



Focus Area: Focus Area 3: Productive water in agriculture and the economy  
Session: 3B: Water-energy-food nexus

## **NEXUS CITY**

### **Water reclamation with resource recovery for net zero carbon urban development**

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Schedule: 9 August 2022 (Tue), 3:00 p.m. - 4:30 p.m. (GMT+08)

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# Water-Energy-Food (WEF) Nexus approach

**CHALLENGE:** Cities consume very high levels of natural resources such as water, energy and food. This drives climate change. Cities need to transition fast to net zero carbon. Key points of action need to be identified.

**OPPORTUNITY:** WEF Nexus approach (Hoff, 2011) as an integrated urban planning framework

- **WEF sectors inextricably interlinked** = potential to “close loops”
- **Water and energy conservation**
- Responsible **governance** key
- Support implementation of **SDGs**
- Rarely implemented at urban scales, e.g. Rajkot India, Vaxjö Sweden
- **WEF Nexus pilot projects urgently needed to generate evidence on Nexus operability**





# Nexus@TUM Lab: research and teaching

**Cities are complex systems with low capacities - Integrated urban Nexus planning needed tackle climate change effectively**

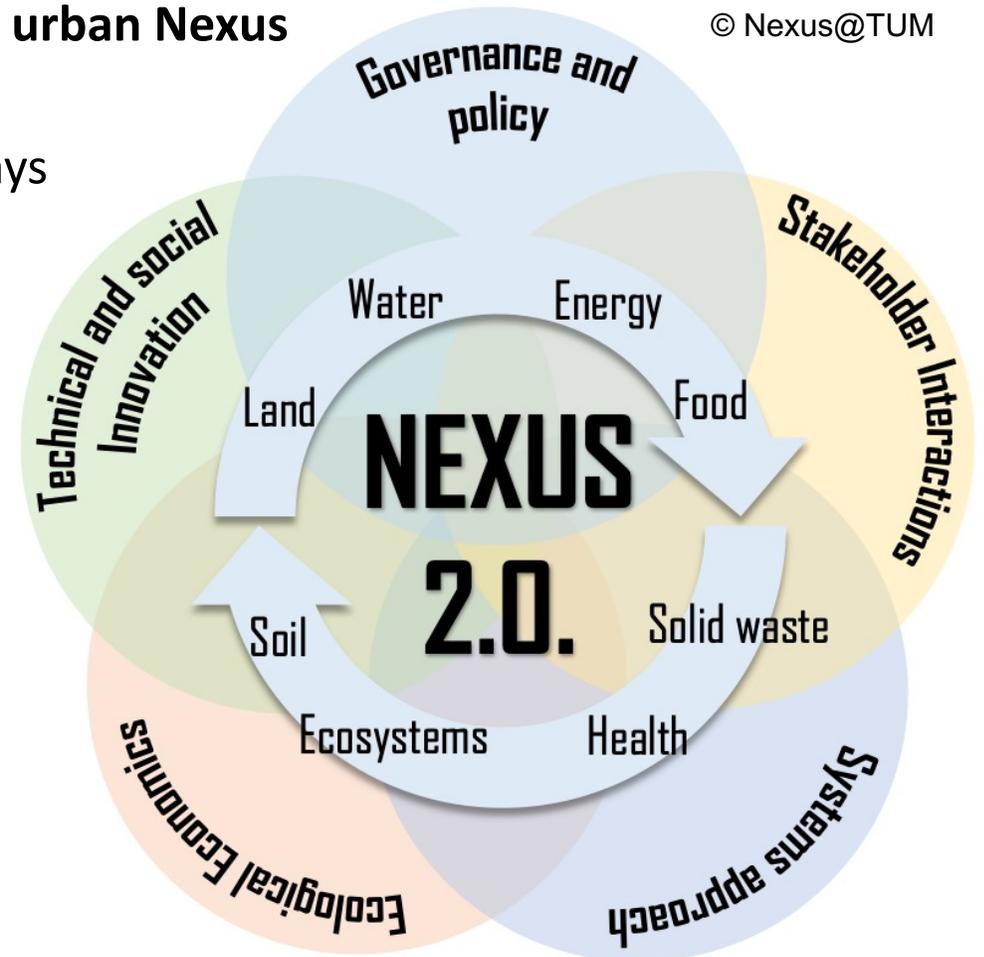
- **Research focus:** Develop alternative development pathways
- **Key cross-sectoral synergy potentials:** WEF + solid waste, mobility, ecosystem services, health
- Climate mitigation & adaptation synergies
- Interlink natural & social sciences
- Case study cities in India, Germany, Ghana, Niger
- **Identify key enablers and barriers to Nexus**

