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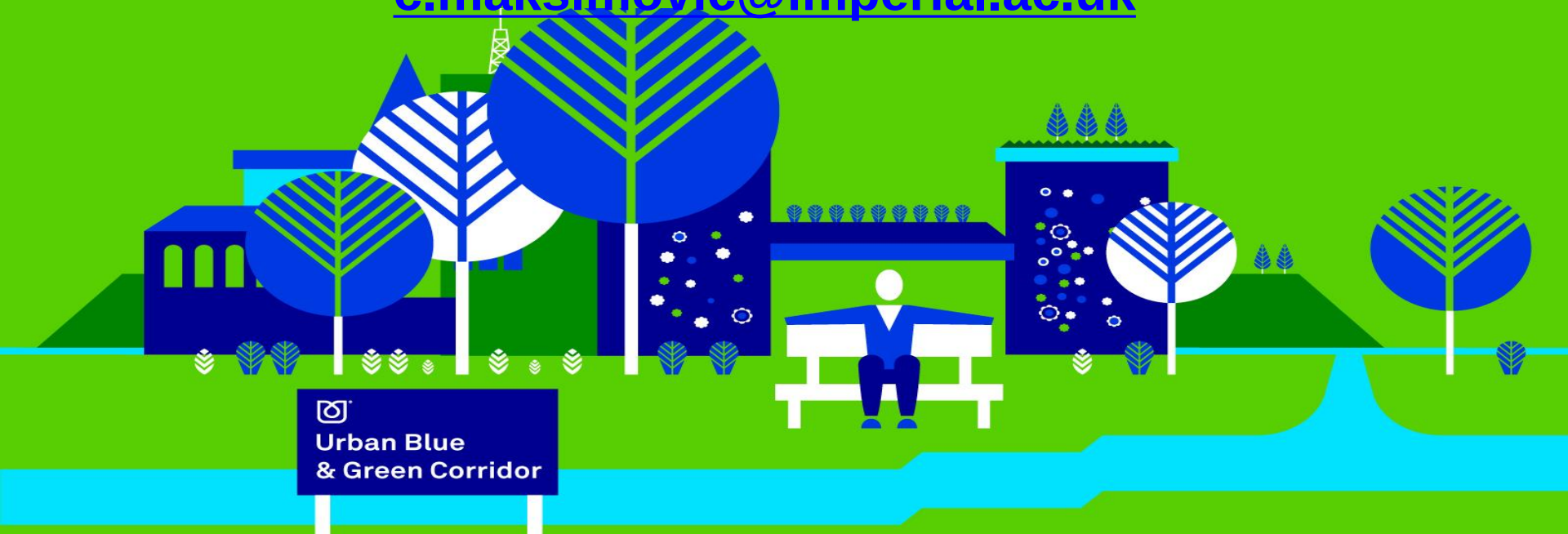
Integrated Planning for Urban Sustainability and Resilience to CC and Weather Extremes

The Blue Green Dream Interactions

Earth Science Conference, Alicante, 16-18th June 2015

Prof. Čedo Maksimović: BGD Lead

c.maksimovic@imperial.ac.uk



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

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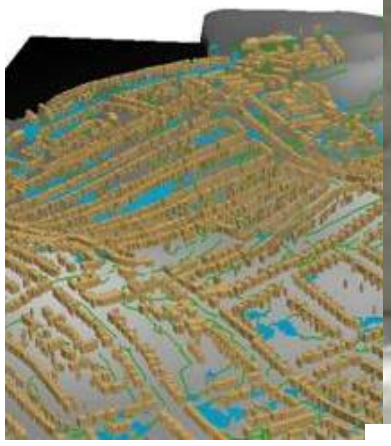
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Some issues tackled by Blue Greening

Flooding



Water pollution



Droughts



Air pollution



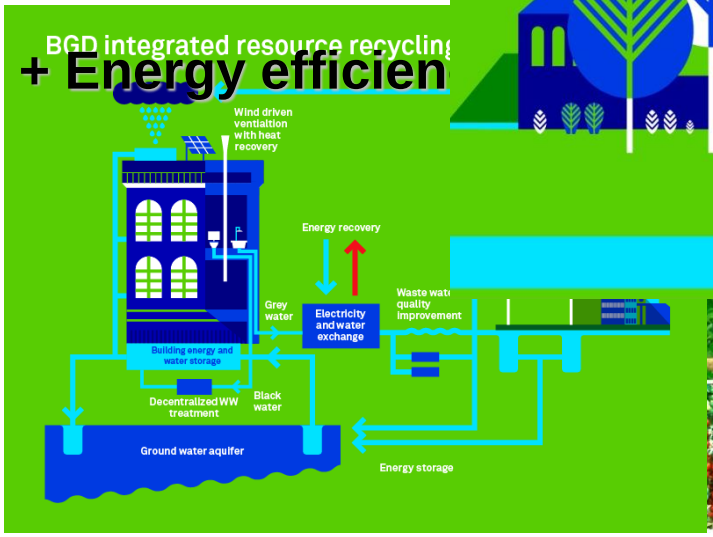
Heat island



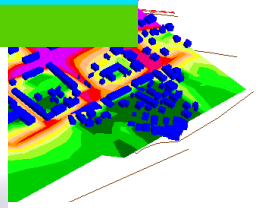
Healthy cities

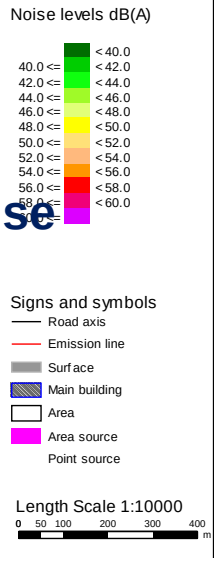


+ Energy efficien



Noise





Urban agriculture



Crime

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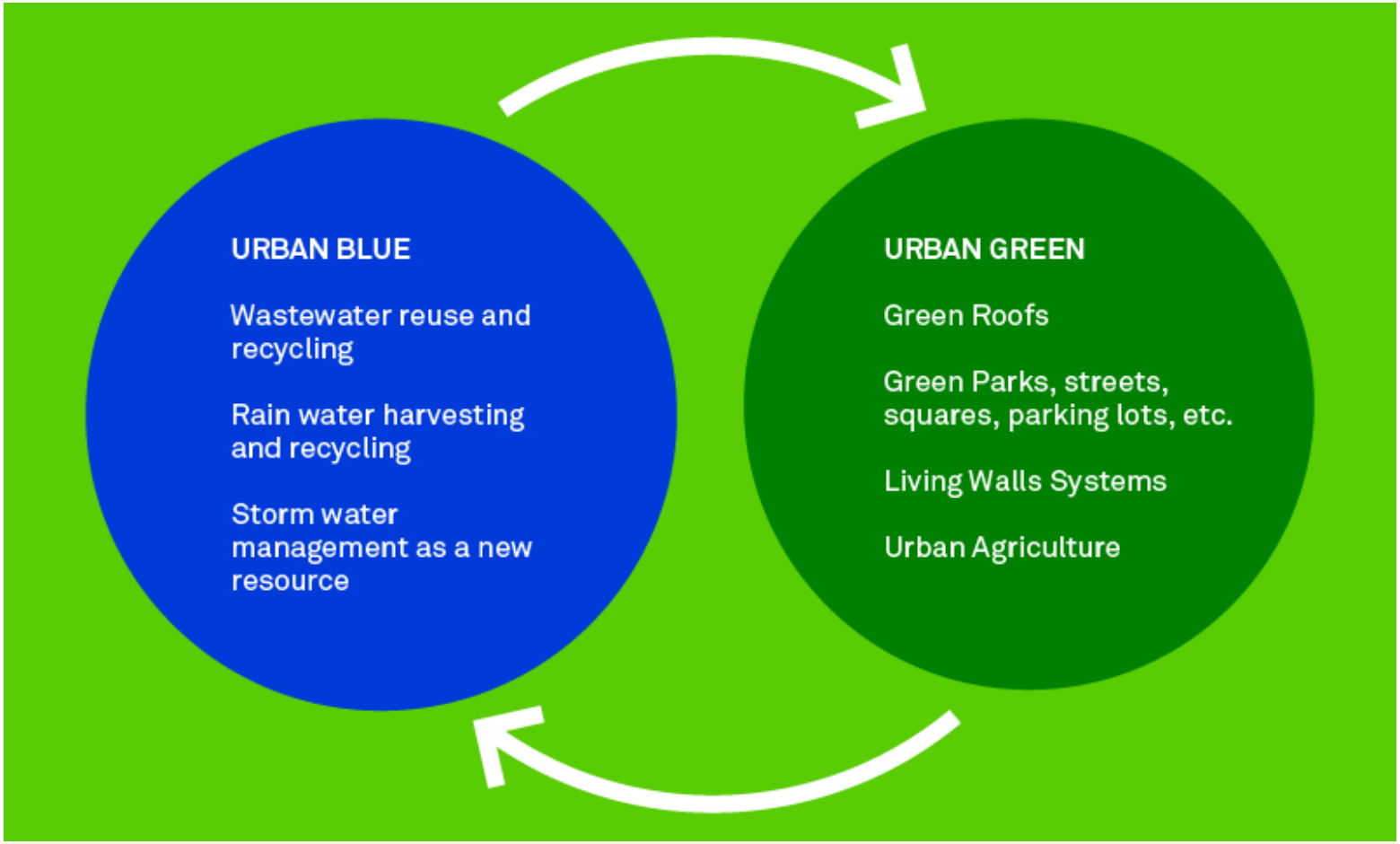
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The Blue Green Dream Principle

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Synergistic merging of Green Infrastructure with Urban Water (Blue) Systems



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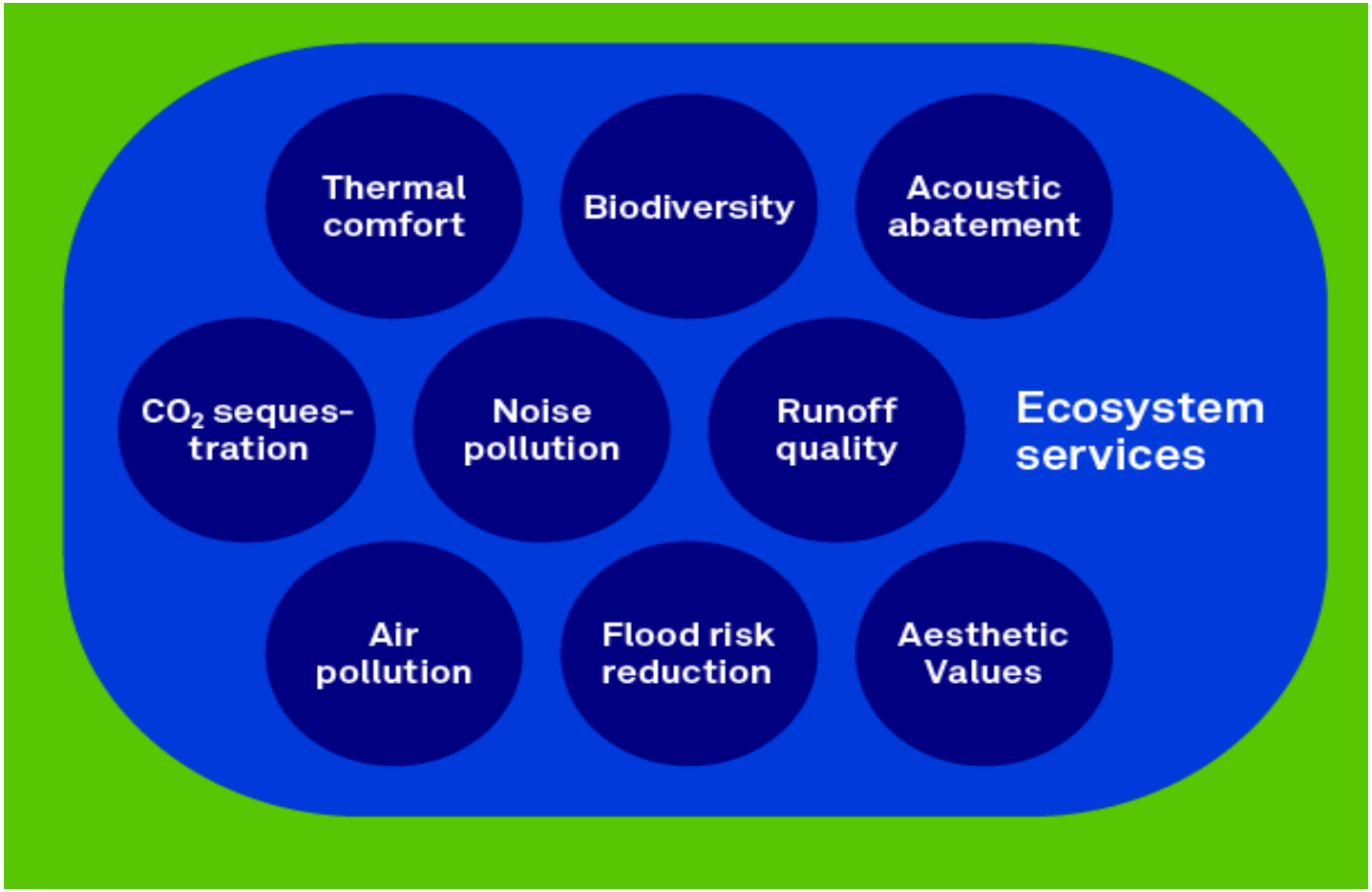
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BGD: Maximising the benefits of vegetation

