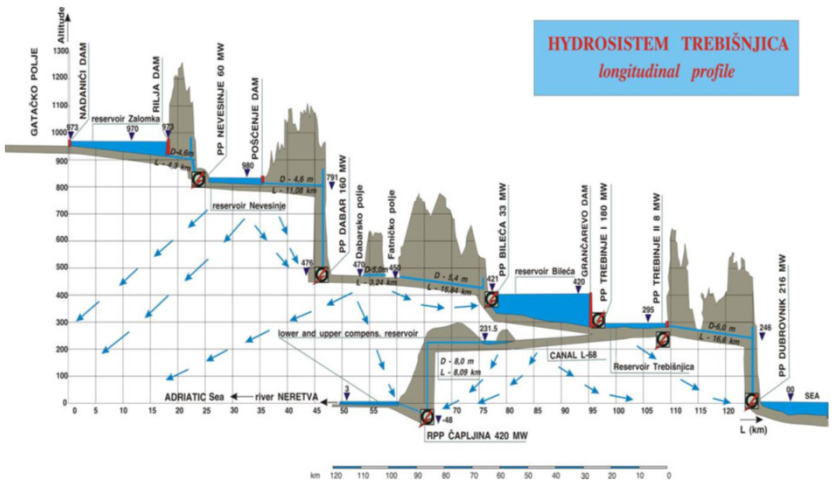
b. Relief map of the basins

A complex Karstic system

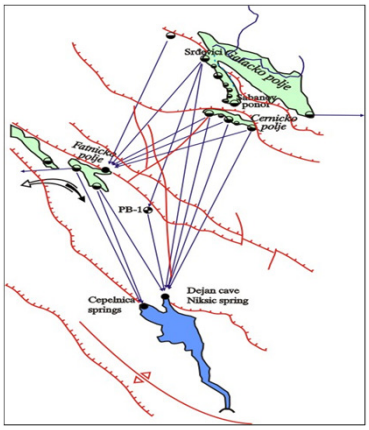
HYDROSISTEM TREBIŠNJICA

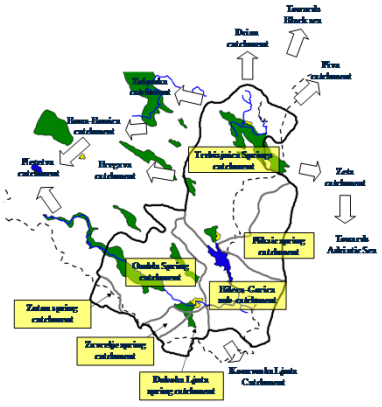
LAYOUT

Ever increasing complexity



Surface water divide does not have to coincide with the subsurface one





Pontbren catchment

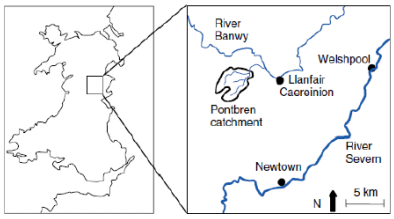


Figure 3.1: Location of Pontbren catchment

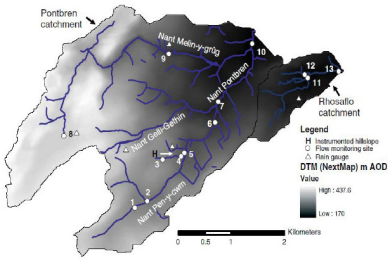


Figure 3.4: Location of flow gauges and rain gauges in Pontbren catchment

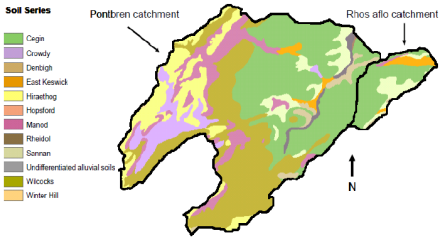


Figure 3.5: Catchment soils

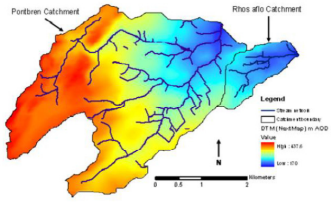


Figure 3.2: Topography of Pontbren catchment

Lower level of complexity – Parallel linear reservoirs

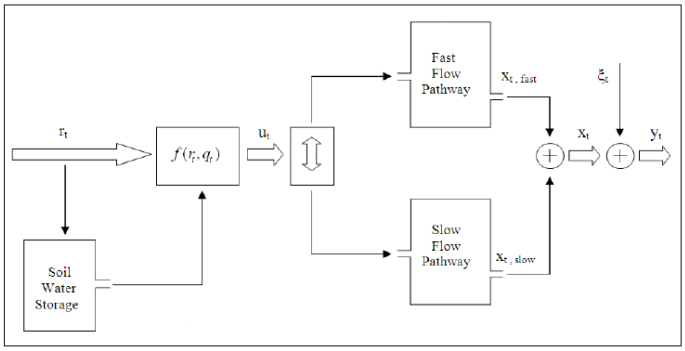


Figure 4.2: Conceptual model for the two linear parallel reservoirs

A higher level of complexity

A three-dimensional unstructured-mesh flooding model using a new wetting and drying method in a high aspect ratio domain

