IWA Water and Development Congress & Exhibition 2025

8-12 December 2025 | Bangkok – Thailand

Evaluating Methane Emissions and Exploring Potential Methane Capturing mechanisms across the Sanitation Service Chain in India

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Sanitation sector is 4th highest methane emitter to global methane emissions. . .

National and International agenda **focus on methane mitigation**

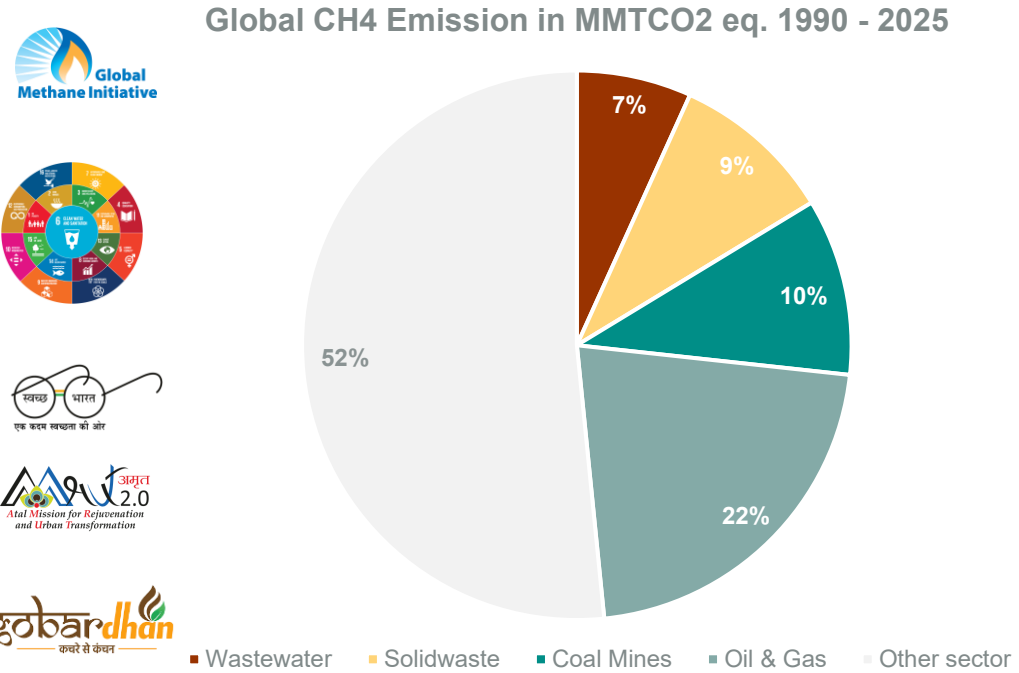
International agenda

- **Global Methane Pledge** focus on **reducing methane emission by at least 30 %** from level in 2020 till 2030.
- Using **methane** as a **resource/ source** for **clean energy**
- **Linkages** between **SDG 6 – SDG 7 – SDG 13**

National agenda

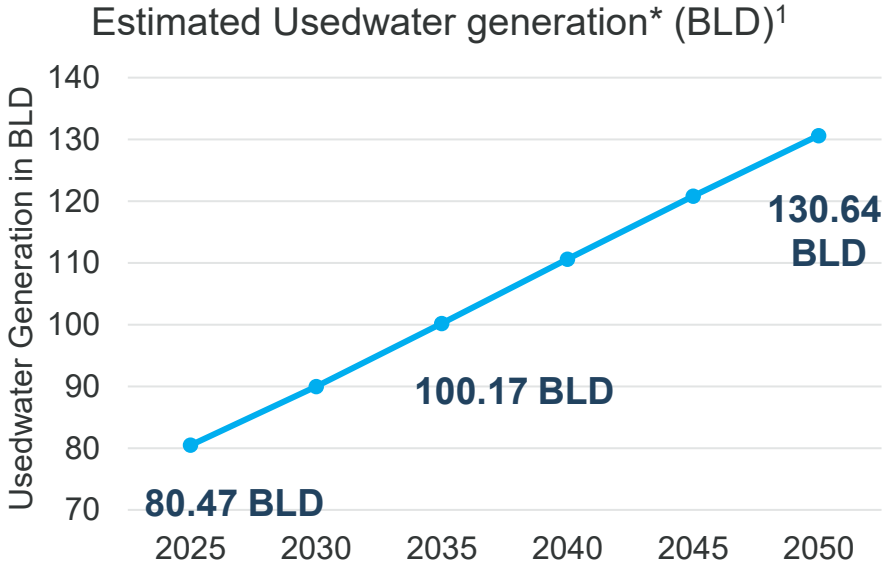
- **SBM 2.0 and AMRUT 2.0** focus on **improving overall sanitation condition** in India across the urban areas with **focus on circularity**

- National level programs like **SATAT and GobarDHAN** focus on making **clean energy from waste.**



Source: https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases extracted from https://www.globalmethane.org/methane-emissions-data.aspx#about

Methane capture potential of 7 Mt CO2 eq annually from 50 BLD of STPs in India by 2026 . . .