- Harnessing ecosystems services to enhance the urban environment

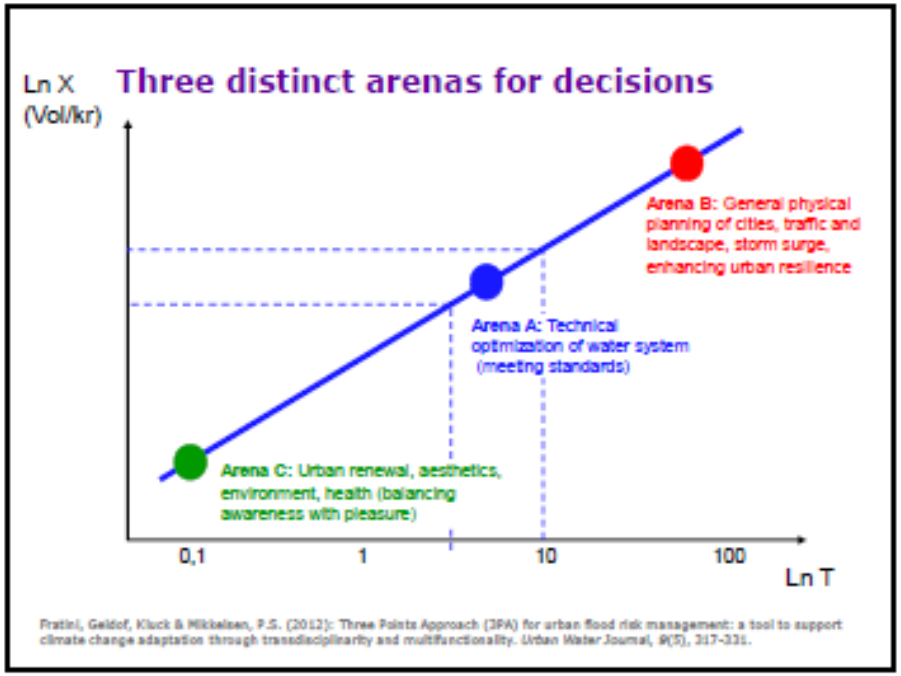


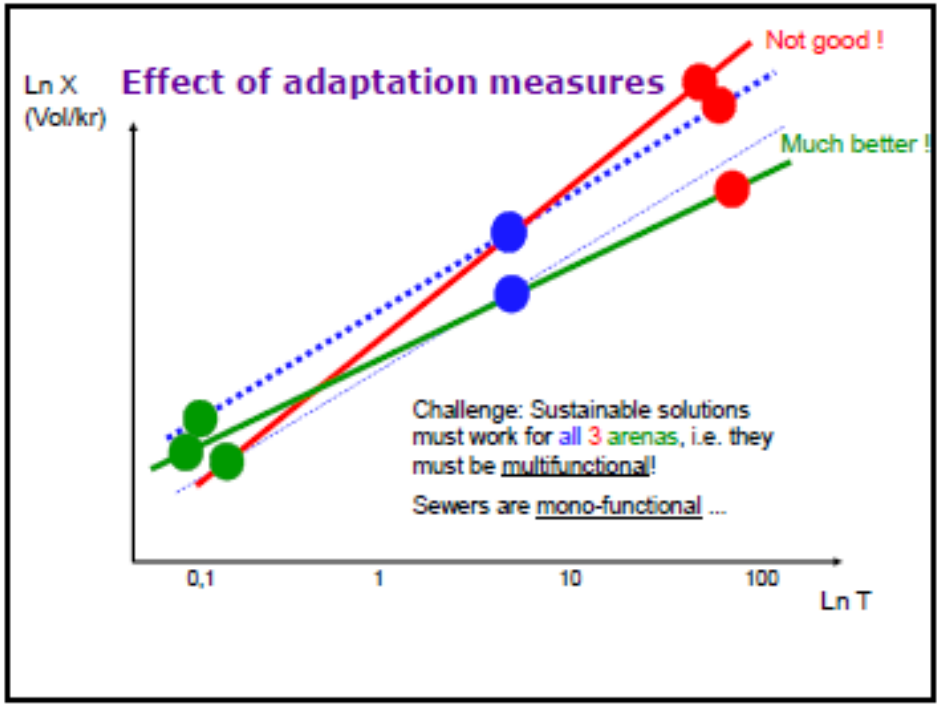
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Scenarios and adaptation

Climate change will render existing systems vulnerable - vital to improve their resilience

Courtesy P. S. Mikkelsen, DTU





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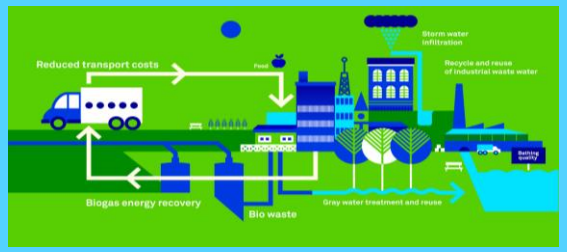
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BGD Benefits:

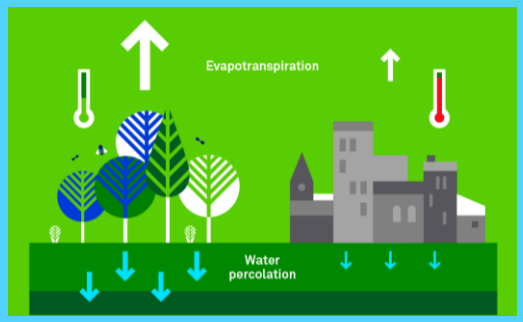
Stormwater/wastewater/ solid waste recovery



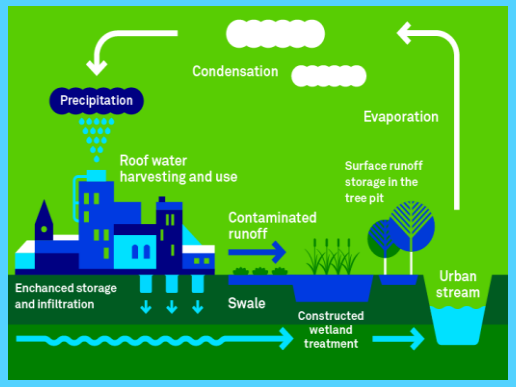
Lowered air pollution



Reduced Urban Heat Island Effect



Flood & drought protection



Reduced noise pollution



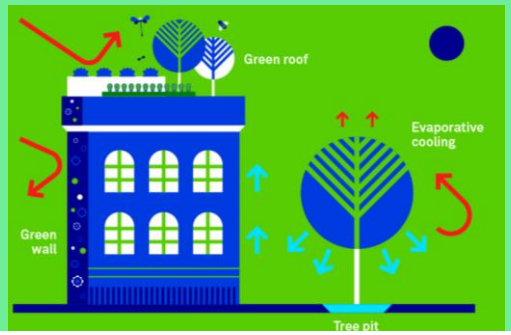
Improved amenity & human health



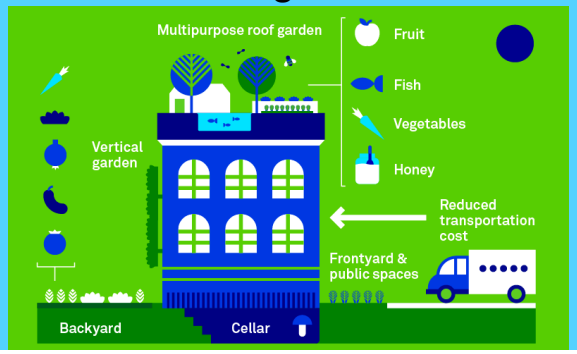
Reduced pluvial flood risk



Raised building energy efficiency



Urban agriculture



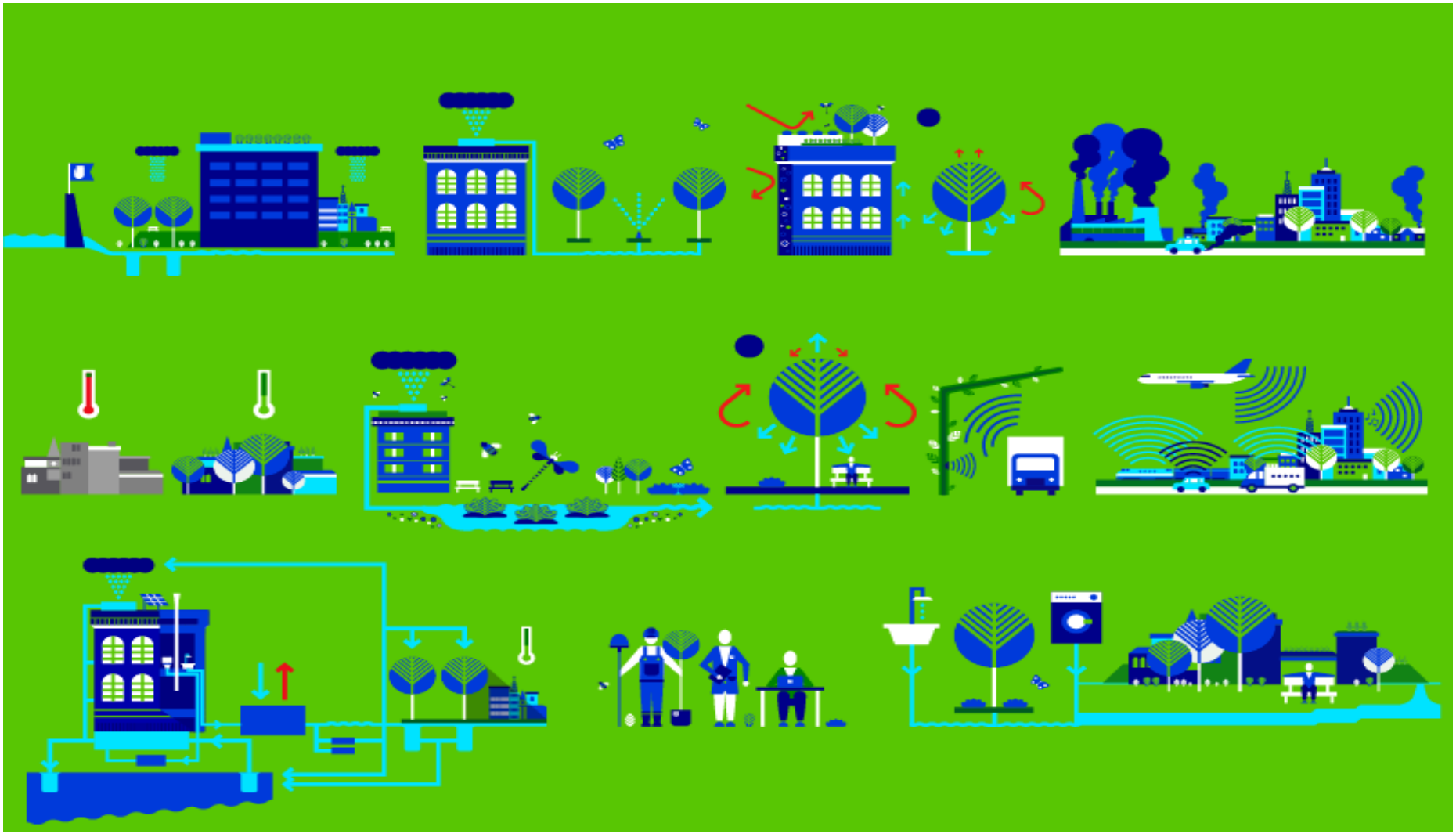
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Interactions of urban ecosystem services



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Blue Green Dream Activities and Services