**25+ students working on master theses**

**Lecture** TUM master-level specialization, lecture: “Urban WEF Nexus”, master level, 6 ECTS. 130+ students

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# Water reclamation with resource recovery

## CHALLENGE

- **Centralized** sewerage systems common in cities worldwide
- Old and **expensive** to maintain, very water and energy intensive
- **Not resilient to climate change impacts** e.g. too little water, public health risk in case of malfunction

## KEY NEXUS OPPORTUNITY

- **Only 12% water reuse globally**
- **Huge untapped potential** to recover valuable resources
- **Market value** of recoverable resources now emerging
- **Decentralized** systems can enhance resource recovery
- Paradigm shift needed:  
we use drinking water to flush toilets - **No longer timely!**

Region	Country	Generated wastewater collected (%)	Collected wastewater treated (%)	Treated wastewater directly reused (%)	
Africa	Burkina Faso	4,9	2,9	2,7	
	Egypt	91,8	56,7	18,4	
	Morocco	-	23,7	10,0	
	Namibia	-	30,8	29,7	
	South Africa	78,2	54,2	45,5	
	Tunisia	84,0	78,8	23,7	
	Americas	Argentina	64,9	11,8	3,7
Brazil		52,3	30,1	0,1	
Mexico		91,7	46,0	11,1	
Nicaragua		59,0	36,6	0,4	
Peru		65,8	27,6	3,1	
United States		78,2	75,1	4,6	
Armenia		-	31,7	0,0	
China		64,2	101,7	8,0	
India		-	28,6	-	
Japan		71,0	68,3	1,2	
Asia	South Korea	-	84,0	2,0	
	Singapore	100,0	100,0	38,0	
	Vietnam	10,0	10,0	8,9	
	Australia	87,3	95,5	20,1	
	Oceania	Cyprus	95,8	95,8	91,7
		France	94,3	94,3	10,3
		Germany	98,6	98,0	0,8
Italy		-	99,4	1,2	
Netherlands		97,0	97,0	0,4	
Poland		96,4	62,6	0,1	
Portugal		93,6	46,8	0,5	
Europe	Spain	-	99,3	15,6	
	UK	99,0	99,0	4,0	
	Middle East	Bahrain	66,9	50,3	10,6
		Israel	96,0	90,0	93,8
		Jordan	63,9	81,7	36,1
		Kuwait	109,3	99,0	26,7
		Lebanon	33,2	18,1	0,7
		Saudi Arabia	74,0	68,8	64,9
		UEA	-	57,8	49,6
	Global		<b>118,6</b>	<b>69,7</b>	<b>11,6</b>

FAO. 2016. *AQUASTAT website*. Food and Agriculture Organization of the United Nations (FAO).  
<http://www.fao.org/nr/water/aquastat>. Website accessed on [2018/04/16].