T. Zhang[a,b], C.C. Pain[a], F. Fang[a,*], A. Avdis[a], A. Candy[a], C. Maksimovic[c], P. Feng[b]

[a] *Applied Modelling and Computation Group, Department of Earth Science and Engineering, Imperial College London, Prince Consort Road, London, SW7 2BP, UK*
URL: http://www3.imperial.ac.uk/earthscienceandengineering/research/amcg
[b] *State Key Laboratory of Hydraulic Engineering Simulation and Safety, Tianjin University, Tianjin 300072, China*
[c] *Civil and Environmental Engineering Department, Imperial College of London, Imperial College Road, SW7 2BU, London, UK*

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2.1. Governing equations

The underlying equations are the incompressible Navier-Stokes equations with the Boussinesq approximation in a time-dependent domain Ω:

$$\nabla \cdot \vec{u} = 0, \tag{1}$$

$$\rho_0\left(\frac{\partial \vec{u}}{\partial t} + \vec{u} \cdot \nabla \vec{u}\right) - \nabla \cdot \mu \nabla \vec{u} + \nabla p = -(\rho' + \rho_0) g \vec{k}, \tag{2}$$

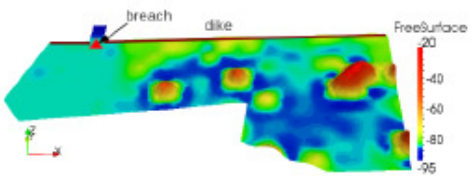


Figure 9: Case 3: The initial free surface height representing the topography of the computational domain of the realistic case.

Hydraulic connectivity analysis

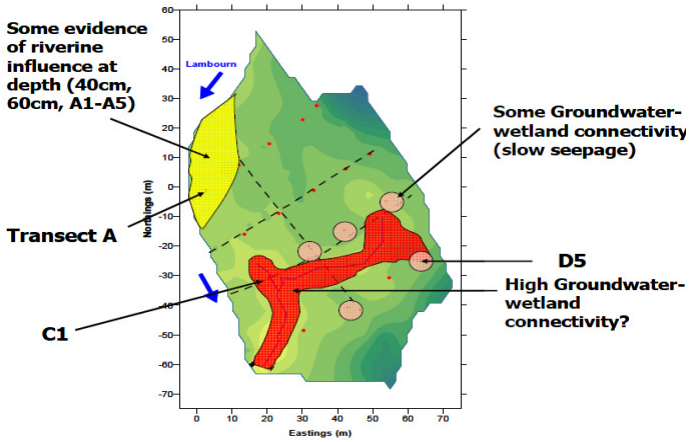


Figure 9.10 Conceptual model of baseflow wetland hydraulic connectivity at Boxford.

Specific issues of KARST catchments

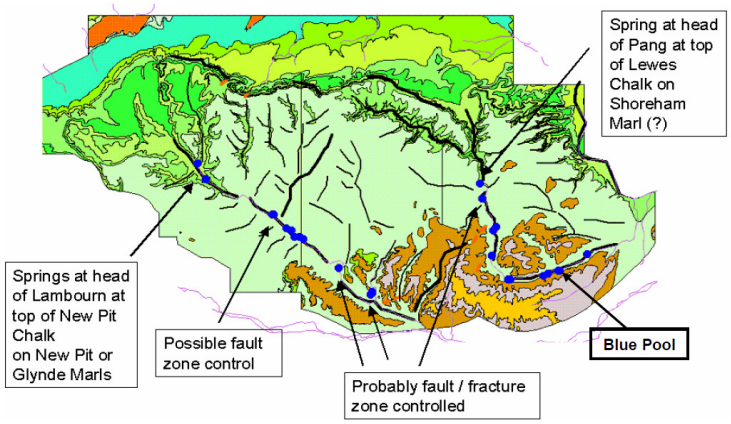


Figure 2.19 Summary of possible geological controls on the location of springs in the Pang and Lambourn valleys.