Quantifying and modelling BG Solution Benefits





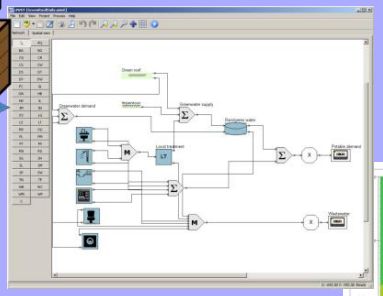


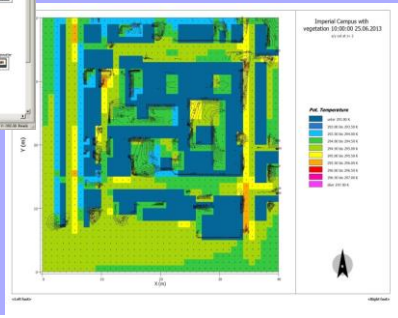




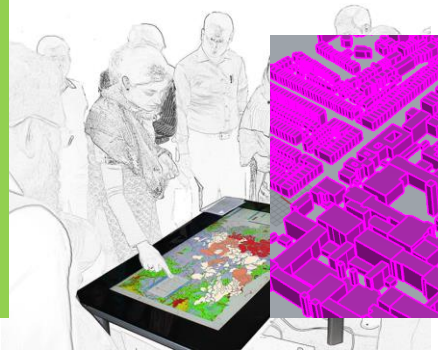
Development of New Computer Models and Planning Tools

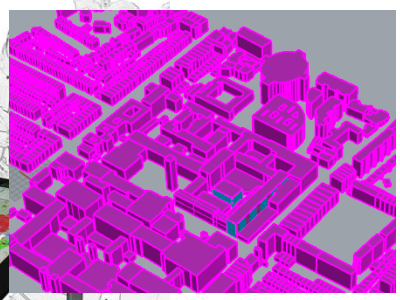






Innovative Urban Planning Consultancy







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Blue Green Dream Activities and Services

Quantifying and modelling BG Solution Benefits











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Measuring/Modelling

Green roof plant performance

University of Reading

Royal Horticultural Society

Sharing the best in Gardening

- 4 plant species studied:
- *Salvia*; *Stachys*; *Heucheral Sedum*






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Climate-KIC

Measuring/Modelling

Green roof plant performance

University of Reading

Royal Horticultural Society

Sharing the best in Gardening

Experiments include:

- Impact of plant canopy structure on rainwater capture capacity
- Impact of synthetic greywater irrigation on plant survival and quality
- Influence of plant species on decontamination of greywater leachate













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Measuring/Modelling

Green roof plant performance

University of Reading

Royal Horticultural Society
Sharing the best in Gardening

Key Results:

1. *Salvia* captures more rainfall than other species → many layers to canopy
2. *Heuchera* canopy acts like an umbrella → low rainfall capture
3. Salvia, Stachys and Sedum all tolerated greywater well over 8 weeks






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Measuring/Modelling

Green roof performance

Imperial College London

- Eastside Hall of Residence, Prince's Gardens
- Green roof test site installed Spring 2014





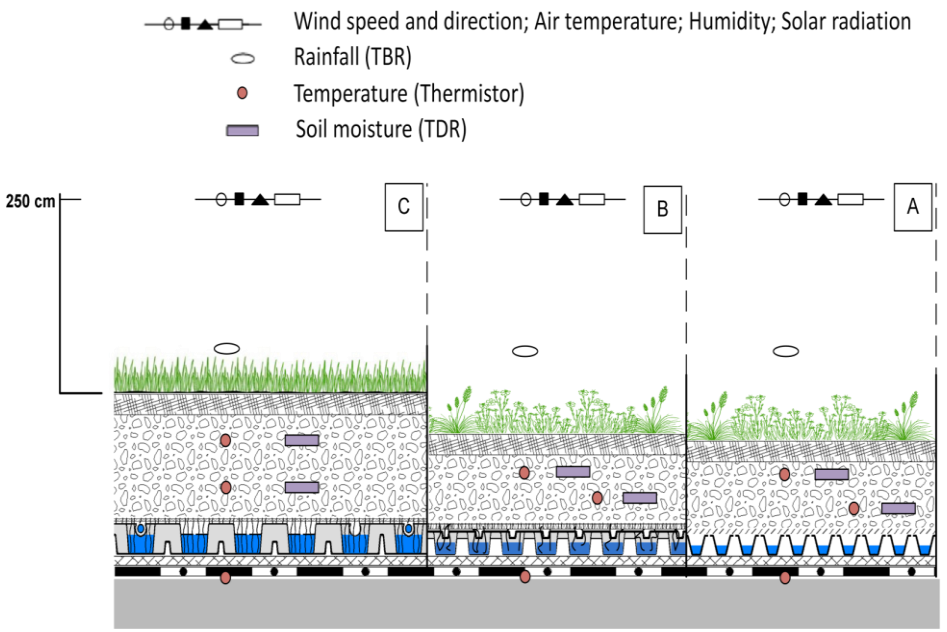
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Measuring/Modelling

Green roof performance

- 3 independent 3m*4m plots: 2 intensive, 1 extensive
- Soil moisture and temperature probes fitted





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Measuring/Modelling

Green roof performance

Parameters assessed:

- Weather conditions
- Soil moisture
- Soil and roof temperature (thermal insulation properties)
- Influence of green roof type (intensive vs. extensive)
- Rainfall and runoff
- Runoff Quality from Intensive and Extensive Green Roofs



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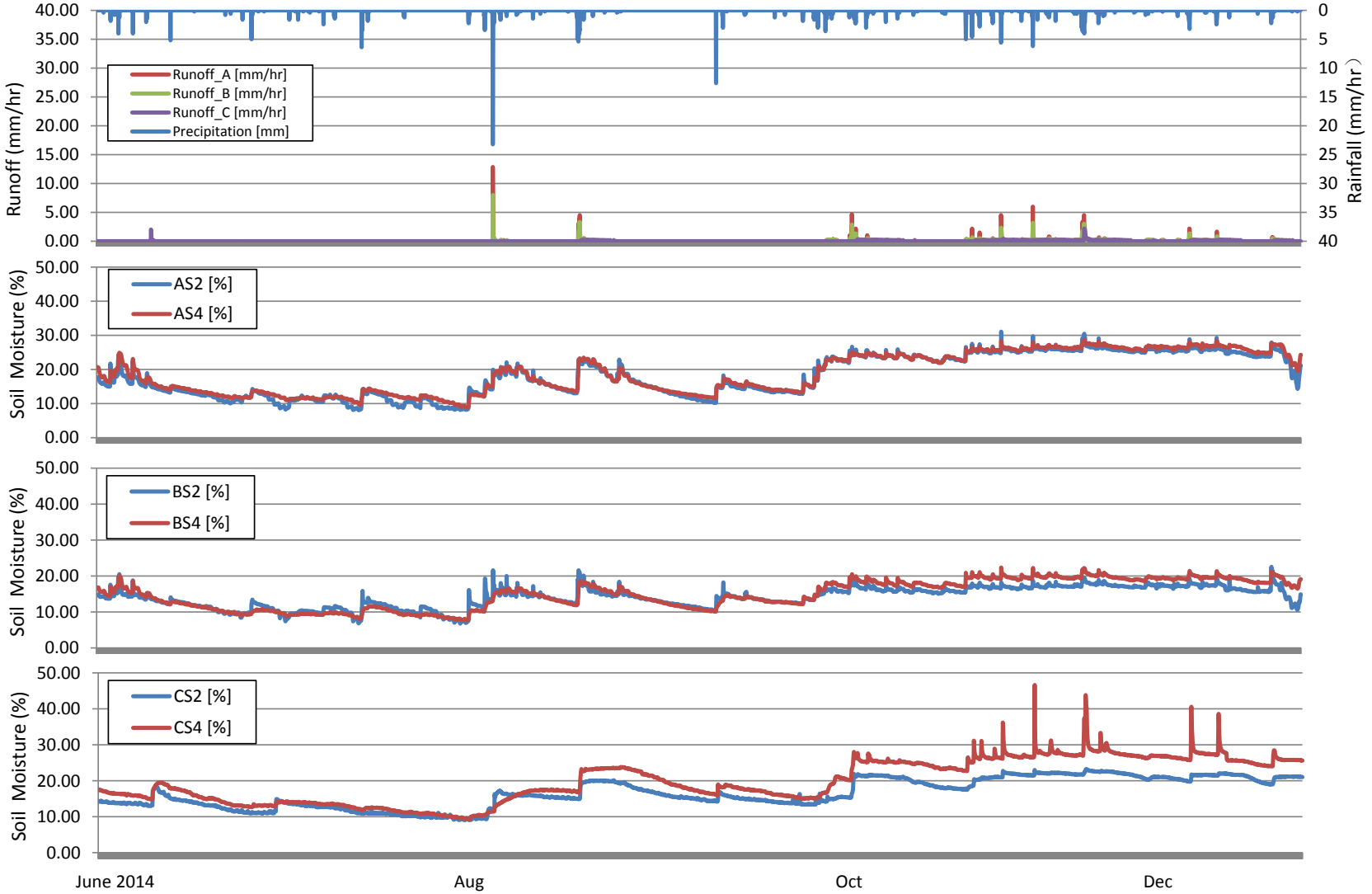
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Climate-KIC

Measuring/Modelling

Green roof performance; Hydro-meteorological Data



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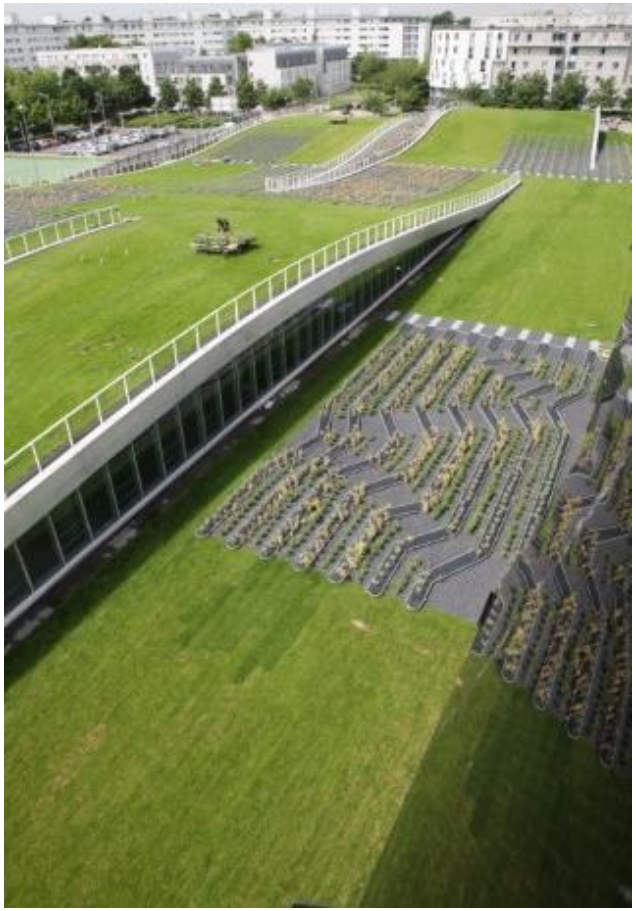
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Measuring/Quantifying

Blue Green Wave

École des Ponts ParisTech

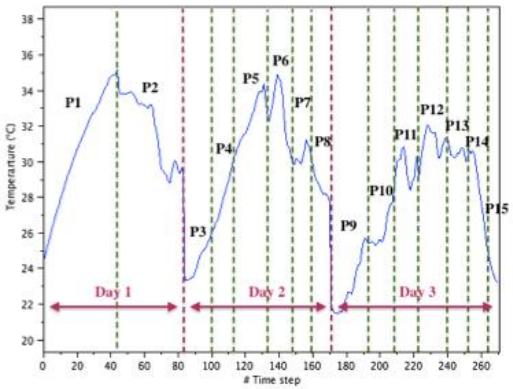
- Experimental site to understand the hydrological behavior of a large blue green structure



Water content



Temperature





Humidity

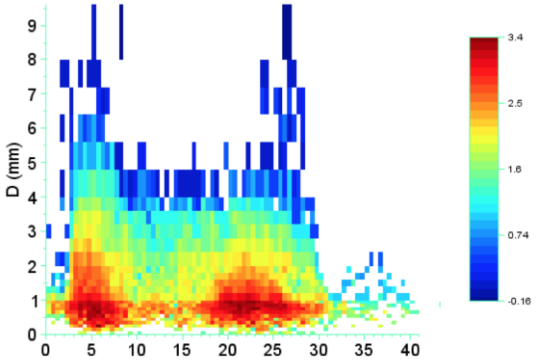


Figure 40: Temporal evolution of N(D)

