# Understanding and Quantifying the Water, Energy and Carbon Nexus for Low Carbon Development in Asian Cities

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# Collaborating Organizations/Team

- Dr. Shobhakar Dhakal, Associate Professor, Energy FoS, SERD, AIT
- Dr. Sangam Shrestha, Assistant Professor, WEM, SET, AIT
- Mr. Ashish Shrestha, Research Associate, SERD, AIT

- Prof. Arun Kansal, Professor, The Energy and Resources Institute (TERI) University, India

- Prof. Shinji Kaneko, Professor, School of International Development and Cooperation, Hiroshima University, Japan
- Dr. Yuki Yamamoto, Hiroshima University, Japan

# Introduction

- Regional, interdisciplinary and comparative studies in three Asian Cities: Bangkok, Tokyo and New Delhi
- Integrating three important key dimensions in cities: Water, Energy and Carbon
- High energy and water demand in cities, its impact on upstream and downstream processes.
- Information on cities regarding this nexus is limited.
- We are carrying out three research activities

a) Comparative case-studies of Asian cities to characterize the nature of water-energy-carbon nexus.
b) Quantification of the nexus to study its direct and indirect importance and to illustrate the potentials of the nexus to the low carbon development in cities.
c) Based on these, we will gauze the extent and relevancy of addressing the barrier and opportunities for optimizing the water-energy-carbon nexus.

# Policy relevance of our study

- Water, Energy and Carbon is complex but important to understand

3. This nexus contribute to the emission of GHGs

1. Energy use in water sector is growing to meet increasing water demand

2. Energy sectors are growing which needs more water.

# Policy relevance of our study

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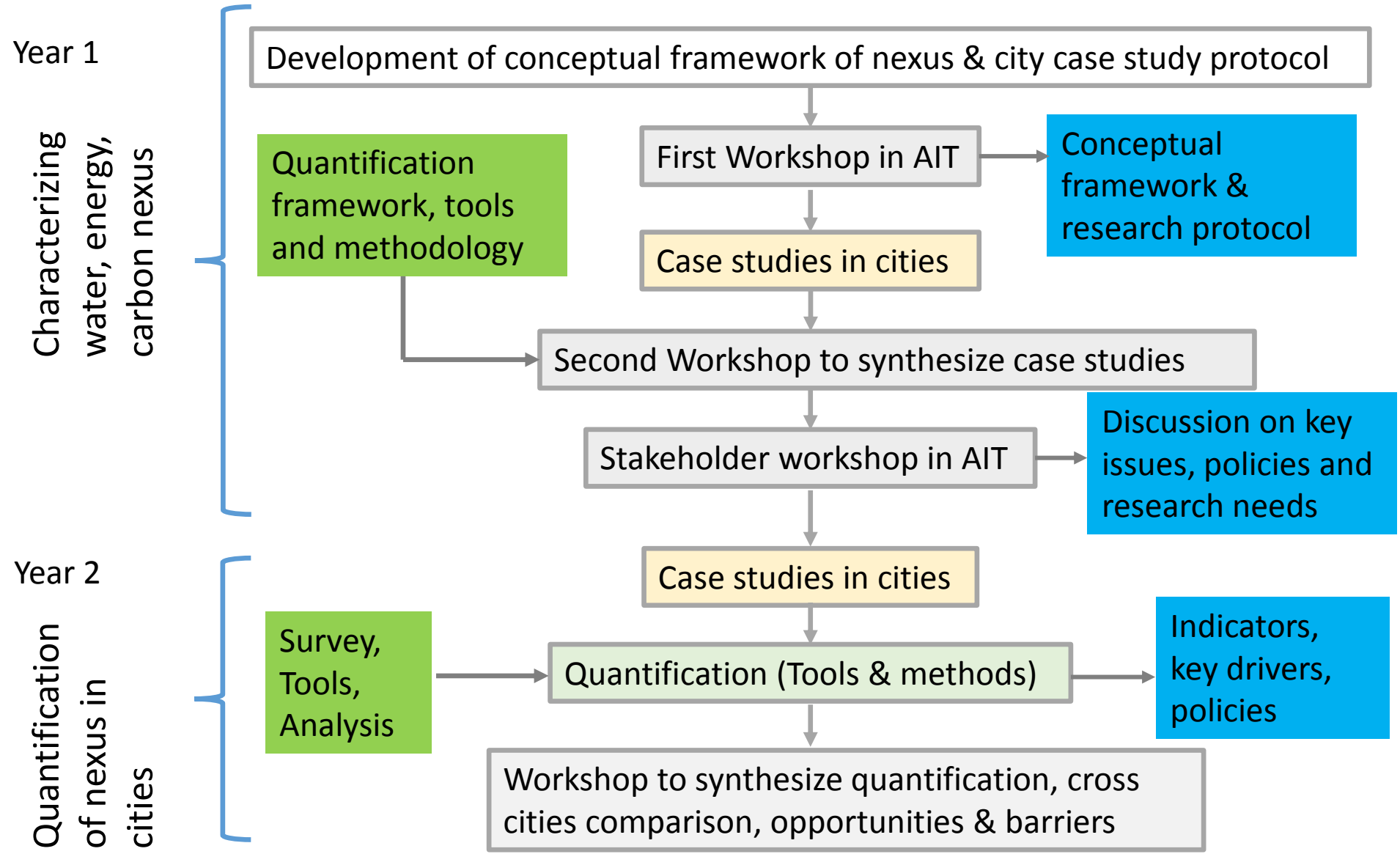
3. This nexus contribute to the emission of GHGs