KARST environment

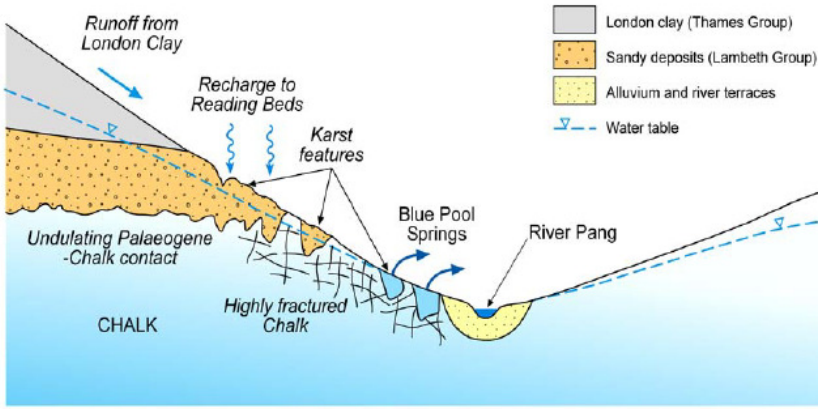


Figure 4.30 Karst flow mechanisms and flow to the Blue Pool.

TDN dynamics

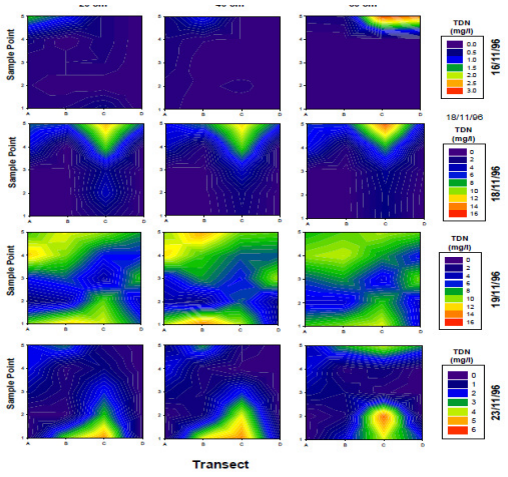


Figure 9.12 TDN dynamics under storm conditions, 16/11 – 23/11/96 (after Prior, 1998)

Field investigation study

Figure 4.2 Layout of boreholes at Westbrook Farm site. Boreholes H is situated to the right of the fence and G further upslope.

Pumpkin tank
(Sri Lanka)

Source : ITDG

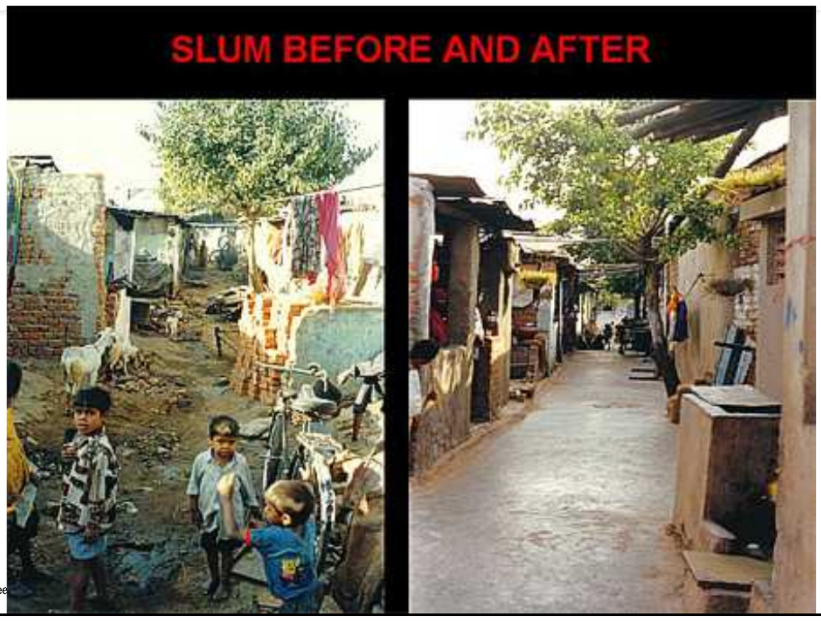
79

(Kenya)