Precipitation

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Climate-KIC

Measuring/Modelling

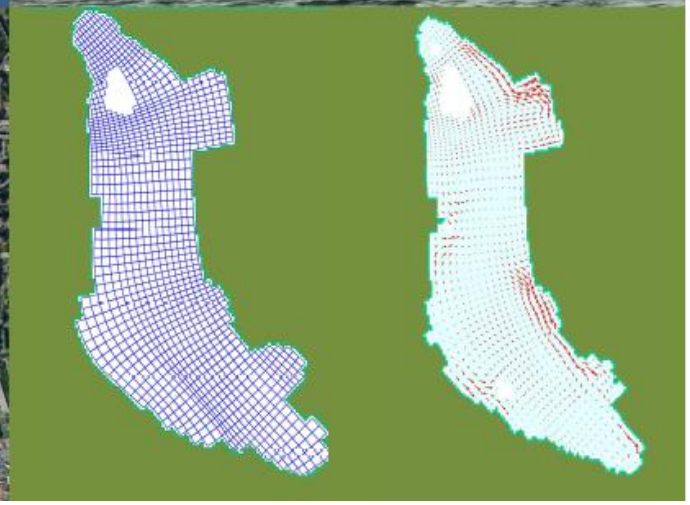
Creteil Urban Lake

Urban Lake Monitoring: preserving lake ecosystems for sustainable cities

Case Lake Créteil







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Climate-KIC

Measuring/Modelling

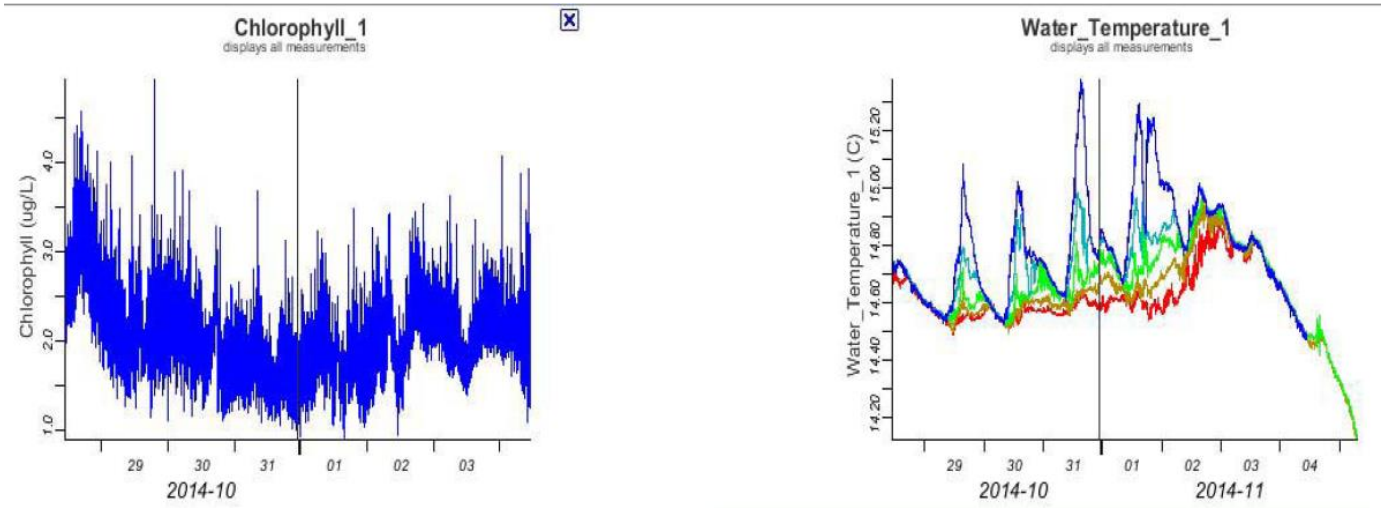
Creteil Urban Lake

École des Ponts ParisTech

Case study for demonstrating how lakes can provide multiple ecosystem services:

- Flood risk reduction
- Humidity control
- Wildlife support and preservation
- Leisure

Focus on: water column characterisation (stratification of temperature and pollutant levels) plus influence of seasons



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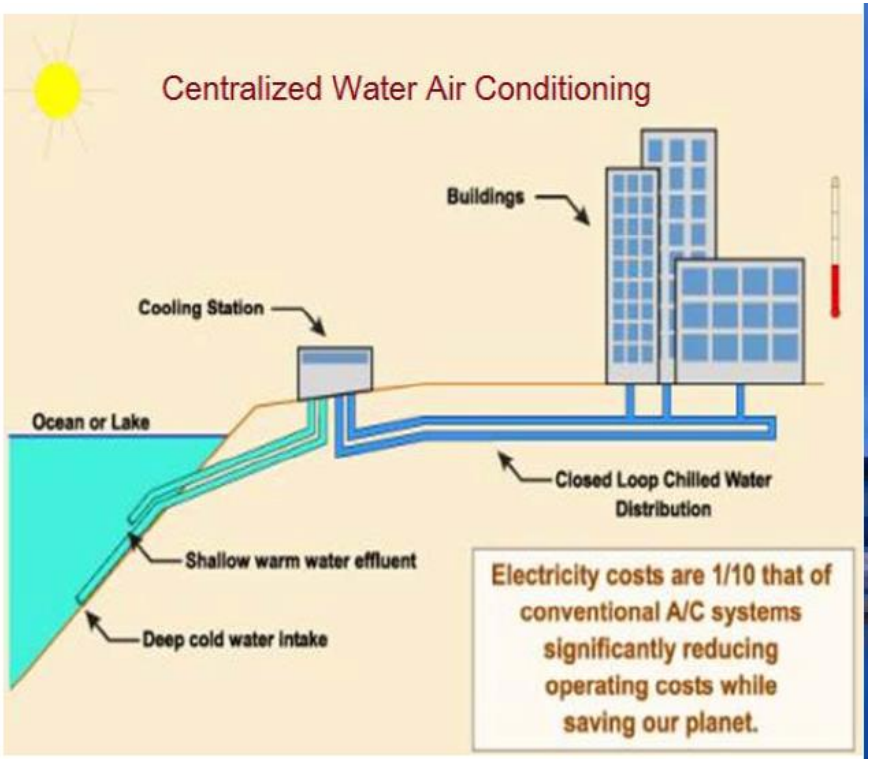
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Climate-KIC

Measuring/Modelling

Creteil Urban Lake



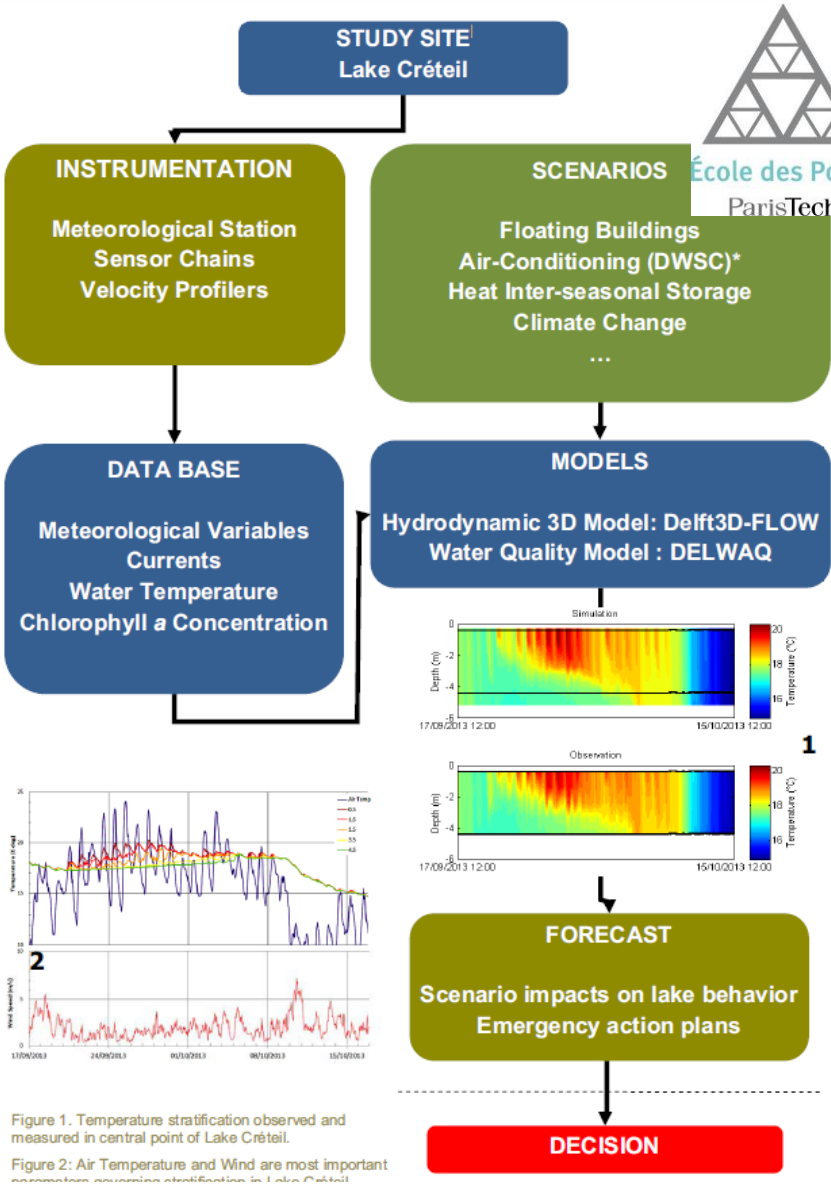


Figure 1. Temperature stratification observed and measured in central point of Lake Créteil.

Figure 2: Air Temperature and Wind are most important

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Blue Green Dream Activities and Services

Quantifying and modelling BG Solution Benefits





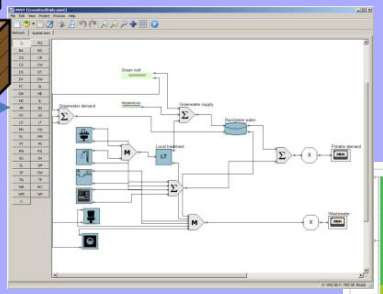


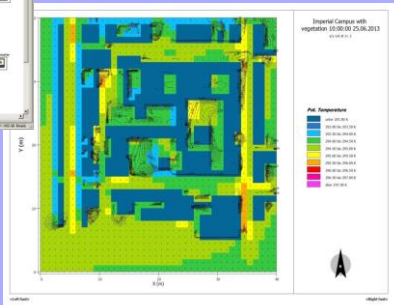




Development of new Tools and Services







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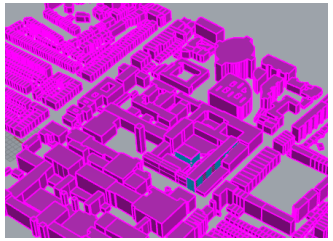
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Climate-KIC

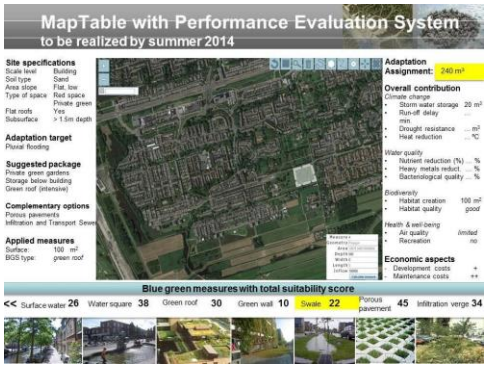
BGD Tools and Services

1. District/neighborhood level

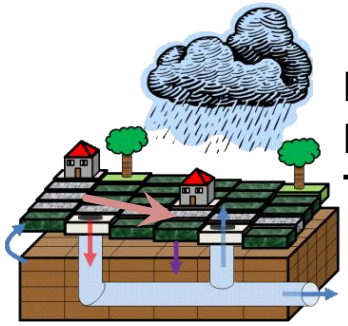
BGD, urban planning methodology



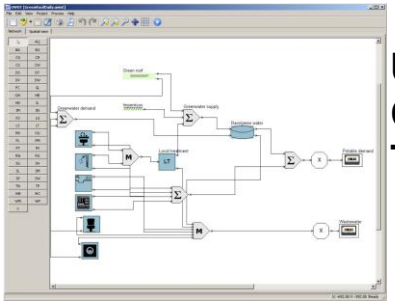
Adaptation Support Tool (AST)



