CLIMATE RESPONSIVE AND WATER SENSITIVE DESIGN: BLUE-GREEN SOLUTIONS FOR RESILIENT CITIES

HENDRIK PORST
PARTNER, RAMBOLL STUDIO DREISEITL, DESIGN DIRECTOR

DLA 2017
One of the most liveable city in the world

COPENHAGEN

Three time winner of the “Quality of Life Survey”

Awarded by Monocle Magazine

A renowned world’s most liveable cities index
What makes Copenhagen liveable?
Our Infrastructures today form all Cityscapes, the Waterscapes and Landscapes
Our Infrastructures today form all Cityscapes, the Waterscapes and Landscapes. Their Influence on Environment, Climate, Lifequality... is dramatic!
Water in the urban fabric

No Time No Space... ... for Rain Water
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Urbanisation ....

Blue, Green and landscape is in danger to be eliminated
water in the urban fabric

... where do we have the space?
The Copenhagen Example

2nd July 2011
The Copenhagen Example
Data from City of Copenhagen 2012

- 2nd of July, 2011 >150 mm in 2 hours
- 1000-year rain event
- 1,000,000,000 € damage
- damage to critical infrastructure (Tivoli, Hospitals)
- Extreme precipitation is already at +30%
- “Making the city resilient is good sound business”
  - Ayfer Baykal, Technical Mayor of Copenhagen
In pictures: Beijing's deadly deluge

Beijing has been hit by its worst rainfall in 60 years.
The Beijing Example
Data from BBC July 2012

• 22\textsuperscript{nd} of July, 2012
• >150 mm to 460 mm in a few hours
• 60-year event
• 1,000,000,000 € damage
• at the same time China approaching water scarcity
But we often turned the cities backside to the water
Water in Urbanization is a challenge
WEATHER-RELATED DISASTERS AND LOSSES

As this graph shows, weather-related losses are growing faster than premiums.

CLIMATE CHANGE

The watercycle is falling out of Balance

Too Wet!  Too Dry!
Biodiversity loss

Extinctions in Singapore | Projected extinctions in Southeast Asia

Singapore in 1819

Singapore in 1990

Percentage of species extinct

TRENDS in Ecology & Evolution
Climate Change and its Consequences
Overheating, dust & air pollution

The Heat Island Effect, air pollution, and fine Dust affect the human Health
The way we manage water in our cities influences almost every aspect of our urban environment and quality of life.
Water is everywhere
It is shaping our Landscape
Water in Forests

Water in Cities

infiltration

evaporation

runoff

infiltration

evaporation

runoff
How to bring Blue-Green Infrastructure into the Urban Fabric
Multifunctional use of open spaces
Open spaces acting as blue-green infrastructure  Cloudburst Juli 2002
An additional 10% of green space in cities can mitigate urban heat island by up to 4 °C (Gill et al, 2007)
Water Sensitive Urban Design

INTEGRATION OF STORMWATER MANAGEMENT

STATUS:
END OF PIPE SOLUTION
DISCARDING OF WATER

GOAL:
INTEGRATIVE SOLUTION
WATER AS A VALUED RESOURCE
REPAIRING THE URBAN WATERBALANCE

Integration of Stormwater Management

OLD Paradigm

urban form and infrastructure impose themselves on the landscape
outcome: loss of biodiversity, higher flood risk, poor water quality and waste of energy

NEW paradigm

ecological landscape
responsive urbanism
sustainable infrastructure
A strong vision is the engine for change

**COMPONENTS OF BLUE-GREEN INFRASTRUCTURE**

- **STRONG VISION AND INNOVATION**: Overcome silo mentality
- **CULTURAL CAPACITY**: Employ pilot projects as learning tools
- **SKILLS AND KNOWLEDGE**: Mobilise people, citizens, and capital for projects
- **FINANCING**: Look for windows of opportunity to initiate BGI
- **STRUCTURAL CAPACITY**: Take care of O&M
- **OPPORTUNITIES**: Basic Conditions

**RING**

**BLUE-GREEN INFRASTRUCTURES**
CASE STUDY

Livable and resilient cities through climate adaptation!
01
CLIMATE ADAPTATION MASTERPLAN
BEFORE: Extensive Flooding
02 July 2011: > 150mm RAIN fell in 2 HOURS.
Map of how and where high tides of 226cm over sea level will flood Inner Copenhagen – a high tide which could statistically come every 20 years in 2110.
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Analysis-Based Solutions
Potential Cloudburst Corridors
Main Traffic and Commercial Arteries
Potential Blue-Green Corridors
Street Tram
Metro
Planned Metro
Planned Light Rail

Detailed Analysis shows the complexity involved in determining areas most at risk to flooding and potential catalyst sites that can serve as test project areas

Common Vision
Cloudburst roads are used to channel and direct cloudburst water. These streets can be formed with a unique V-shaped profile and raised kerbs to ensure water will flow in the middle of the road, away from the buildings - contrary to standard engineering practice. Channels and swales can be established along road edges so that water runs in urban rivers or green strips. Cloudburst roads may also be combined with Cloudburst piping below the surface to create tool synergies.