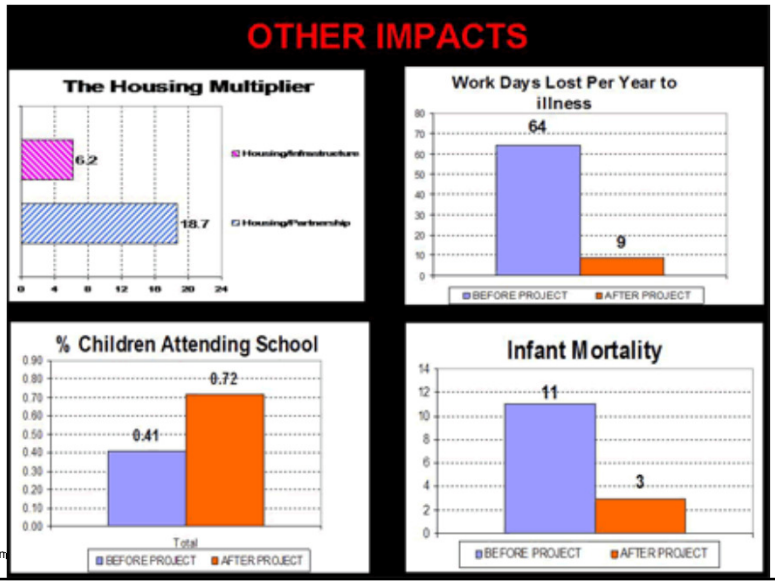
Source : Waterlines

80

Before and after



Other impacts



Case 4 Flooding in Jakarta Indonesia Anthony Hurford, MSc student 2008/09

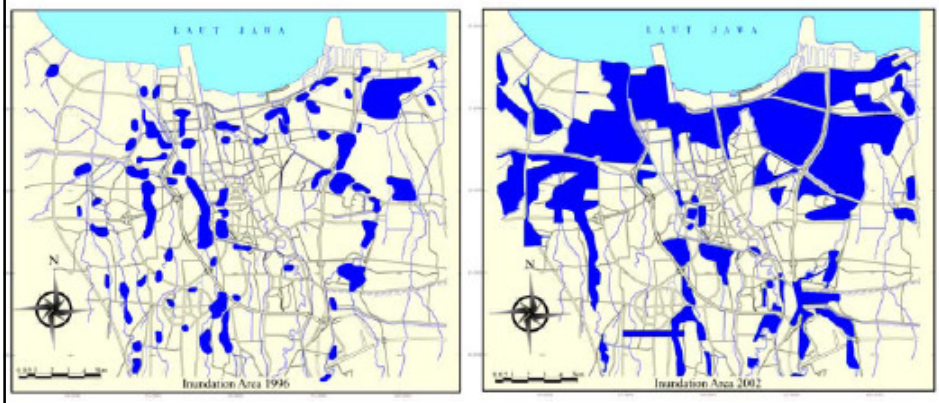
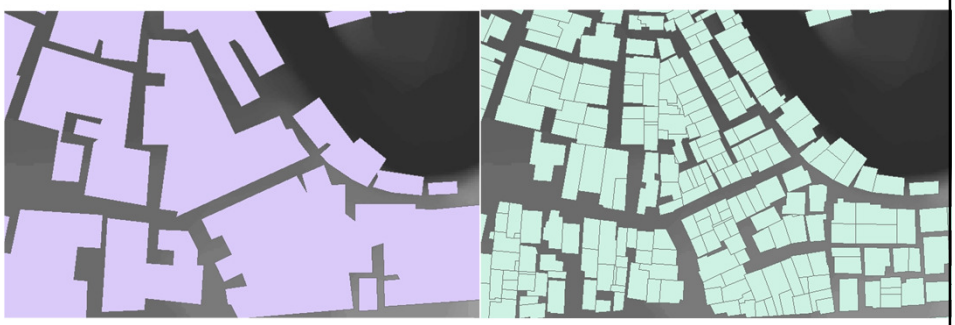


Figure 2 Jakarta-wide flood extents from 1996 (left) and 2002 (right) (source: Nippon Koei and Kwarsa Hexagon, 2005)