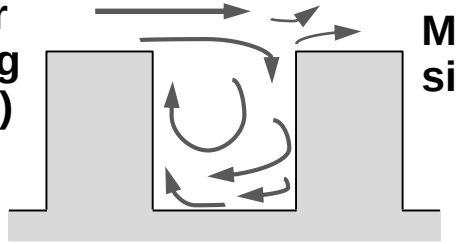
2. Street level



Multi-Hydro Tool



Urban Water Optioneering Tool (UWOT)



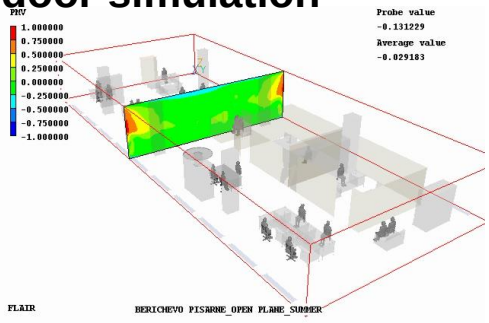
Micro-climate simulation

3. Building level

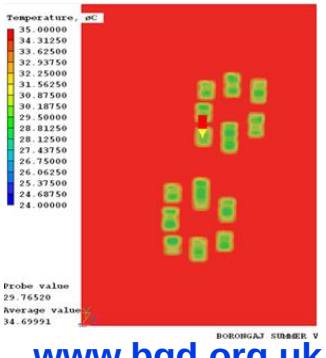
BIM, BGD module



Indoor simulation



Outdoor simulation



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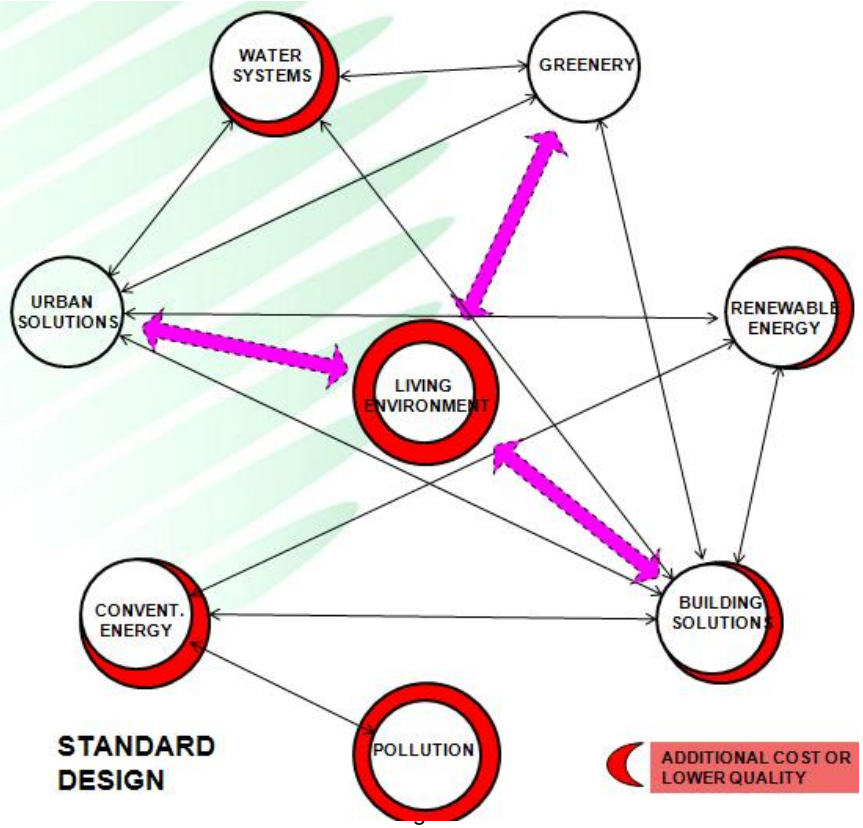
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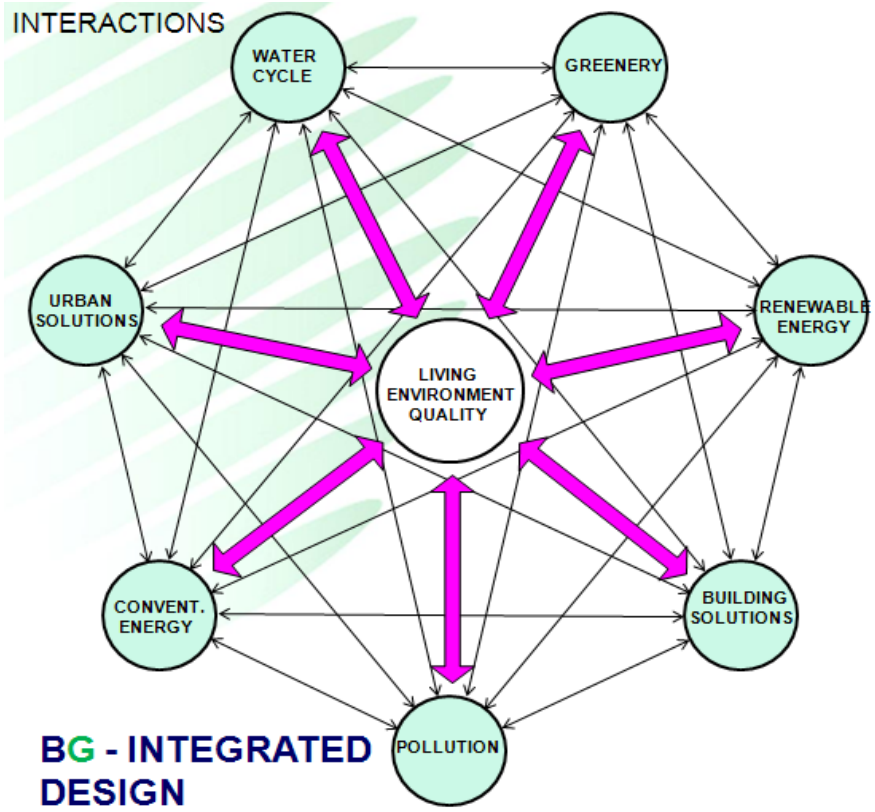
BGD Tools and Services

The integrated, BGD, planning approach

Conventional design

- Not all interactions addressed
- Additional costs incurred or lower quality obtained (red zones)





Resulting benefits:

- Lower construction & operational costs
- Higher market value of properties
- Enhanced human health and wellbeing

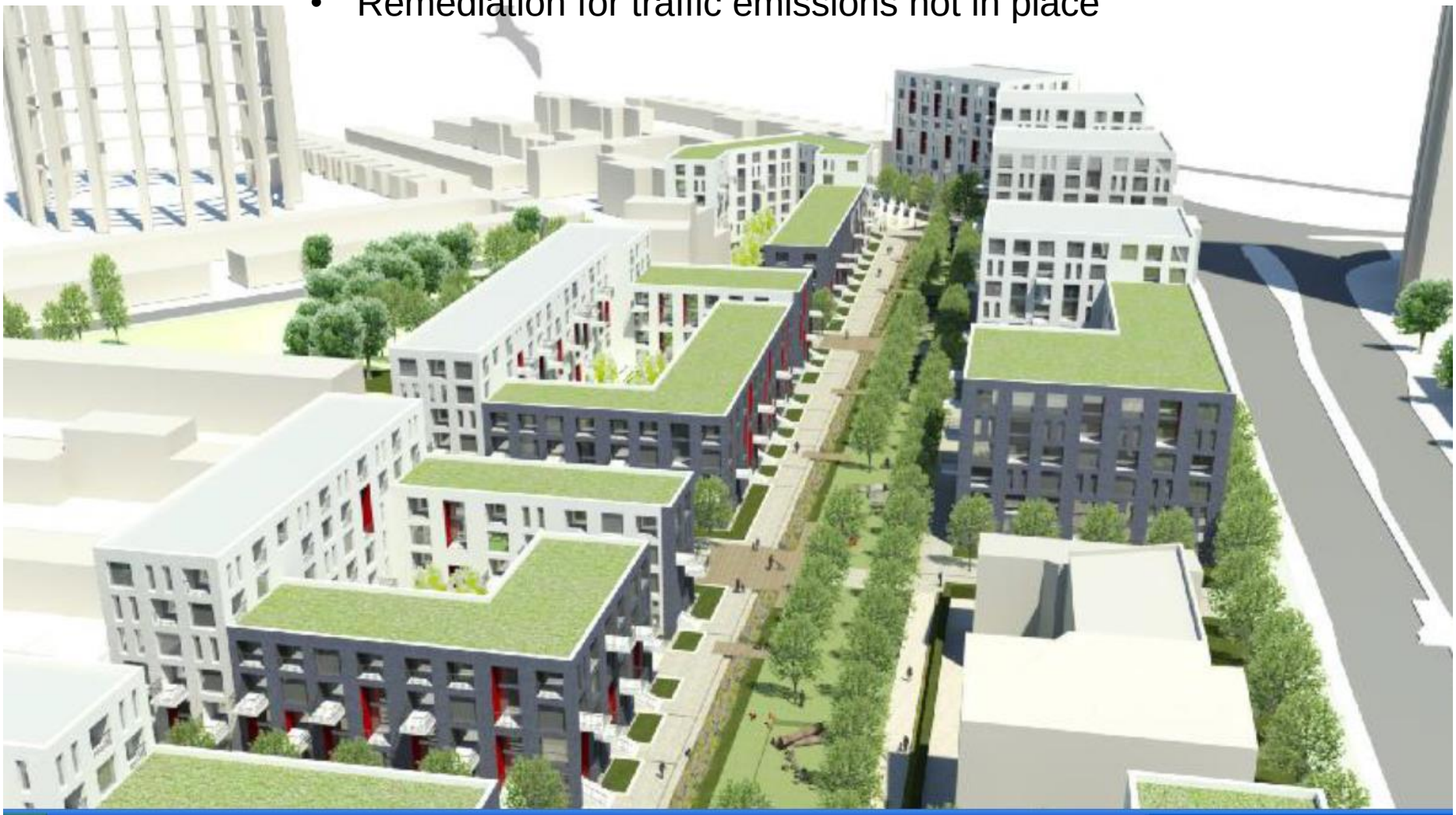
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Compartmentalised Planning

- Main walkway not protected in summer (heat island)
- Walkway position?
- Remediation for traffic emissions not in place



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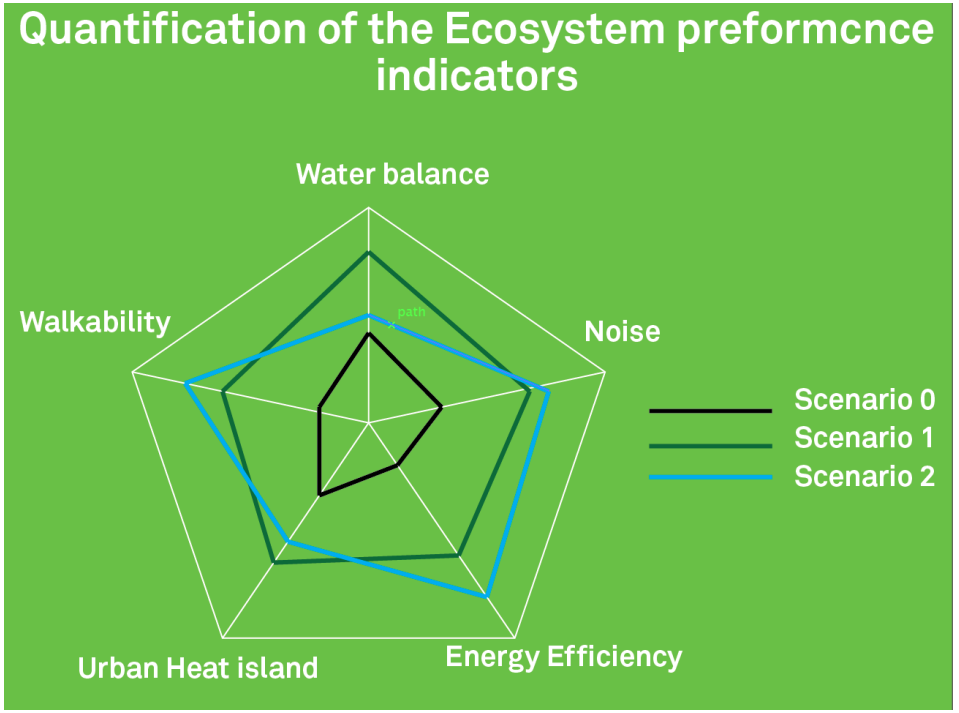
Climate-KIC