Detention streets are streets that are typically located slightly upstream of vulnerable low-points. In these streets there should be a detention volume established to handle stormwater before reaching the more vulnerable points downstream.

Central retention areas are proposed in the squares and parks where it is possible to delay stormwater, so that Cloudburst roads can be established in smaller dimensions. The central retention elements can be, for example, open depressions in the parkland or lowered seating areas. Alternatively, they can be established as underground storage such as soak-away crates or rain gardens. Central retention elements will typically be placed in connection with adjacent Cloudburst roads.

A Cloudburst pipe handles rainwater in the same way as Cloudburst roads. This is placed just below street level to ensure connection to other surface solutions. This solution is used if there is no useable space for aboveground solutions.

Evaluating Development Options
The Copenhagen Formula adapts to interdisciplinary approaches - away from siloist, isolated thinking. A common vision aligned engineers, hydraulic experts, GIS, information technologists, architects and planners, biologists, economists, communication specialists, and landscape architects with the local municipality.
Selective Intervention

Bispebjergparken
A special urban place with a robust character, an interesting spatiality and many possibilities for activities. The place can function as a blue park and be a facilitator for day and evening events. Underground parties.

Holger Danskes Vej
Local residents' environment, a possible wide green road. The green road and courtyards can create a special place in the city.

Dronning Olga's Vej
Residential neighborhood and local road with an established green character. The rainwater solution can create a gathering point and accentuate the existing exclusiveness.

Bülowsgade
Minor traffic road. A general green character can be further supported by retention basins.

Sankt Knuds Vej
Neighbourhood with green local roads. LSH can support the green character and ensure traffic safety.

Frederiksberg Allé
Significant for Denmark's history and important cultural heritage. Special pavements and planning. The water projects have to support the majestic character.

Mathausgade
The heart of Vesterbro. A strong community and active participation in the public life. Water can support the local character and create new outdoor spaces with room for play and gatherings.

Enghavevej
Area with city life such as concert, cafés and shopping. Water on terrain can create more new micro spaces and meeting places.

Sønder Boulevard
New park and main street with character. Water can support this character and create interesting blue and green areas in the existing structure.
Tool: Green Streets
Existing Street Majorly Flooded in 2011

Dry, Normal

Rain Event

Cloudburst

Conventional: Existing Crowned Street

Proposed V-Profile Street

Tool: V-Shaped Canal
Driving Investment

Blue-Green infrastructure helped to lower capital, operational, and maintenance spaces by as much as 75% (American Rivers 2012) while Danish Consultants calculated that $200 million investment cost could be saved by combining Blue-Green with minimized conventional piping.

Rain Event Handled within Multi-Functional Tools including Urban Creek, Retention Boulevard, and Boulevard

Dry, Normal

Cloudburst
Applying the Copenhagen Formula
Multi-functional edges with accessible waterfronts, creating habitat zones paired with beach and recreational program while retaining and improving existing urban structure. Even during rare Cloudbursts, the lake provides flood storage and protects surrounding areas from flooding.

Existing Lake Edge

SANKT JØRGENS SØ
Dry

Safety Zone
Flood Zone

40,000m³ retention capacity

Flood Outflow

Safety Zone
Flood Zone

7,000m³ retention capacity

Flood Event
Residents in green neighborhoods are three times more likely to be physically active when compared to non-green neighborhoods (Forestry Commission).

Green areas increase adjacent real estate value between 10-15%, or $10 for every 100 square feet within walkable proximity (Trust for Public Land, 2009).

Cloudburst solution to combine Blue-Green solutions with a reduced pipe size both saves money and creates a multi-functional solution, establishing benefit synergies.

A New ‘Old’ Destination
The lake becomes a multi-functional park space with recreation, fitness, and heritage amenities that capitalize space use, simultaneously mitigate Cloudbursts and normal rain events, and beckons residents and guests to engage with the active waterfront edge.
COPENHAGEN
Hans Tavsens Park
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The park basins will be able to hold 18,000 cubic metres of water.
02

URBAN PARKS AND WATERBODIES
200 km² Central Watershed

- 15 reservoirs
- 32 major rivers
- 7,000+km of waterways
Before
Singapore
Before
Singapore
KALLANG RIVER Amk-Bishan Park

Kallang River 2008

SEPARATION BETWEEN CANAL AND PARK
KALLANG RIVER Amk-Bishan Park

INTEGRATION BETWEEN RIVER AND PARK
This means:
Overlapping of Territories River – Park
Overlapping of Responsibilities PUB - NP
Overlapping of Maintenance and Service PUB - NP
Recycling of the old concrete canal
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25 year flood - test run
Bishan - Ang Mo Kio Park, Singapore
Cleansing biotope
Bishan - Ang Mo Kio Park, Singapore
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Bishan - Ang Mo Kio Park, Singapore
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BISHAN – ANG MO KIO PARK
Reconnect people with the waterways!

Ecological Benefit
(Quelle Luftbild: http://www.bing.com/maps/)
BISHAN – ANG MO KIO PARK
Reconnect people with the waterways!
THANK YOU