# Case study town: Leh, Ladakh, India

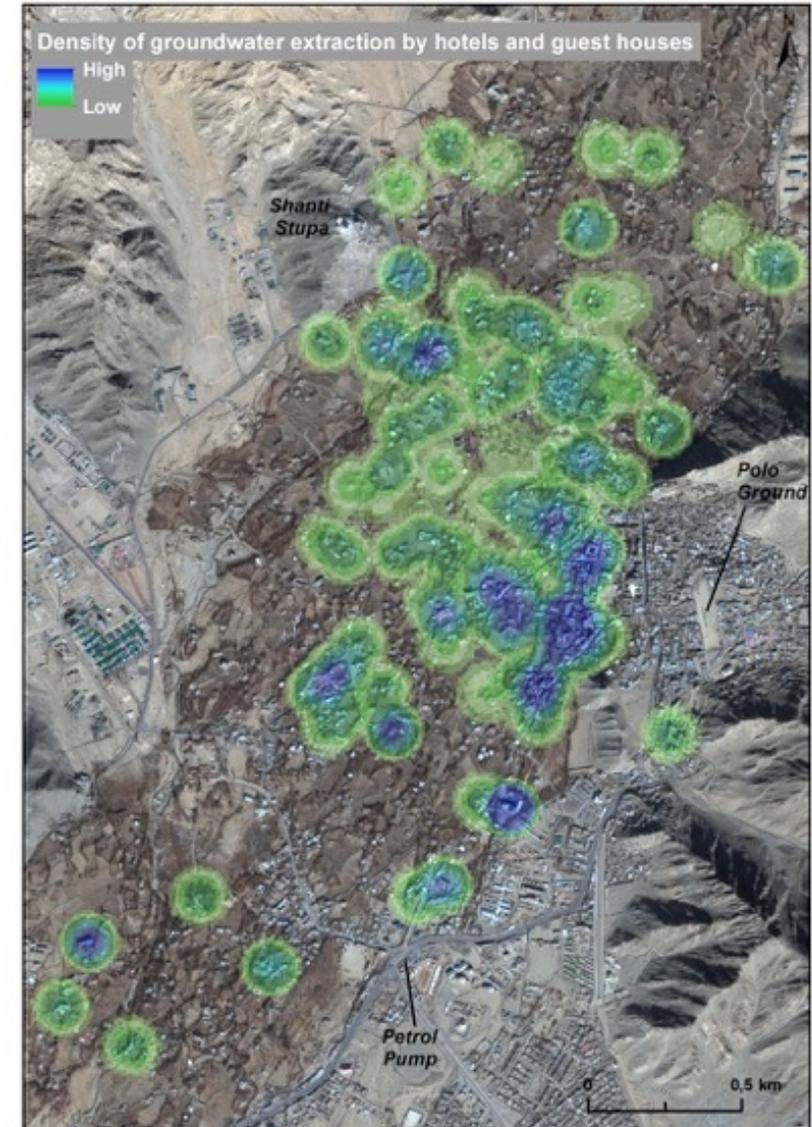
- **Very rapid urban growth** due to tourism industry
- **Private groundwater abstraction** by hotels / guesthouses is huge, not regulated
- Groundwater pollution due to **inadequate wastewater management**
- TUM supports a multi-stakeholder process since 2012 to **visualize alternative urban development pathways**

Documentary film:

**"If not now, when?  
Planning for the urban Water-Energy-Food Nexus"**

Duration: 18 minutes:

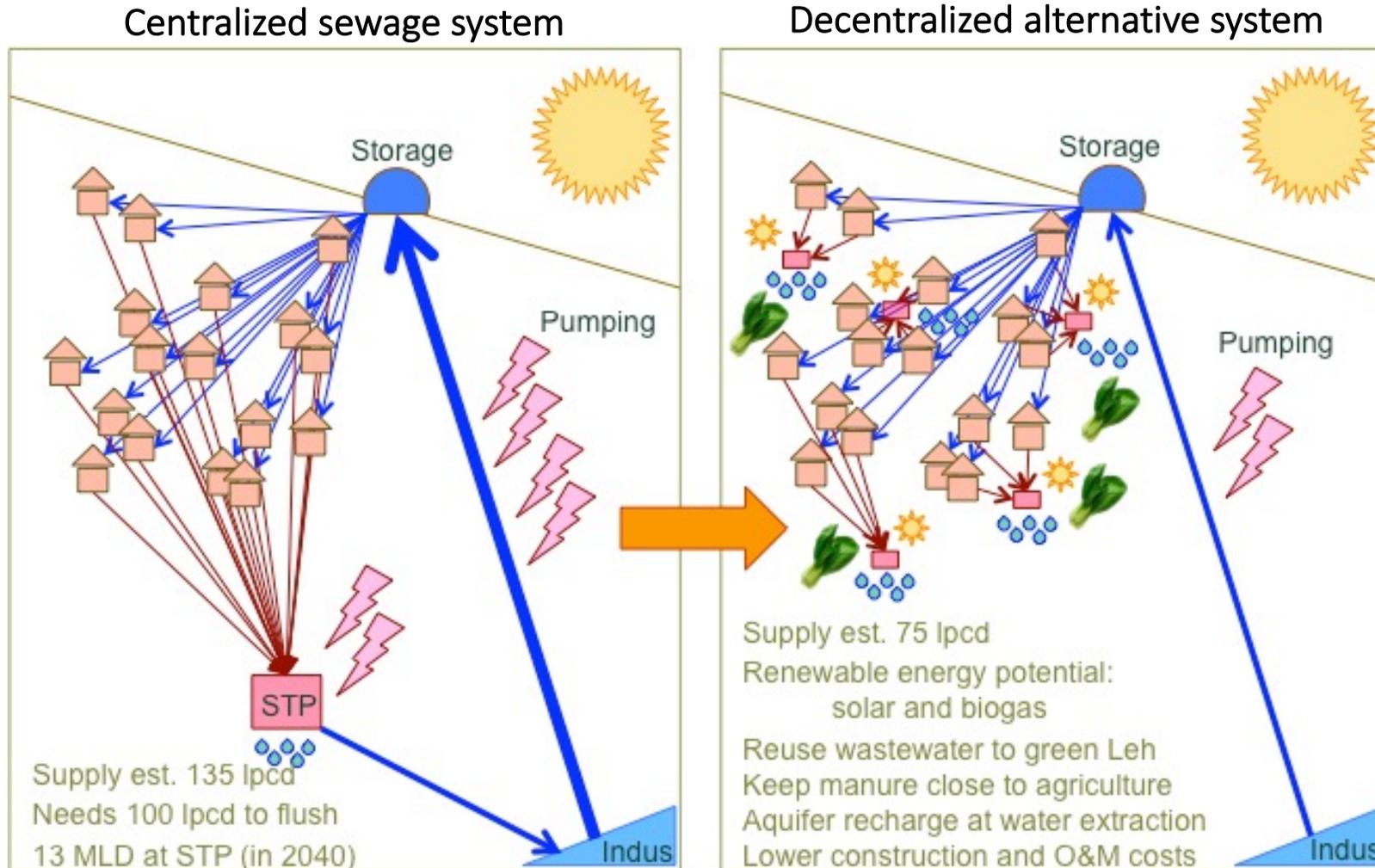
<https://vimeo.com/142941443>







# Decentralized alternative system





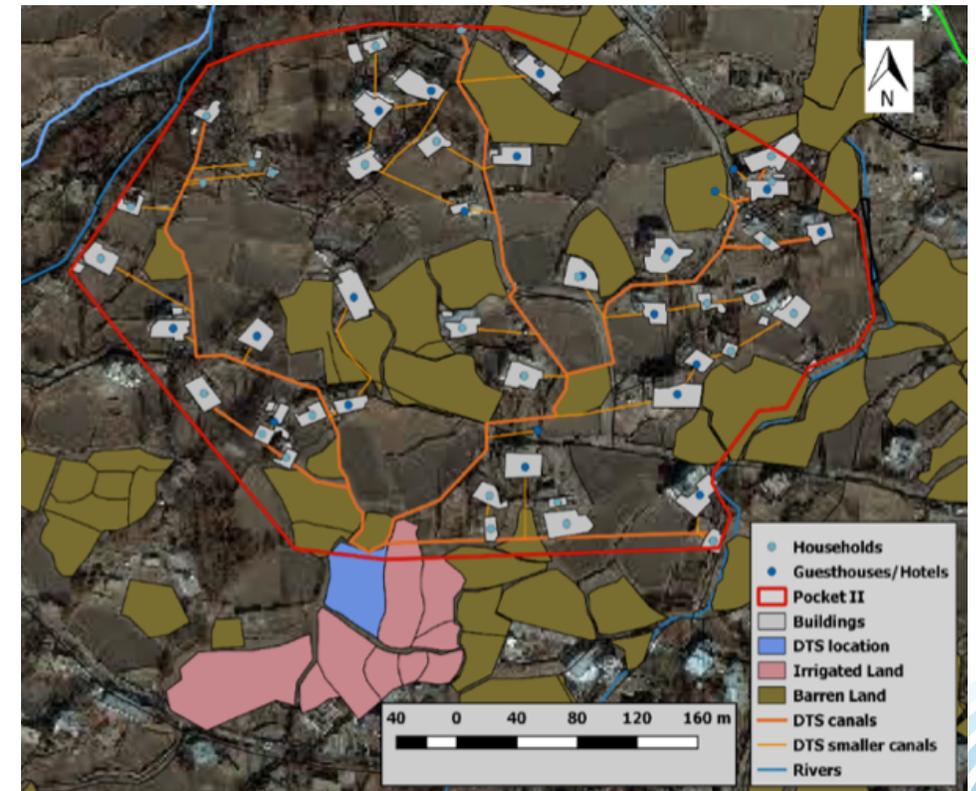
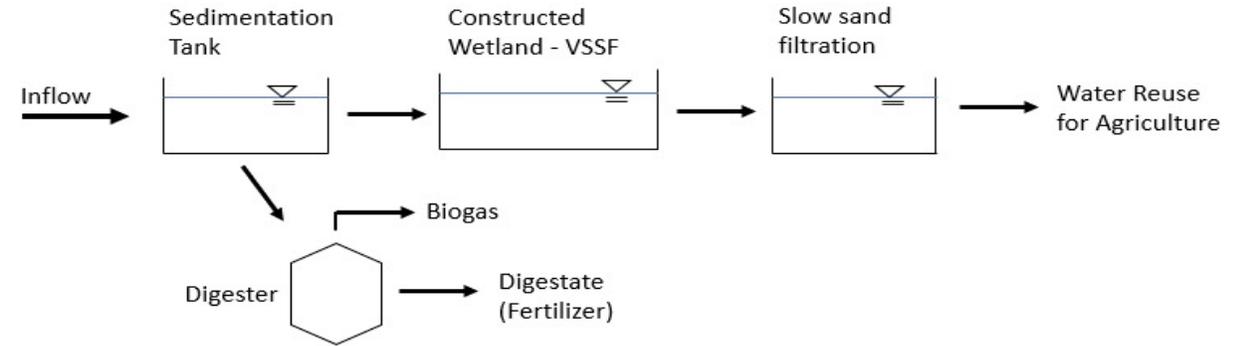
# Alternative option constructed wetlands technology

## Water reclamation using constructed wetlands:

This option is effective, low in capital and O&M cost, and can be maintained by local community with some capacity building

- Can irrigate 1-2 ha of cabbage
- Decrease energy for pumping water
- **Energy generation**
  - 5-8 m<sup>3</sup>/d methane → cook for 30-40 people per day
- **Nutrient recovery**
  - **Organic fertilizer** to replace synthetic fertilizer: 12 tons/year

Can support water, energy & food security, model for other cities in India and beyond