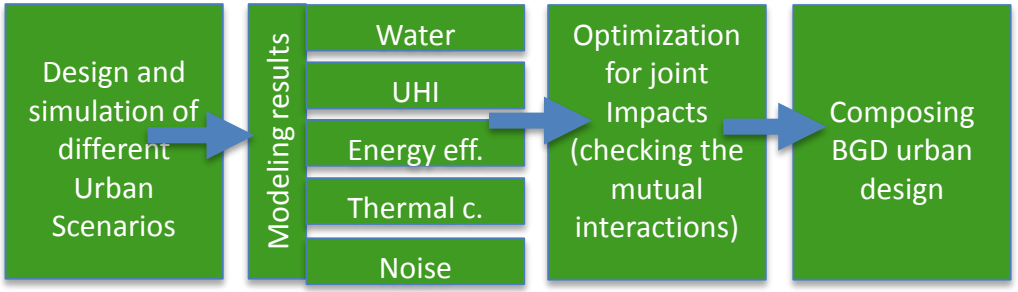
BGD Tools and Services

Optimised urban design via ecosystem services provision

Following parameters considered:

- **Water balance**: runoff from site, captured rain water, water for irrigation (tree pits, swales), infiltration (soil and surface type)
- **Urban Heat Island**: Evaporation, evapotranspiration, radiation, wind speed, urban geometry, humidity, albedo, atmospheric data
- **Energy efficiency**: air temperature, wind speed/direction, radiation, material properties





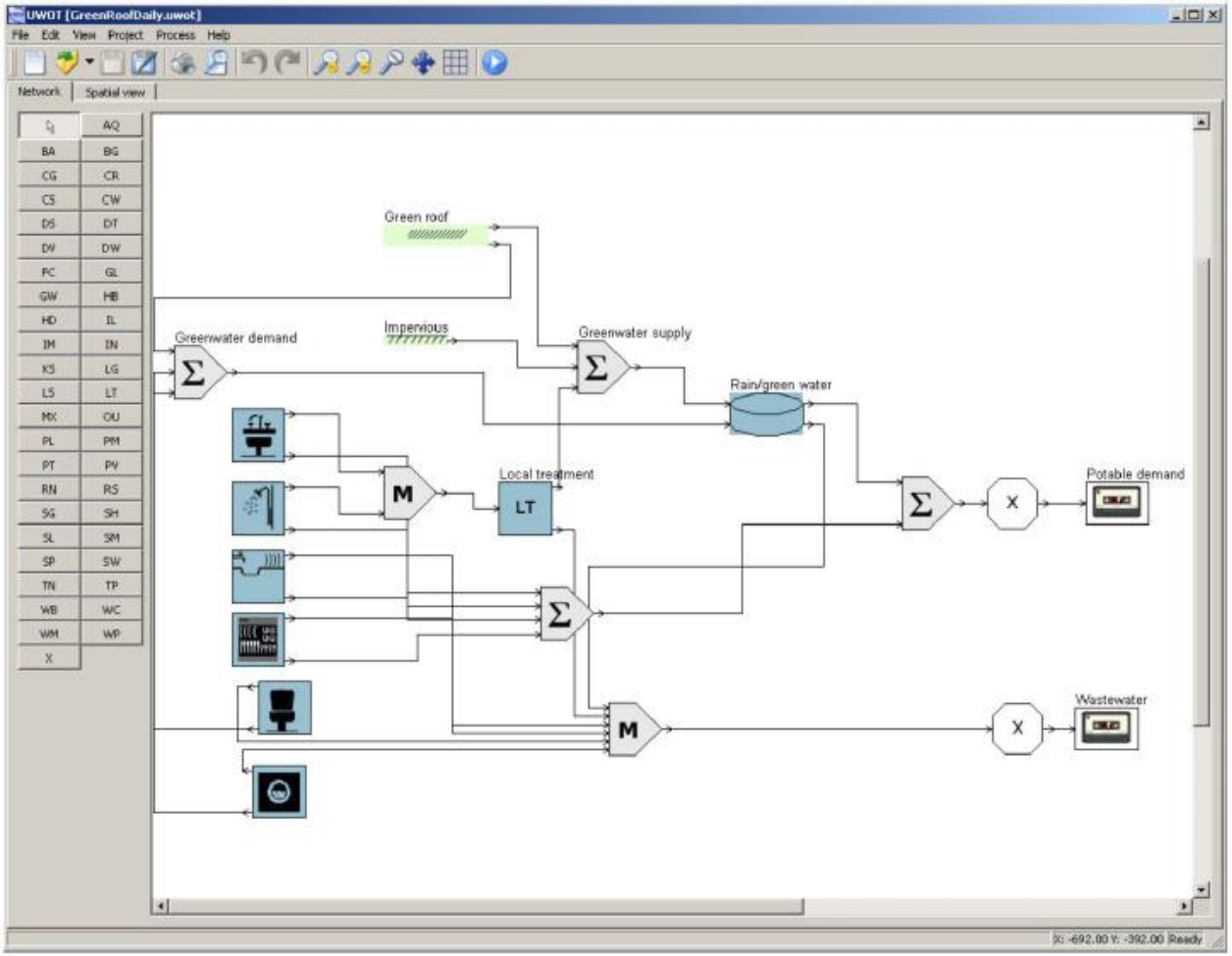
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BGD Tools and Services

UWOT – intermediate level tool: networks of buildings/households



- Simulates effects of BG Solutions on networks of buildings
- Predicts water/energy savings for different future scenarios, including climate change and population growth
- Output parameters include reduction in waste water generation, potable demand, energy consumption.

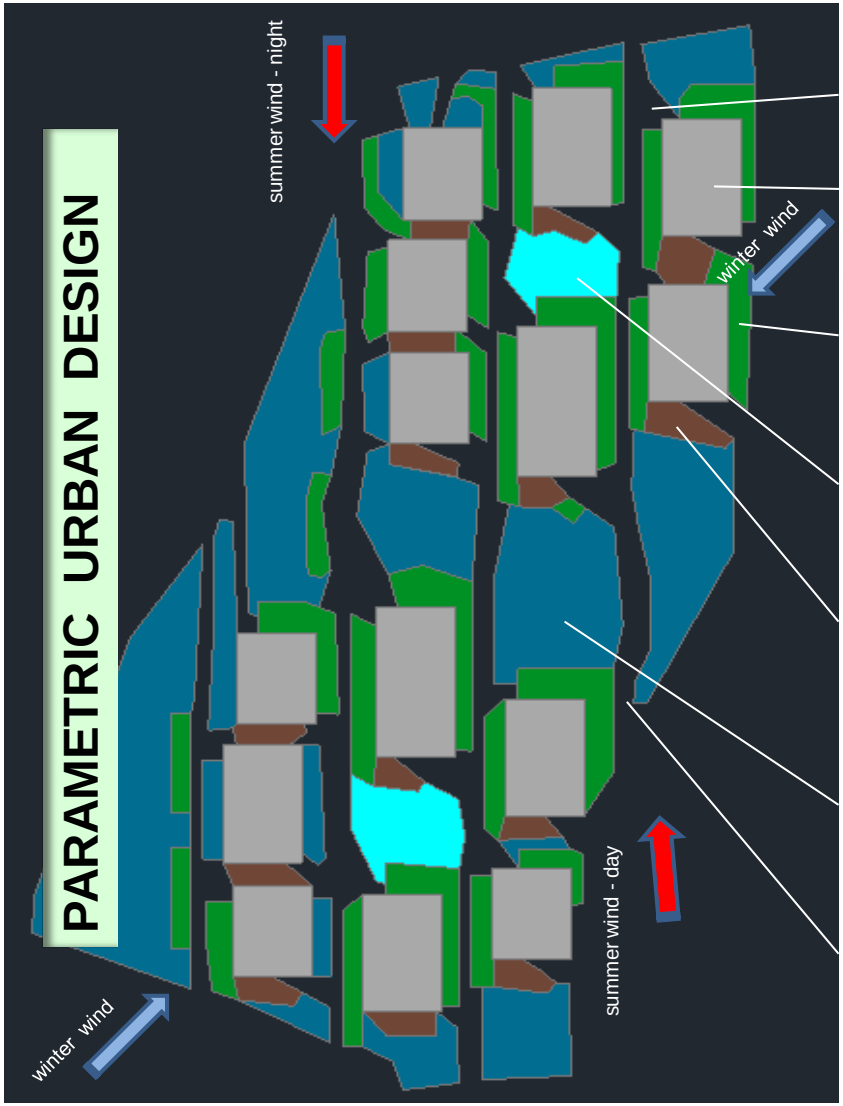
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Climate-KIC

BGD project 1: University Campus - Zagreb



Wind corridor for the building free cooling - summer night

Clusters orientation – south /north to maximize passive heating and sun energy harvesting by PV and Solar collectors

Winter wind barrier - evergreen threes
-existing - *Picea abies*, *Taxus baccata*, *Pinus* sp., *Pseudotsuga* sp.
-new - Pinus nigra, Thuja columnaris,
-Juniperus communis „Hibernica“



Semi open space - for social activities central zone threes - high treetop(3-4m)
- *Celtis Australis, Rhustiphina, Betula verrucosa*

Passive heating - threes that loose leafs first week in October
- *Acer platanoides*, *Alnus glutinosa,*



Urban adiabatic cooling – particular selectio of deciduous threes with high leaf surface area
- existing - *Carpinus Betulus, Catalpa bignonioides*, Acer sp., *Juglans nigra*, *Platanus* sp
- new - Liqiudambar sp.



Wind corridor for the urban adiabatic cooling - summer day

EnPlus

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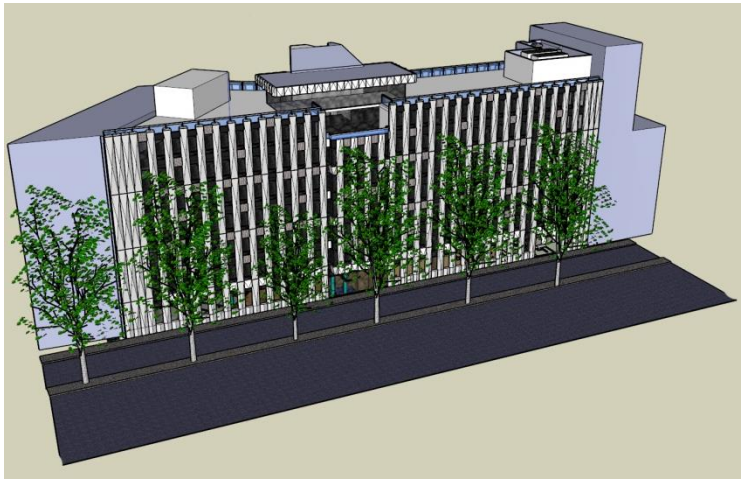
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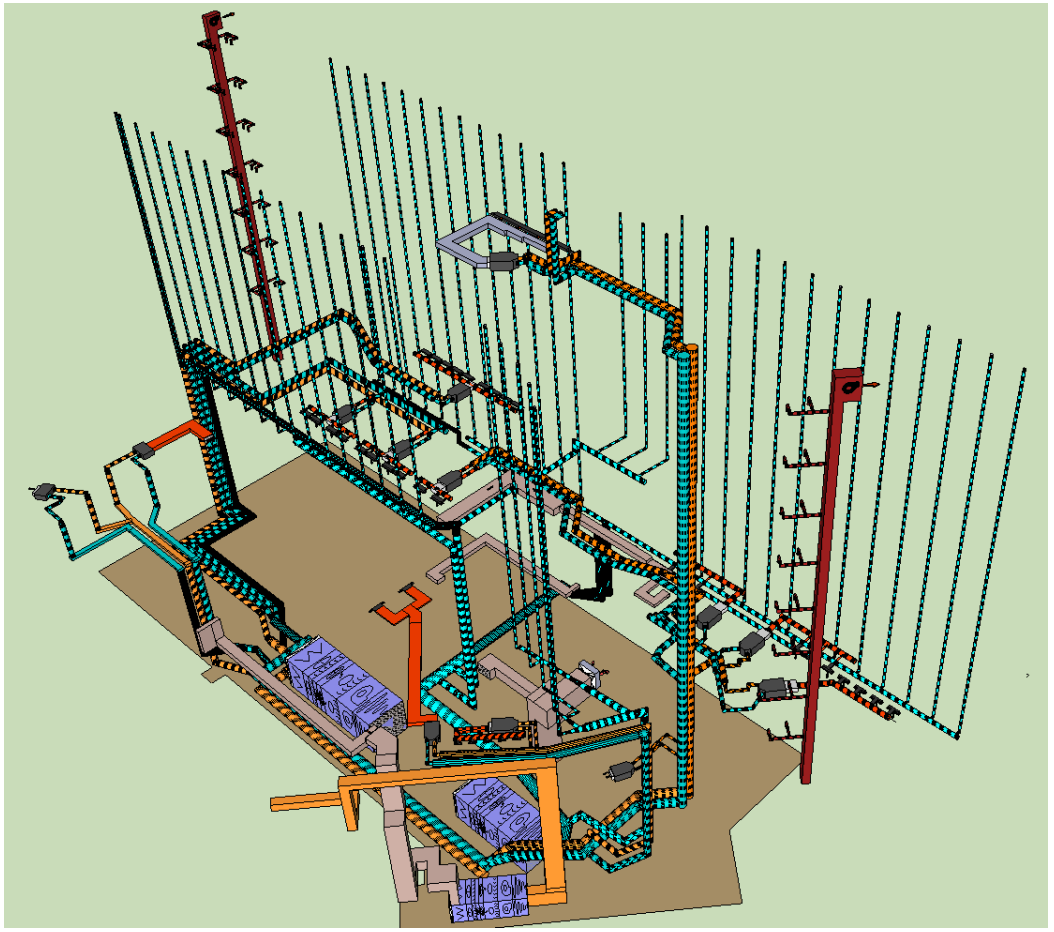
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BGD project 2: Holland Plain, Singapore



