City and water in local balance
– Experience from Beijing and Copenhagen

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Urbanization – water stress

Figure 1 – Unbalanced urban water cycle

(Liu & Jensen, 2014)
Groundwater level - Beijing

In 1960s, 3m in depth

In 2000～2009, declined 12m (1.2m per year)

In 2009, 24m in depth

Limit depth 35 m

Bedrock

Ground surface

(Based on Meng, Q.Y., 2014)
Flooding (water logging)
City & water in local balance (CWLB)

Close the urban water cycle locally – reduce the impact on the environment

Resilience – pluvial flooding avoided by controlled retention

Pure water – quality of water discharged comparable to that of the incoming water

Strong green infrastructure – linked with urban water management, providing multiple ecosystem services

Figure 2 – City and water in local balance

(Liu & Jensen, 2014)
Conventional approach: Make the sewers larger

New approach: Remove stormwater from sewers

Sewerbased adaptation (hard & grey infrastructure)

Landscape based adaptation (soft & green infrastructure)

(Jensen, 2014)
Synergy – how to make more of the investment

(Jensen, 2014)
Method and cases

The distance to CWLB =

Transferred water from beyond city limit + over exploitation of groundwater within city limit

Total water supply

<table>
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<tbody>
<tr>
<td>Area (km²)</td>
<td>16,410</td>
<td>89.6</td>
</tr>
<tr>
<td>Population (persons)</td>
<td>19,720,000</td>
<td>501,664</td>
</tr>
<tr>
<td>Population density (persons/km²)</td>
<td>1202</td>
<td>5599</td>
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Major water flows

Figure 4 – Beijing 2009. Unit: $10^9$ m$^3$ (adapted from Liu et al., 2014)

- Limited available local natural water resource, most precipitation lost by evapotranspiration
- Groundwater abstraction exceeds infiltration
- Some water reuse
- Severe discharge of untreated wastewater

Figure 5 – Copenhagen 2003. Unit: $10^6$ m$^3$ (adapted from Binning et al., 2006)

- Significant amount of stormwater running to sewers, heavy load for wastewater treatment plant
- All water transferred from outside city
- Insignificant water reuse
CWLB – the related factors

The related factors

• Availability of local natural water resources (precipitation and river water)

• Water reuse ability

• Population density

• Water use efficiency (average water consumption per capita)

Figure 3 – Sustainable population density depends on water resources and reuse skills
Maximum population density & the distance to CWLB

Table 1 - Maximum population density that natural water resources can support

<table>
<thead>
<tr>
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<th>Beijing2009</th>
<th>Copenhagen2003</th>
<th>Beijing Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available local natural water resources*</td>
<td>2.03 (billion)</td>
<td>41.9 (million)</td>
<td>2.03 (billion)</td>
</tr>
<tr>
<td>Water consumption (m³/person/year)</td>
<td>180</td>
<td>65.4</td>
<td>100**</td>
</tr>
<tr>
<td>Support population (million)</td>
<td>11.3</td>
<td>0.641</td>
<td>20.3</td>
</tr>
<tr>
<td>City area (km²)</td>
<td>16410</td>
<td>89.6</td>
<td>16410</td>
</tr>
<tr>
<td>Support population density (persons/km²)</td>
<td>687</td>
<td>7150</td>
<td>1237</td>
</tr>
</tbody>
</table>

Actual population density (persons/km²) 1202 5599

* Assumption: Available local water resource is formed by precipitation in case area deducting evapotranspiration.
** Average water consumption in European countries in the 1990s.

The distance to city & water in local balance

The distance to CWLB =
Transferred water from beyond city limit + over exploitation of groundwater within city limit
Total water supply

Figure 6 – The distance to CWLB, Beijing & Copenhagen
Discussion

• The size of a city

• People’s behavior, technology and energy issue

• Data and scales of the two cities in comparison

• City form issues
Prospect

To what extend green infrastructure can contribute to city and water in balance?

How can we as urban planners and landscape architects facilitate the transformation of a city from unbalanced urban water cycle to city and water in local balance?

• Close the urban water cycle locally
• Resilience
• Pure water
• Strong green infrastructure

Unbalanced urban water cycle

City and water in local balance
Distance water transfer & unconventional water resource

(Zhang, X.X., 2014)
Increase Water Resource

- Preserve 2 existing Wastewater reclaimed plant
- Update 8 existing WWTP
- Set up 5 Wastewater reclaimed plant

(Zhang, X.X., 2014)
The Strategic layout of unban flood control and drainage

Storage in western unban area

Western deep tunnel stores and discharges water to Yongding river

Drainage in eastern unban area

Eastern deep tunnel stores water for landscape use

“西蓄、东排、南北分洪”

(Meng, Q.Y., 2014)
Plan for "water smart use city"
Gravel Pit, Beijing – infiltration & retention basin
Copenhagen

- All drinking water are groundwater from surrounding regions
- Need simple treatment
- Groundwater table in some places decreased up to 10 m
- Only 2% water reuse (second water) in 2011, and planned to be 4% in 2017
- Climate change brings further falling of groundwater table in the in-land regions
Climate Adaptation Plan 2011–30% more precipitation

**Methods:**

1. Larger sewers, underground basins and pumping stations;

2. Manage rainwater locally instead of guiding it into the sewers;

3. Flooding takes place only where it does least damage – a “plan b”.
Copenhagen Cloudburst Plan 2012

**Methods:**

1. Service level 10 years retain period; Retrofitting city to hold 10cm flood for 100 years rain.

2. Efficient storage capacity and water ways, e.g. open channels on streets, retention reservoirs in parks.

3. Inner city – large pipes underground draining water to ocean

4. For small rainfalls, keeping rainwater in the city for multifunctional uses

(Rambøll, 2014)
Implementation

- Cloudburst Implementation Plan - for the next 20 years.

- 300 projects in 7 catchment areas. Political decision - Spring 2015.

- Prioritize areas: with high flooding risk, with easy implementation, with ongoing construction & with synergetic effects.

- Stakeholders: The property owners, the utility companies & the city Administration, because 1/3 of the areas are in private common road areas. Budget to make partnership in 2015.
Thank you!

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