1. Energy use in water sector is growing

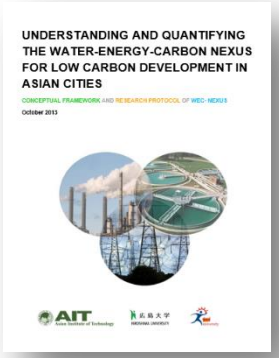
**1.climate change mitigation**
**2.energy security**
**3.water security**

2. Water use and consumption for producing energy is growing

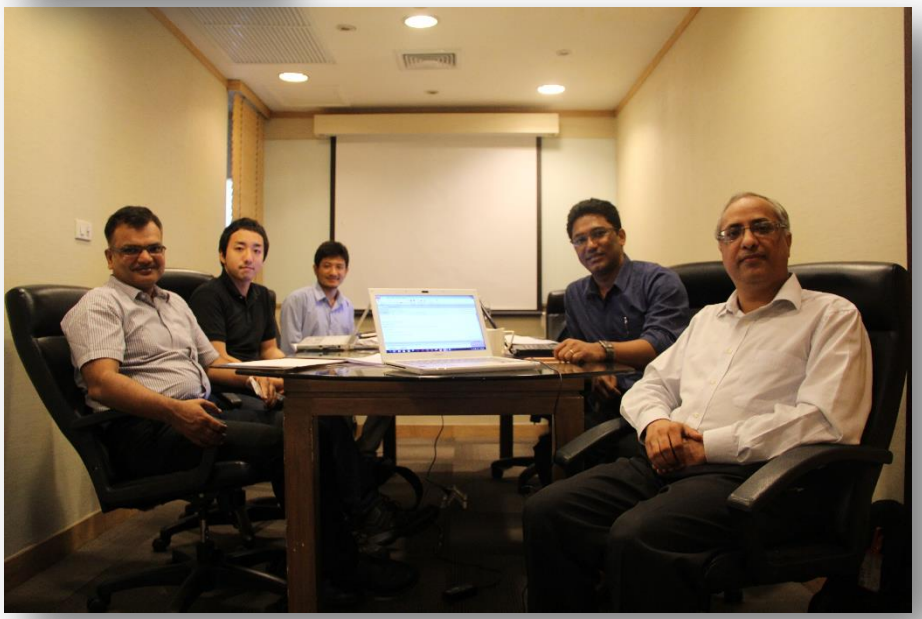
# Project Activities



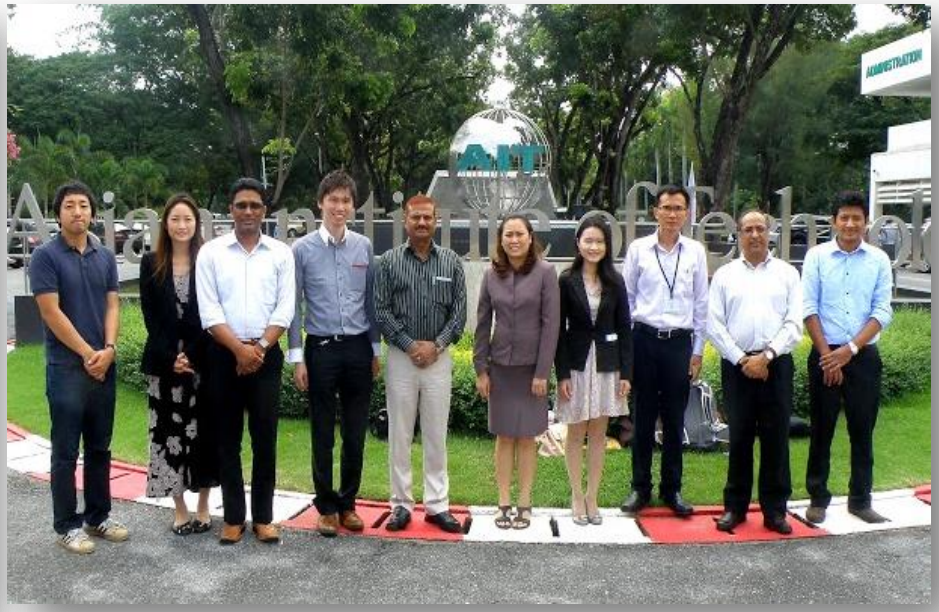
# Project Workshops




First workshop to develop conceptual framework & research methodology, *Sep 2013*, among AIT, Hiroshima University and TERI University



Second workshop to synthesize case studies, *June 2014*, 6 participants from AIT, TERI University and Hiroshima University