BGD project 3: World Bank, Paris





- Coefficient of energy consumption ($\mathbf{C_{ep}}$) [consumption of heating, cooling, hot water and lighting]:
- Original C_{ep}= 154.0 kWh/m^2
- New C_{ep}= 88.0 kWh/m^2
- Improvement in energy consumption = **42.9%**

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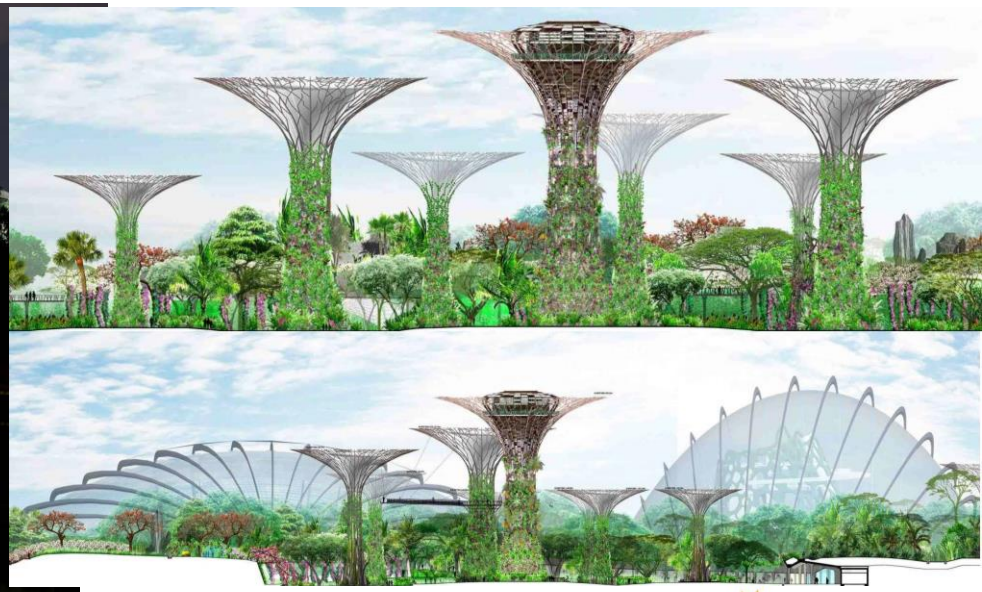
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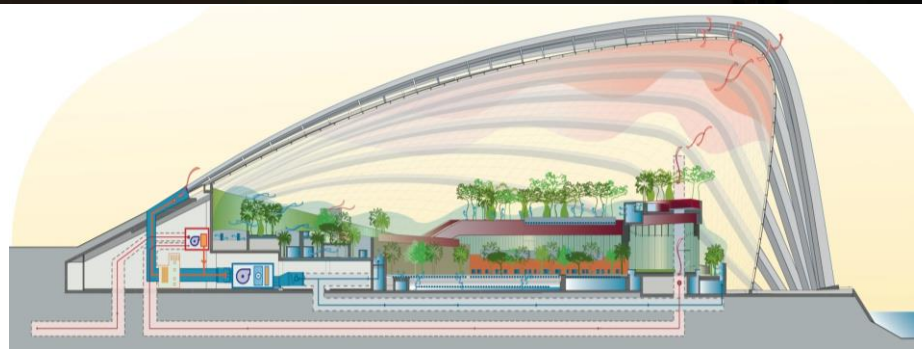
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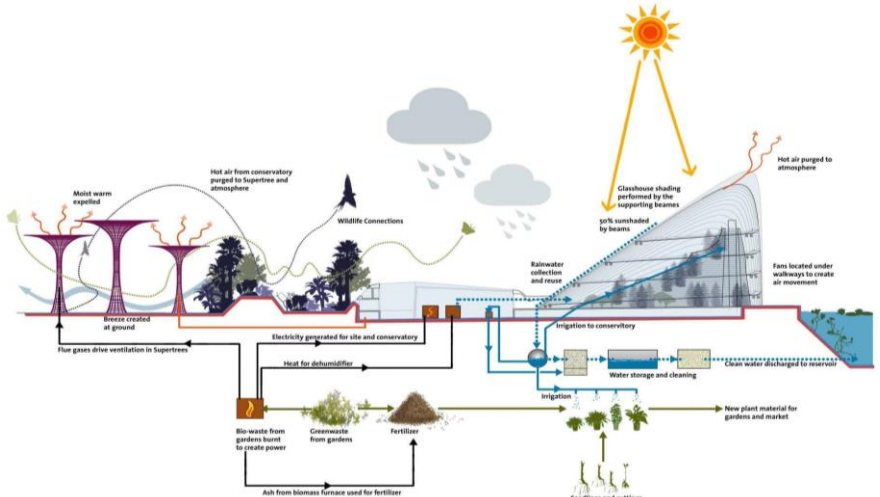
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BGD affiliate project; Gardens by the Bay, Singapore







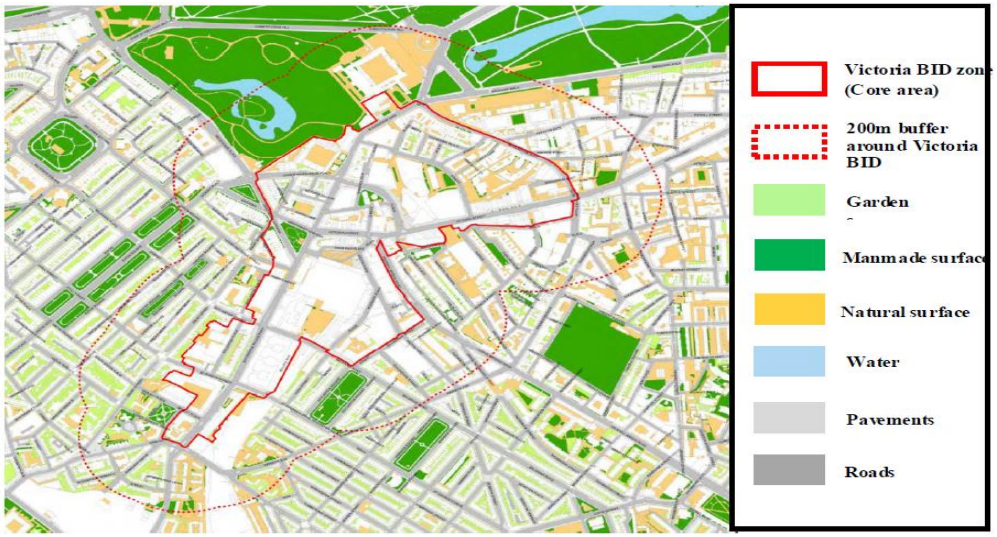


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Courtesy of Grant Associates

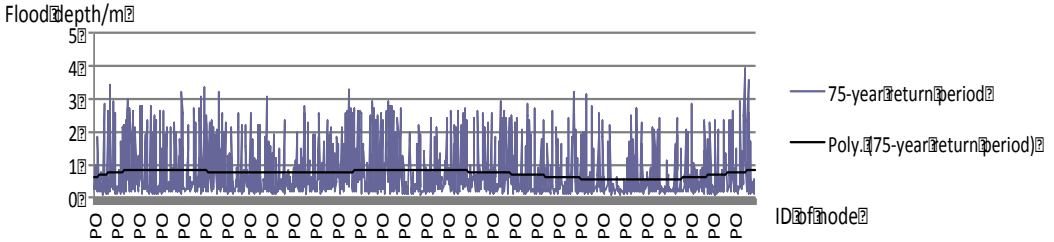
BGD Projects in London: Cheapside and Victoria BID

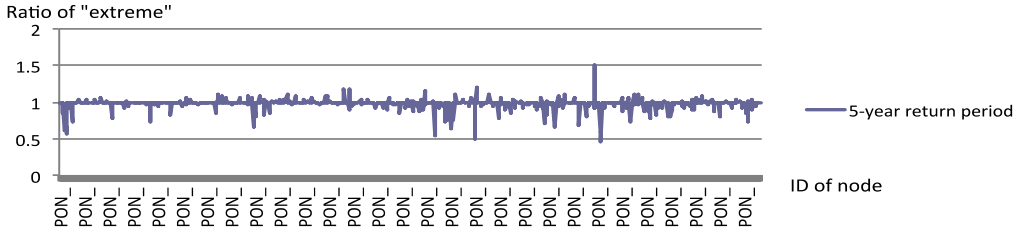




Planned

Imperial West and ICL Kensington
Elephant and Castle
Earl's court
Royal Oak
Knight Frank





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BGD affiliate project (PTE Architects): Marlow Road London



Model with proposed trees layout

Total solar radiation on facade during June, July & August:

83.1 kWh/m^2 **(solar load reduction 38.0% + transmission reduction 16%)**

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BGD affiliate project (Wilder Associates)
King Edward Memorial Hospital, Bermuda



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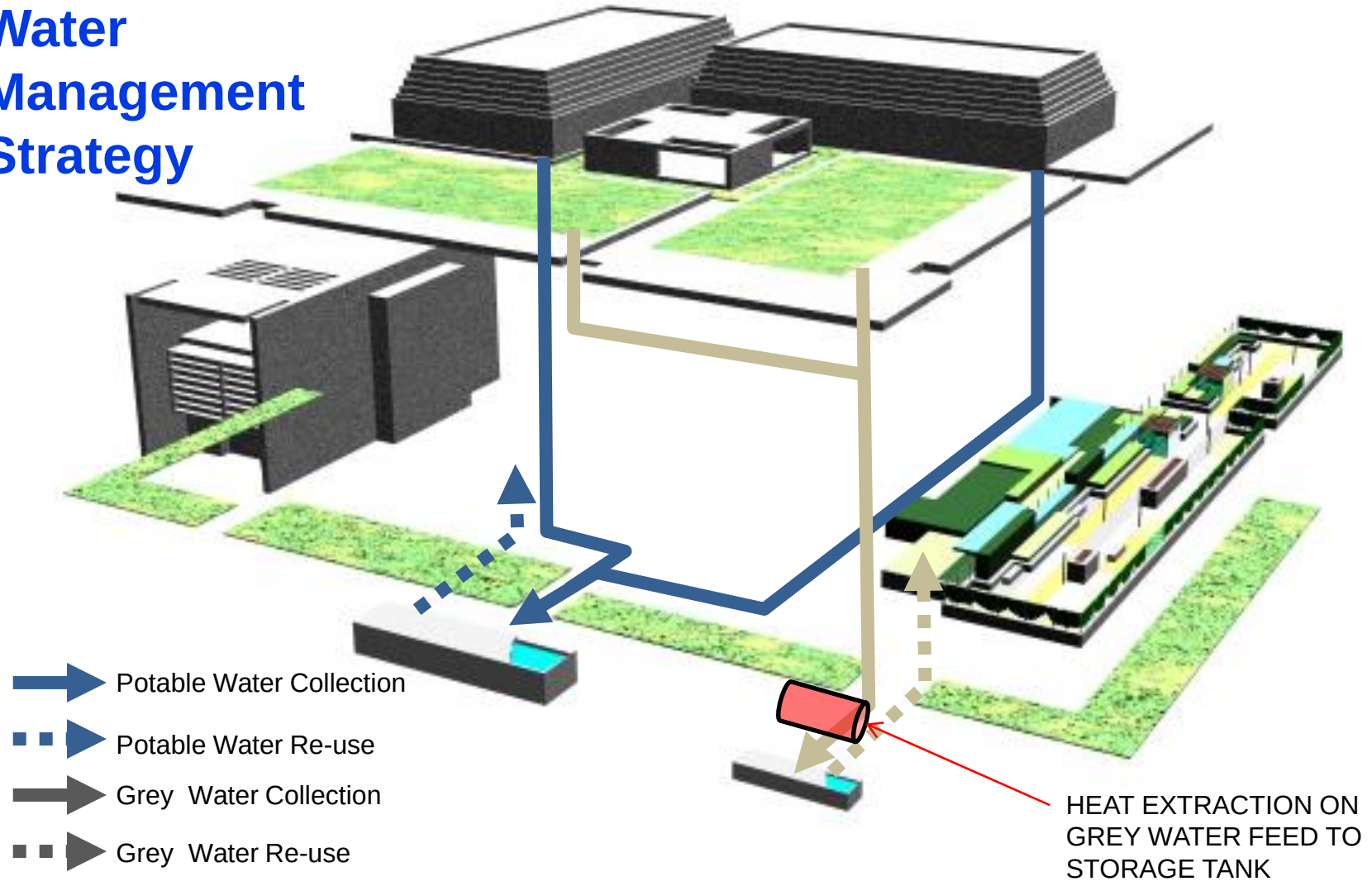
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Water Management Strategy



