Towards the Nexus City

Closing the Water, Energy, and Food Loops in Cities for Synergistic Climate Action

Dr. Daphne Gondhalekar

Chair of Urban Water Systems Engineering, Technical University of Munich (TUM), Germany
TUM is a high-ranking university in Germany and worldwide with 40,000 students and 520 professors.

Chair of Urban Water Systems Engineering is headed by Prof. Jörg E. Drewes and has the research groups:

- Stormwater Management and Sewer Systems
- Engineered Natural Treatment Systems
- Anaerobic Technologies and Energy Recovery
- Advanced Water Treatment and Water Recycling
- Microbial Systems
- Analytical Research Group

Dr. Daphne Gondhalekar (TUM) | 19.7.17
Development challenges worldwide

Challenges include:

• Increasing resource consumption worldwide
• Urban population: 3.9 billion in 2014 → 6.4 billion in 2050
• Most urban growth in developing economies and in metropolitan regions

• Solutions need to be implemented by 2030 to prevent disastrous climate change impacts (IPCC, 2015) and fulfill the Paris Agreement.

• Integrated urban planning is needed, that can leverage on synergies between climate change mitigation and adaptation strategies and measures.
WEF Nexus approach: urban water reclamation and resource recovery as key opportunity

Urban water reclamation and reuse with resource recovery is a key opportunity to operationalize the WEF Nexus at city / neighbourhood scale

• Links the water, energy and food sectors directly.
• Much potential for synergies of climate change mitigation and adaptation.
• Water and energy conservation through more “closed loops”
• Greater adaptive capacity of cities due to more flexibility of systems, in view of climate change related water-uncertainty

Few operationalized examples of WEF Nexus approach exist at city or neighbourhood scales.

More WEF Nexus pilot projects are urgently needed to test and monitor the efficacy of WEF Nexus approach
Cities of the future: closing the resource loops

Applying WEF Nexus to cities:
- Energy requirements and carbon footprint
- Wastewater as a resource
- Integration of natural treatment processes
- Economical and ecological aspects

Drewes & Horstmeyer, Österr Wasser- und Abfallw (2016) 68:99-107 (Adapted from source)
Example: Hamburg Water Cycle

• Use of a brownfield site
• Ca. 2000 inhabitants
• Black and grey water collection is separated (vacuum toilets)
• Black water mixed with organic waste used to generate biogas
• Geo- and solarthermal energy
  Recycled water used for landscape irrigation
• **Synergies** of different infrastructure systems used

Sources
Since 2016: “The Study Line Water-Energy-Food NeXus is meant to enable the students of the Master Environmental Engineering to combine the different core issues as water - food - energy for their education.”

www.nexus.wasser.tum.de
Ladakh in the north of India is a semi-arid high-altitude region.

The capital Leh (ca. 60,000 population) is facing serious water-related challenges due to groundwater overextraction and groundwater pollution.

Project funding: European Commission and German Research Foundation.
• Around **500 hotels and guesthouses** have been built since early 1980’s.
• **Regular stakeholder meetings with local government** since 2012.
WEF Nexus project in Leh, India since 2012

Planned centralized system

Supply est. 135 lpcd
Needs 100 lpcd to flush
13 MLD at STP (in 2040)

Alternative option

Supply est. 70 lpcd
Renewable energy potential: solar and biogas
Reuse wastewater to green Leh
Keep manure close to agriculture
Aquifer recharge at water extraction
Lower construction and O&M costs
WEF Nexus project in India since 2012

March 2017: Visit in Leh, Ladakh with Bavarian Environment Minister
Climate change impacts in Munich, Germany

- Munich one of densest cities in Germany: **urban block type**.

- **Heat island effect**: especially young children and the elderly already face serious health risks.

<table>
<thead>
<tr>
<th>Climate variables</th>
<th>2050</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average temperature</td>
<td>+0.9 – +1.7°C</td>
<td>+2.3 – +3.6°C</td>
</tr>
<tr>
<td>Summer days (max. temp. &gt; 25°C)</td>
<td>+9 (+4 – +19)</td>
<td>+30 (+12 – +43)</td>
</tr>
<tr>
<td>Heat days (max. temp. &gt; 30°C)</td>
<td>+2 (+1 – +9)</td>
<td>+13 (+6 – +25)</td>
</tr>
<tr>
<td>Tropical nights</td>
<td>+1 (+0 – +5)</td>
<td>+5 (+1 – +16)</td>
</tr>
<tr>
<td>Average precipitation winter half-year</td>
<td>-1 – +11%</td>
<td>-2 – +21%</td>
</tr>
<tr>
<td>Average precipitation summer half-year</td>
<td>-7 – +5%</td>
<td>+3 – +17%</td>
</tr>
</tbody>
</table>

Climate change projections for Bavaria. Source: Bayerische Klimaanpassungsstrategie, StMUV, 2016

Dr. Daphne Gondhalekar (TUM) | 19.7.17
Implications for WEF Nexus

- Intensive greening can help to cool the micro-climate.

- Urban agriculture may supply significant amount of fruits and vegetables.

- Rainwater and reclaimed water could be used for urban agriculture irrigation or toilet flushing.

- Decentralized energy production potential may be significant.

Implementing such an alternative in Munich may difficult. But thinking about it is the first step to effect paradigm shift.

<table>
<thead>
<tr>
<th>Crop type</th>
<th>Area (ha)</th>
<th>Potential yield (t/ha)</th>
<th>Potential yield (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White cabbage</td>
<td>92</td>
<td>91.6</td>
<td>8,427</td>
</tr>
<tr>
<td>Fruit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apples</td>
<td>50</td>
<td>39.4</td>
<td>1,970</td>
</tr>
<tr>
<td>Grapes</td>
<td>26</td>
<td>11.4</td>
<td>296</td>
</tr>
</tbody>
</table>
Ongoing WEF Nexus project activities

**From 2017**: Feasibility pre-study for pilot project in Leh, funded by Bavarian Ministry of Environment and Consumer Protection (4 Master Theses on-going)

**March 2017**: 1st WEF Nexus Workshop in collaboration with Water Future Programme, Indo-German Centre for Sustainability at IIT Madras, Chennai (Master Thesis completed on Chennai, Study Project on-going)

**July 2017**: First meeting with City of Würzburg, Bavaria for potential pilot project (Study Project on-going)

**October 2017**: 2nd WEF Nexus Workshop in Delhi

**Aims**:  
- Involve city representatives, industry partners  
- Identify funding proposal options  
  (European Commission, German Government)
WEF Nexus pilot projects

Research questions:
• What is the **water and energy conservation** potential of the WEF Nexus at city or neighbourhood scale?
• How can such an approach enhance **food security** and contribute to implementing the **SDGs**?

Components may include:
• Urban **water reclamation** including rainwater harvesting
• **Reuse** for urban agriculture irrigation, toilet flushing, groundwater recharge etc.
• **Resource recovery**: bio-energy, organic fertilizer, etc.

The project aims to create a **revenue stream** enabling a community co-managed operation as **part of a novel governance model** with **participatory approach**.

**Pre-feasibility study for WEF Nexus pilot project in Chennai, Rajkot, Nagpur with GIZ under discussion**
Preliminary policy recommendation

To implement WEF Nexus effectively needs top-down as well as bottom-up, but local government support is the first crucial ingredient for innovation.

Thank you for your attention!