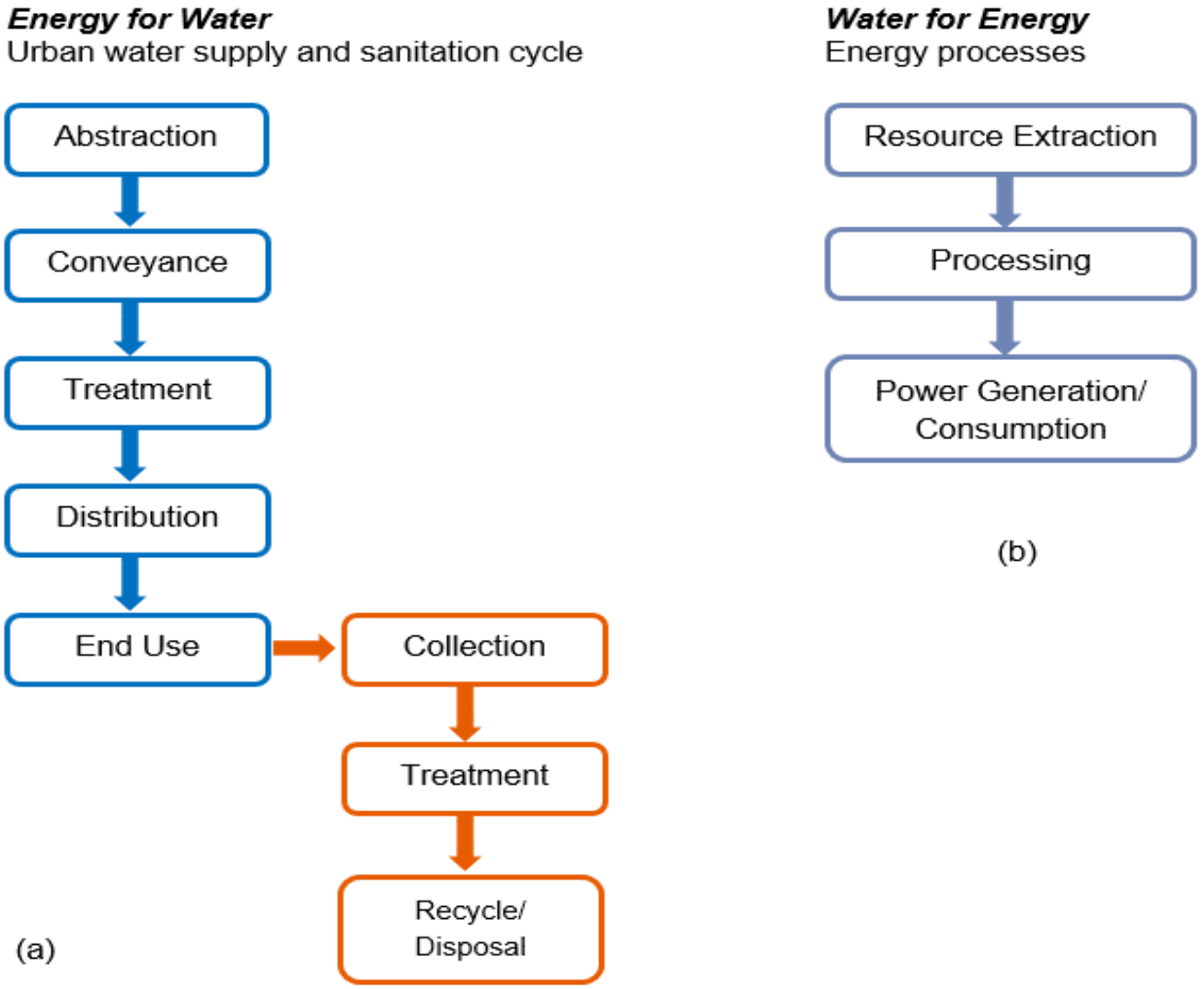



Stakeholder workshop on policies discussion, *Nov 2014*, 13 participants from collaborating institutions, stakeholders from MWA, BMA, DWB, TMG

# Conceptual Framework and Research Protocol for WEC Nexus

- Scoping research activities
- Relevancy of optimizing nexus
- Policy implications
- Nexus in every elements of the urban water/energy cycle
- Water for Energy
- Energy for Water

# Conceptual Framework and Research Protocol for WEC Nexus



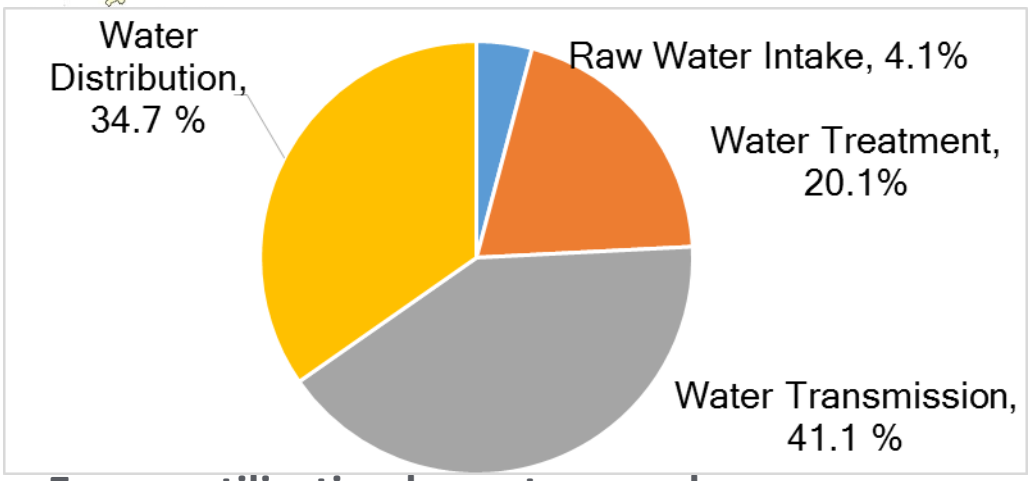
# Case Study: Key findings

## Bangkok Metropolitan Region

- Responsible bodies for water/wastewater systems: Metropolitan Waterworks Authority (MWA), Provincial Waterworks Authority (PWA)/ Bangkok Metropolitan Administration (BMA)
- Drinking water source is totally surface water.
- Ground subsidence led to prohibition of ground water extraction from 2003, but ground water flooding is becoming an issue, affecting underground infrastructures.
- Non Revenue Water is 23.4%
- MWA has capacity more than 5.9 mil. cum/day, 4 major WTPs.
- 7 WWTPs with capacity of 992,000 $m^3$/day and 12 community WWTPs of 24,800 $m^3$/day.

