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

The Blue Green Dream Interactions

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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
Some issues tackled by Blue Greening

Flooding

Water pollution

Droughts

Air pollution

Heat island

Healthy cities

Urban agriculture

Noise

Crime

Water companies with hosepipe bans, spring 2012

Pasto Montenegro
day noise level after reconstruction

Noise levels dB(A)

- < 40.0
- 40.0 <= < 42.0
- 42.0 <= < 44.0
- 44.0 <= < 46.0
- 46.0 <= < 48.0
- 48.0 <= < 50.0
- 50.0 <= < 52.0
- 52.0 <= < 54.0
- 54.0 <= < 56.0
- 56.0 <= < 58.0
- 58.0 <= < 60.0

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The **Blue Green Dream Principle**

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

- **URBAN BLUE**
  - Wastewater reuse and recycling
  - Rain water harvesting and recycling
  - Storm water management as a new resource

- **URBAN GREEN**
  - Green Roofs
  - Green Parks, streets, squares, parking lots, etc.
  - Living Walls Systems
  - Urban Agriculture
BGD: Maximising the benefits of vegetation

• Harnessing ecosystems services to enhance the urban environment
Scenarios and adaptation

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

Courtesy P. S. Mikkelsen, DTU
BGD Benefits:

**Stormwater/wastewater/solid waste recovery**
- Reduced transport costs
- Enhanced storage and infiltration
- Roof water harvesting and use
- Contaminated runoff
- Evaporation
- Condensation
- Stormwater/wastewater/solid waste recovery

**Flood & drought protection**
- Precipitation
- Roof water harvesting and use
- Contaminated runoff
- Evaporation
- Condensation
- Urban stream

**Reduced pluvial flood risk**
- Enhanced storage and infiltration
- Roof water harvesting and use
- Contaminated runoff
- Evaporation
- Condensation
- Urban stream

**Lowered air pollution**
- Urban air pollution
- Evapotranspiration
- Water percolation

**Reduced noise pollution**
- Reduced noise pollution
- Urban air pollution

**Reduced Urban Heat Island Effect**
- Evapotranspiration
- Water percolation

**Improved amenity & human health**
- Urban agriculture

**Raised building energy efficiency**
- Green roof
- Evaporative cooling

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www.bgd.org.uk
Interactions of urban ecosystem services
Blue Green Dream
Activities and Services

Quantifying and modelling BG Solution Benefits

Development of New Computer Models and Planning Tools

Innovative Urban Planning Consultancy
Quantifying and modelling BG Solution Benefits
Measuring/Modelling

Green roof plant performance

• 4 plant species studied:
  • Salvia; Stachys; Heucheral Sedum
Measuring/Modelling

Green roof plant performance
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
Measuring/Modelling

Green roof plant performance

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
Measuring/Modelling

Green roof performance

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

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

Green roof performance; Hydro-meteorological Data

- Runoff (mm/hr)
  - Runoff_A [mm/hr]
  - Runoff_B [mm/hr]
  - Runoff_C [mm/hr]
  - Precipitation [mm]

- Soil Moisture (%)
  - AS2 [%]
  - AS4 [%]
  - BS2 [%]
  - BS4 [%]
  - CS2 [%]
  - CS4 [%]

- Rainfall (mm/hr)

June 2014 Aug Oct Dec
Measuring/Quantifying

Blue Green Wave

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

Figure 40: Temporal evolution of N(D)
Measuring/Modelling

Creteil Urban Lake

Urban Lake Monitoring: preserving lake ecosystems for sustainable cities

Case Lake Créteil
Measuring/Modelling

Creteil Urban Lake
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
Measuring/Modelling

Creteil Urban Lake

Centralized Water Air Conditioning

Electricity costs are 1/10 that of conventional A/C systems significantly reducing operating costs while saving our planet.

INSTRUMENTATION
Meteorological Station
Sensor Chains
Velocity Profilers

STUDY SITE
Lake Crétteil

SCENARIOS
Floating Buildings
Air-Conditioning (DWSC)*
Heat Inter-seasonal Storage
Climate Change

DATA BASE
Meteorological Variables
Currents
Water Temperature
Chlorophyll a Concentration

MODELS
Hydrodynamic 3D Model: Delft3D-FLOW
Water Quality Model : DELWAQ

FORECAST
Scenario impacts on lake behavior
Emergency action plans

DECISION

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Blue Green Dream
Activities and Services

Quantifying and modelling BG
Solution Benefits

Development of new Tools and Services
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
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
Compartamentalised Planning

- Main walkway not protected in summer (heat island)
- Walkway position?
- Remediation for traffic emissions not in place
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
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.
Urban adiabatic cooling – particular selection of deciduous threes with high leaf surface area
- existing - Carpinus Betulus, Catalpa bignonioides, Acer sp., Juglans nigra, Platanus sp
- new - Liquidambar sp.

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 selection of deciduous threes with high leaf surface area
- existing - Carpinus Betulus, Catalpa bignonioides, Acer sp., Juglans nigra, Platanus sp
- new - Liquidambar sp.

Wind corridor for the urban adiabatic cooling - summer day

Wind corridor for the building free cooling - summer night

PARAMETRIC URBAN DESIGN
BGD project 2: Holland Plain, Singapore

- Trees as barriers
- This building is a barrier to winds penetration
- This building corner is a barrier to winds penetration
- These trees are missing to provide shade and free cooling
- Required trees lineup for free cooling
- These trees are not shading pedestrians
- These trees are shading pedestrians
BGD project 3: World Bank, Paris

• Coefficient of energy consumption \( C_{ep} \) [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 = \textbf{42.9\%}
Planned
Imperial West and ICL Kensington
Elephant and Castle
Earl’s court
Royal Oak
Knight Frank

Flood depth/m

- 75-year return period
- Poly. (75-year return period)

Ratio of "extreme"

- 5-year return period

ID of node
Model with proposed trees layout

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

83.1 kWh/m² (solar load reduction 38.0% + transmission reduction 16%)
BGD affiliate project (Wilder Associates)
King Edward Memorial Hospital, Bermuda
BGD affiliate project (Wilder Associates)
King Edward Memorial Hospital, Bermuda

Water Management Strategy

- Potable Water Collection
- Potable Water Re-use
- Grey Water Collection
- Grey Water Re-use

HEAT EXTRACTION ON GREY WATER FEED TO STORAGE TANK

IMAGE: WILDER ASSOCIATES
BGD affiliate project (Wilder Associates)
Sustainable Surburbia

SUDS APPROACH
1. Green roof as primary filtration system
2. Collection channel to catch pit & silt trap
3. Petrol and Oil Interceptor
4. Rainwater harvesting tank
5. Oversized pipe attenuation system
6. Discharge headwall to attenuation pond
7. Attenuation and biotreatment lagoon
A. Main distributor roads
B. Residential roads or Honeszones
C. Traffic island and pedestrian crossovers
D. Play zones within wildlife and SUDS corridor
E. Recycling and composting centre
F. Communal gardens and allotments

IMAGE: WILDER ASSOCIATES
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.
South Kensington (London), 1851 Estate – Proposed BGD hub
The World Class BGD site: Is it really just a dream?
Agreement between the Consultant and the Sub-Consultant.

THIS AGREEMENT is made the 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");
Why adopt the BGD philosophy?

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

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