# Cities in Germany also need innovative solutions

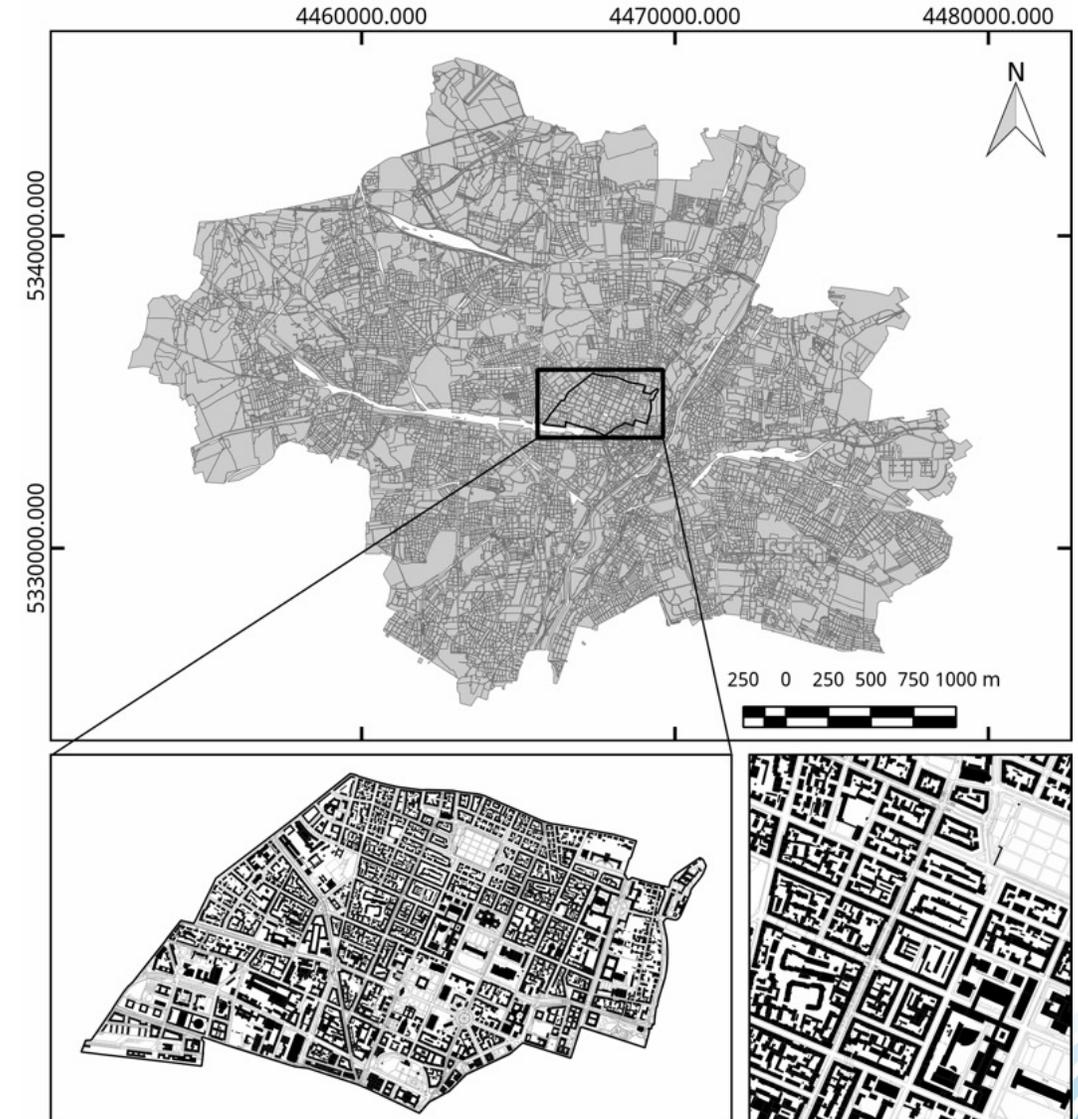
## Challenges

- Example Munich: very dense urban fabric
- Heat island effect already public health risk
- Centralized sewage system needs expensive repairs

## Opportunities

- Reclaimed water for urban agriculture irrigation
- Rainwater harvesting could cover toilet flushing demand, with energy implications
- Biogas production in Maxvorstadt blocks: 20% of local household electricity demand
- Potential crop yield could cover **66% of local demand for fruits** and **246% for vegetables**

The capital costs for a decentralized alternative could be recuperated in ca. 2 years





# Conclusions

- Many cities worldwide need to **evaluate the sustainability** of cost-intensive maintenance of old centralized sewage systems, to create a **new model for cities**
- **Cost of hybrid / decentralized wastewater management** may be lower than maintaining conventional systems, but alternatives not yet readily available
- **Climate action benefits, e.g. lower GHG emissions & methane capture**
- **Revenue stream** from products such as recycled water, bio-energy & –fertilizer, etc.
- **Novel governance approach**, public-private partnerships & green jobs creation
- **Demonstration of Nexus approach at urban scale needed to generate evidence, relevant to cities worldwide**

**Thank you for your attention!**





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