# Case Study: Key findings

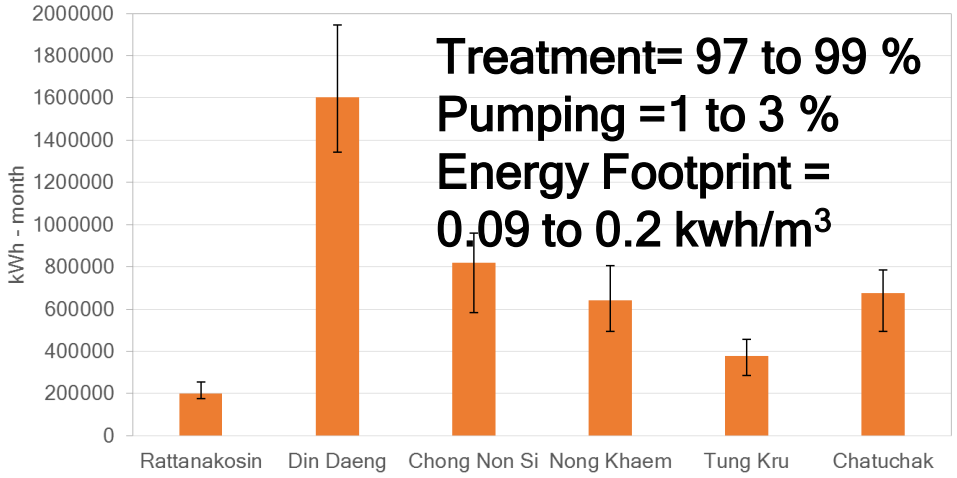
## Bangkok Metropolitan Region




| Process | Energy Intensity ($kWh/m^3$) from 2003 to 2012 |
|---|---|
| Raw Water Intake | 0.009 |
| Water Treatment | 0.047 |
| Water Transmission | 0.096 |
| Water Distribution | 0.081 |

Total = 0.233

### Energy utilization by water supply




### GHG emission from WWTPs

| Source | Emission Ton $CO_2$/year |
|---|---|
| Septic tank | 524,286 |
| Untreated ww(sediment) | 93,060 |
| Electricity consumption | 31,870 |
| Transportation of excess sludge | 142.781 |
| Sludge digestion | 360 |