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IMAGE : WILDER ASSOCIATES

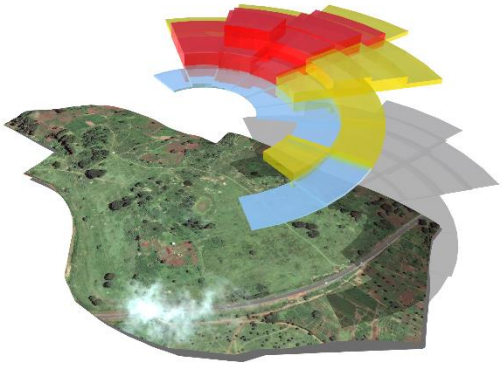
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BGD affiliate project (PTE Architects): Limuru Development, Kenya



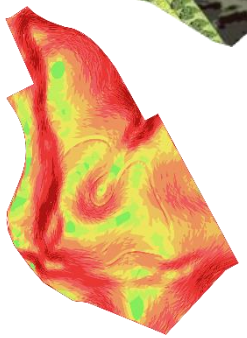


Prevailing Wind

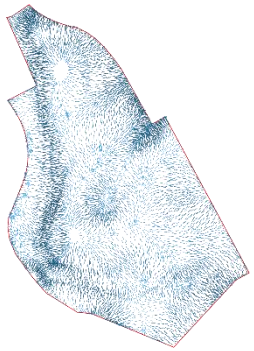
Wind



Vegetation



Topography



Hydrology

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BGD affiliate project (Wilder Associates)
Sustainable Surburbia



IMAGE : WILDER ASSOCIATES

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BGD affiliate project (Biodiversity by Design) Multi-habitat - Biodiverse SUDS

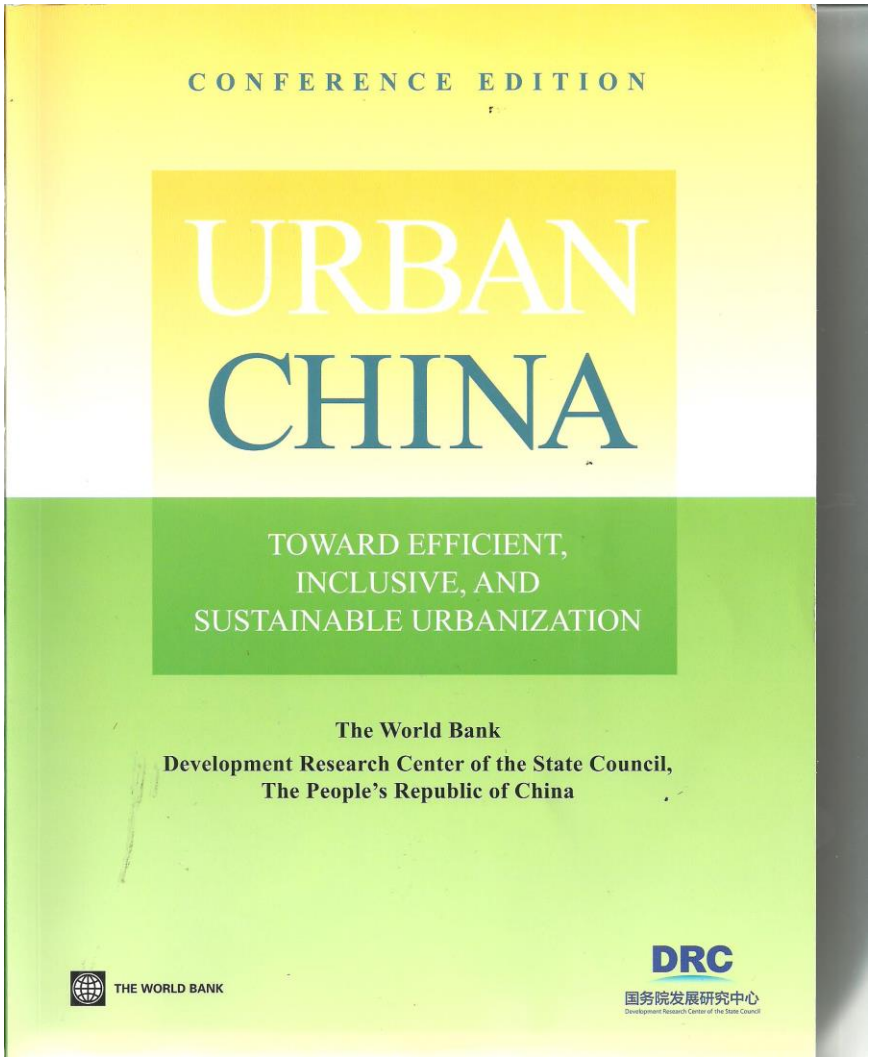
Athletes Village, Olympic Park, London

- Based completely on native wetland species, without reeds or other dominant grasses.





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South Kensington (London),1851 Estate – Proposed BGD hub



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The World Class BGD site: Is it really just a dream?



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ICL - Current & Prospective collaborators

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INTERNATIONAL COMPETITION FOR AN URBAN PLANNING AND PRELIMINARY ARCHITECTURAL DESIGN OF TOURIST CENTRE ON THE KLEKOVAČA MOUNTAIN IN THE REPUBLIC OF SRPSKA, BOSNIA AND HERZEGOVINA

KLEKOVAČA COMPETITION 2014

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Eurbanlab

Accelerating urban innovations

UNIVERSITY of GREENWICH

UEL University of East London

United Nations University
13th floor
World Trade Center
Dresden 01067
Germany

Consultant Contract

Agreement between the Consultant and the Sub-Consultant.

THIS AGREEMENT is made 24th day of June 2013

BETWEEN

1. Grant Partnership Limited trading as Grant Associates whose registered office is situated at 22 Milk Street Bath, BA1 1UT England ("The Consultant");

2. Professor Cedo Maksimovic, CUW-UK whose registered office is situated at 44 Hanover Steps, LONDON, W2 2YG ("The Sub-Consultant");

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Why adopt the BGD philosophy?

eit Knowledge & Innovation Community Climate-KIC

Maximise:

- **efficient use of resources (cost savings)**
- **human health benefits**
- **climate change resilience**

Create an urban environment that blends the best of 21st century living with the comforts of the countryside



The Imperial College Green Roof

Blue Green Dream

Imperial College London

eit Knowledge & Innovation Community Climate-KIC

Contact details

Prof. Čedo Maksimović c.maksimovic@imperial.ac.uk

http://www3.imperial.ac.uk/people/c.maksimovic

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

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

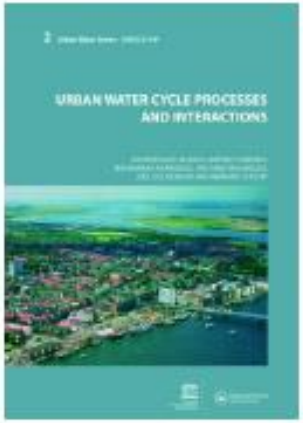
Blue Green Dream project http://www.bgd.org.uk

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









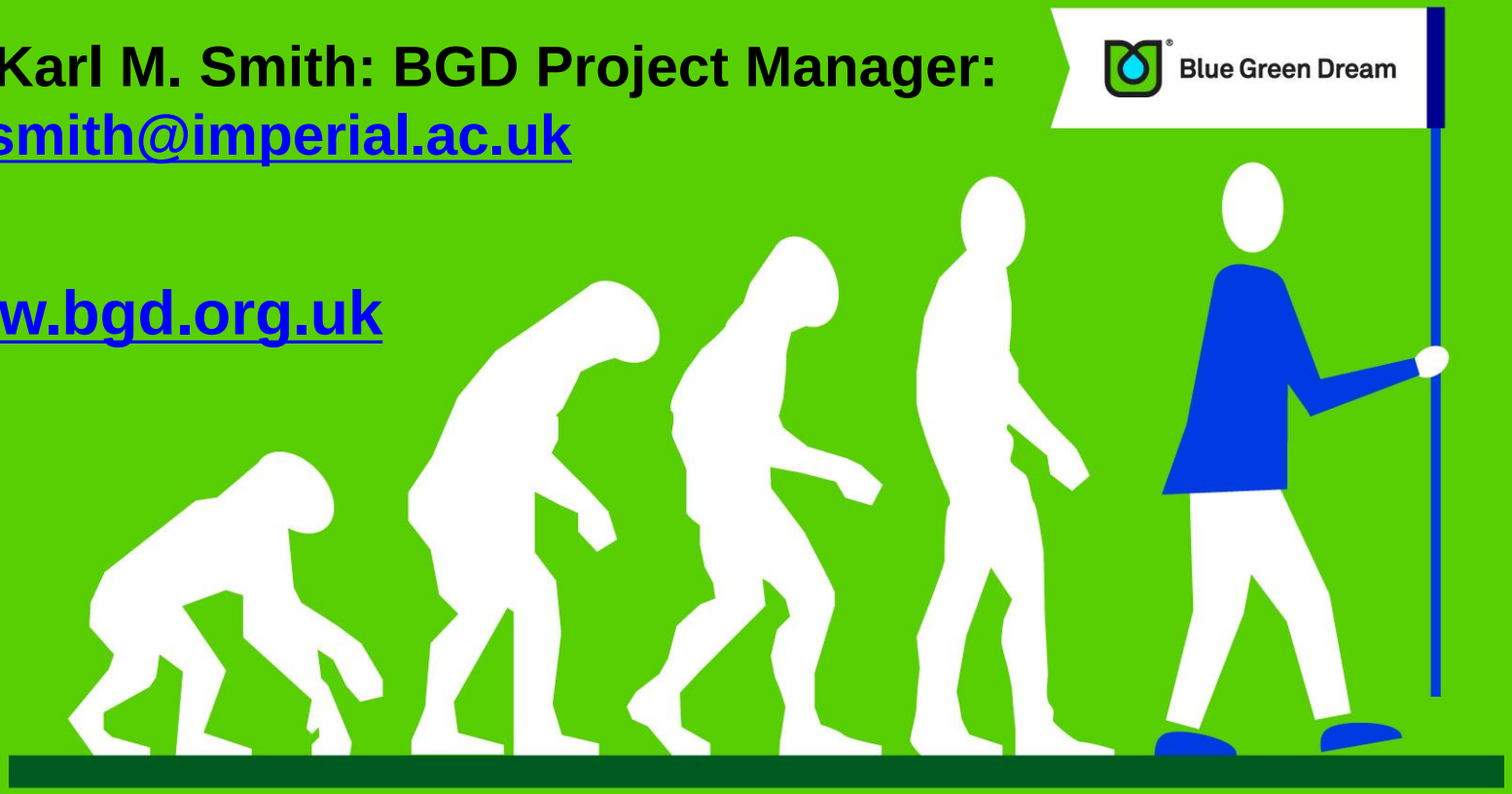
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Contact details

Prof. Cedo Maksimovic – BGD Principal Investigator:
c.maksimovic@imperial.ac.uk

Dr. Karl M. Smith: BGD Project Manager:
kmsmith@imperial.ac.uk

www.bgd.org.uk



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