Land use mapping



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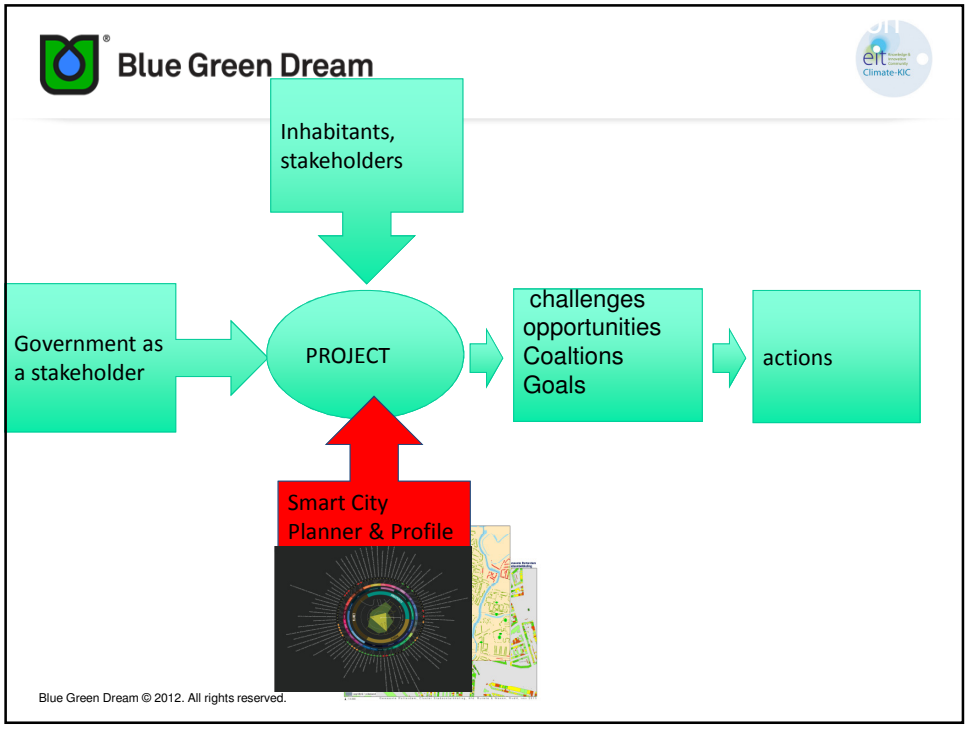
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Inhabitants, stakeholders
Government as a stakeholder
PROJECT
challenges
opportunities
Coaltions
Goals
actions
Smart City Planner & Profile
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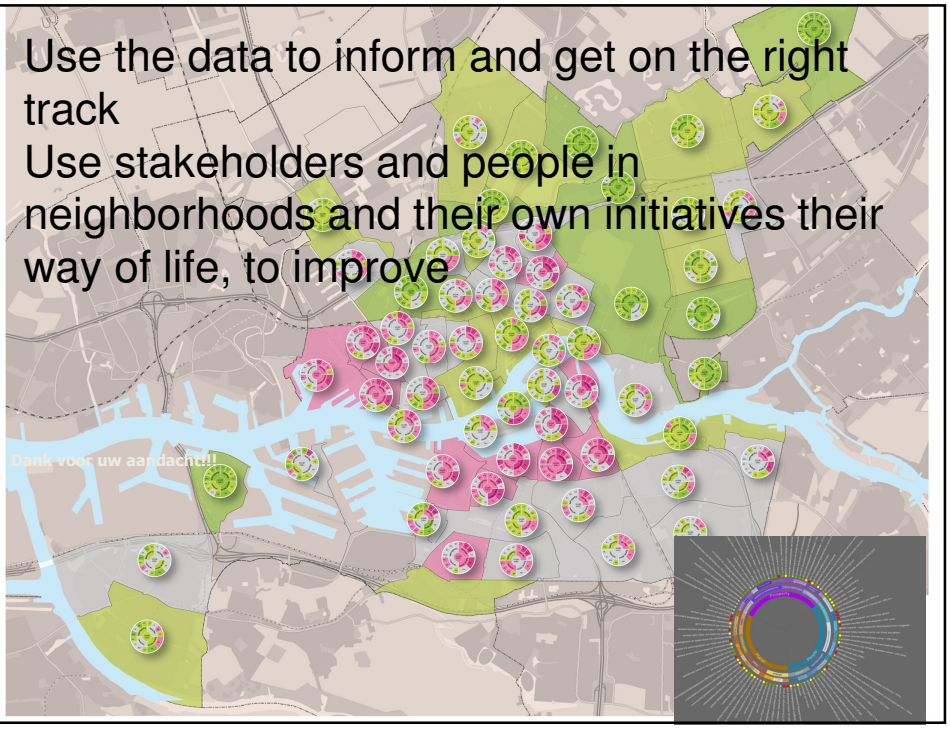
Blue Green Dream
Study from the 'De urbanisten' Rotterdam
Blue Green Dream ©
Nico Tillie - ICLEI Resilient Cities - Bonn, Germany, 30th of May 2014
Gemeente Rotterdam
Stadsontwikkeling

Use the data to inform and get on the right track
Use stakeholders and people in neighborhoods and their own initiatives their way of life, to improve



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Contact details

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Urban Water Journal http://www.tandfonline.com

Urban Water Book Series http://www.routledge.com/books/series/UWS/

Blue Green Dream project http://www.bgd.org.uk

RainGain project http://www.raingain.eu/en