### Energy utilization in waste water


# Case Study: Key findings

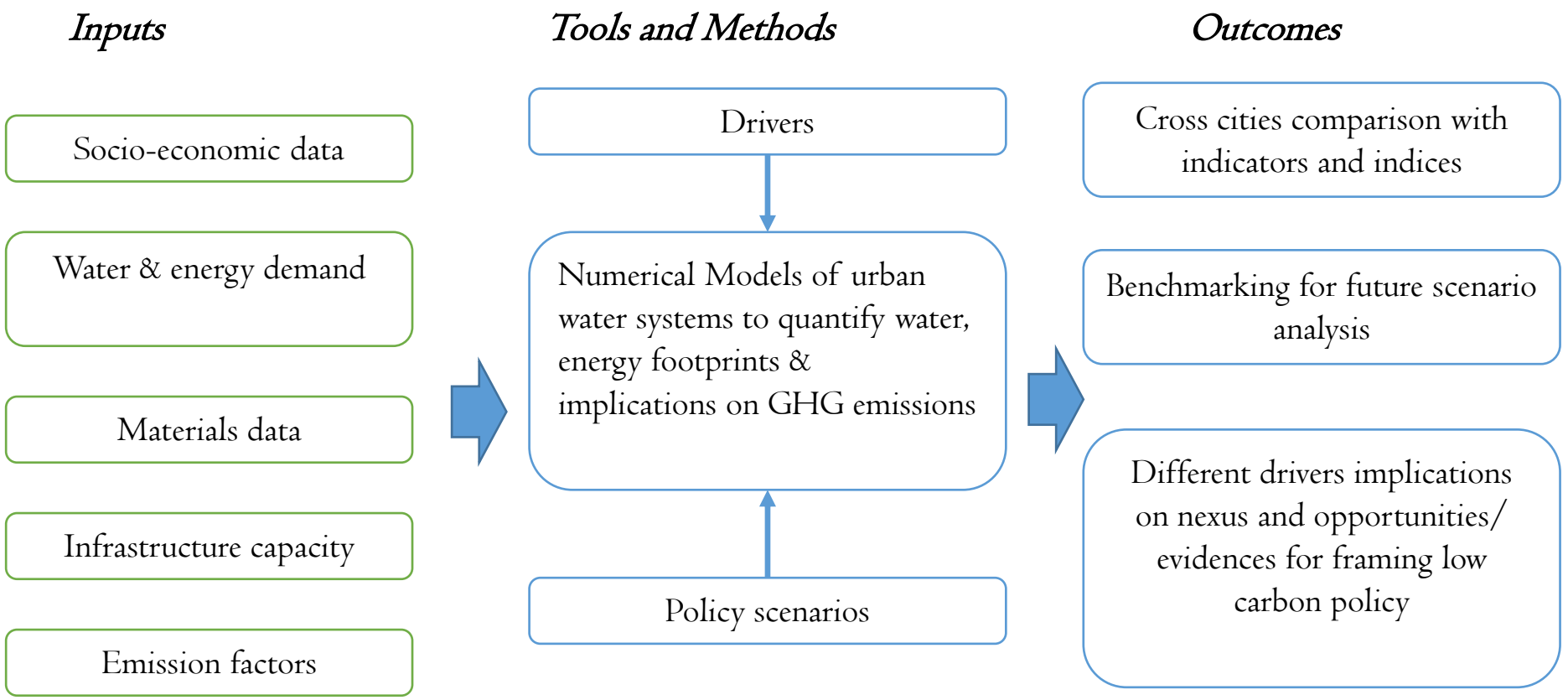
- 11 WTP supplied 3.9 million Cum/day in 2012 (capacity is 6.9 million Cum/day)
- Non revenue water is 8%.
- 13 WWTP facilities treated 4.3 million Cum/day in 2012
- Energy Intensity of drinking water supply is 0.25 - 0.29 kWh/$m^3$ from 2008 to 2012
- Energy Intensity of wastewater treatment is 0.15 - 0.16 kWh/$m^3$ from and pumping is 0.13 – 0.14 kWh/$m^3$ from 2008 to 2012.


# Case Study: Key findings

## National Capital Territory of Delhi (NCTD)

- Delhi has subtropical climate with huge variation in summer and winter temperature (from 4°C - 45°C).
- Drinking water constitute 86% of surface water supply and remaining from ground water.
- Delhi Water Board (DWB) is responsible body.
- Non revenue water is 50%, Technical (20-25%) and Commercial Losses (25-30%)
- DWB has capacity to supply 3.16 mil. cum/day (2.86 surface water and 0.3 ground water) drinking water and waste water treatment capacity of 2.29 mil. cum/day
- 0.54 mil. cum/day water are currently recycled for non potable use
- Groundwater depth is increasing. GW abstraction increased by 2.4 times and energy consumption by 3 times in last 10 years.
- Energy footprint of WTPs is 0.2 to 0.4 kWh/$m^3$
- Choice of technologies have changed drastically over years.
- 1910 private and 400 public tankers distribute 21.73 $m^3$ water all over Delhi in a day, which consumes 526.3 MWh/d of energy and emits 139.3 t-$CO_2$ e/d direct GHG
- Energy footprint of WWTP is164 MWh/d and carbon footprint is 4.83 Gg $CO_2$e/annum

# Quantification of Water, Energy & Carbon Nexus



# Relevancy to low carbon initiative

- Water and waste water systems consumes 1 to 18% of electrical energy in urban areas.
- Waste water contribute significantly to GHG emission.
- Capacity utilization of water infrastructures have significant impacts on this nexus.
- Different drivers affects this nexus in different scales.
- Demand and supply management to reduce GHG emission.
- Effective policies in urban water systems.
- Promote innovative low carbon technologies.
- Our findings will support policy makers and stakeholders to built low carbon city.

# Conclusion

- Energy security, climate change mitigation and water security are three key contemporary policy agenda globally related to the sustainable development.
- Addressing them in an integrated fashion is useful for local decisions makers and also to maximize the benefits from global support mechanisms tailored to each issue.
- Our study will fill crucial knowledge gaps in Asian context and address the barrier and opportunities for optimizing nexus.
- We look forward to disseminate the key messages from our research to the local governments.

# Thank you!!

http://wec-nexus.ait.asia/