Current operational treatment facility capacity – **31.4 BLD (40 % of total usedwater generated)[2]**

Planned capacities by year 2026

7 BLD

Namami Gange Programme by 2026[3]

+

5.7 BLD

Additional capacity under AMRUT 2.0[4]

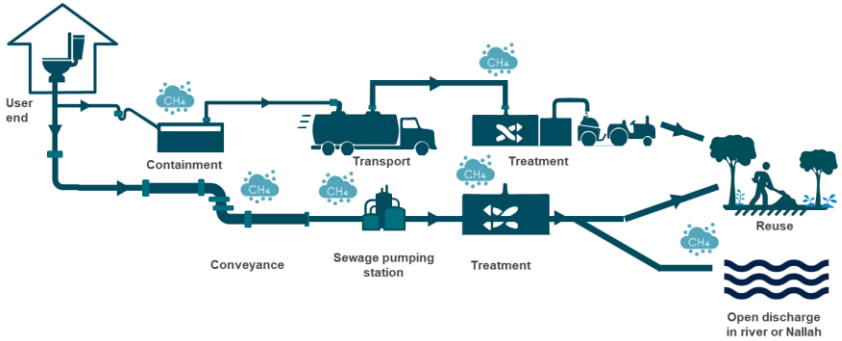
+

4.9 BLD

Additional capacity under SBM 2.0

Source: 1. NITI Aayog. (2023). *Revised strategy paper on reuse of treated Usedwater in peri-urban agriculture in India*. National Institution for Transforming India. https://www.niti.gov.in/sites/default/files/2023-08/Revised_Strategy_Paper_on_Reuse_of_Treated_Usedwater_in_peri-urban_agriculture_in_India.pdf; 2. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2025/nov/doc20251119698701.pdf ; 3. https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=1986271&reg=3&lang=2#:~:text=Under%20Namami%20Gange%20Programme%2C%20in,state%20and%20other%20government%20agencies).; 4. https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2041571&reg=3&lang=2

Accurate estimation across sanitation service chain : To understand methane recovery potential . . .



Emission factors for India

Septic tanks	Sewer network	Sewage treatment Plant	Open Discharge
0.24 – 0.42 kg CH_4/kg BOD	0.018 – 0.180 kg CH_4/kg BOD	0.018 – 0.6 kg CH_4/kg BOD	0.06 – 0.24 kg CH_4/kg BOD

IPCC as a base for emission estimation

- **Provides emission factors** for estimation of emissions across the sanitation service chain
- **Three tier quantification** methodology for emissions estimate formed and developed based on existing literature.

Tier 1	Tier 2	Tier 3
National level	Sub National level	Local level

Most countries are dependent on **tier 1 and tier 2 level emission factors** for emission estimation

Emission factor studies mostly dominated by global north literatures and currently few global south countries are contributing to enhance the methodology through carrying out **on field quantification studies at local level**.

Studies required for Indian cities at local level to assist in understanding the methane potential for resource recovery and capture

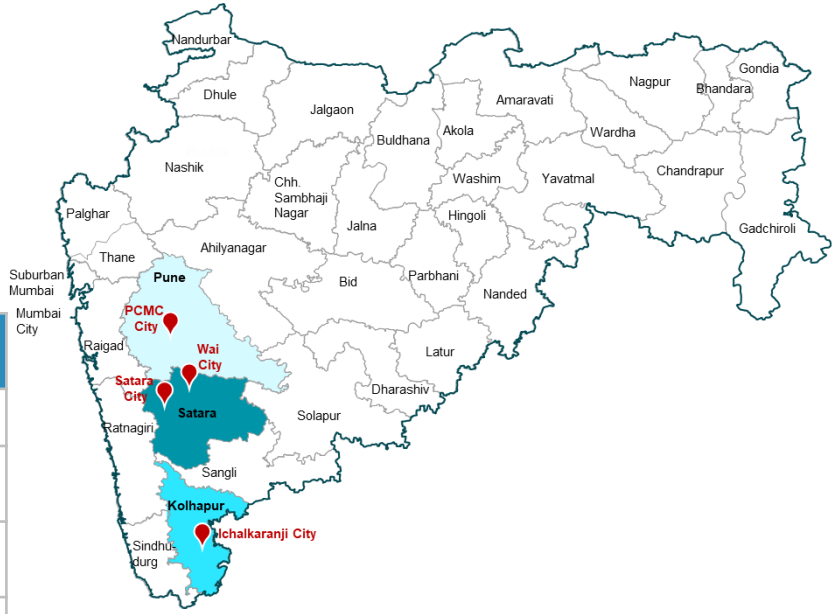
Cities identified in Maharashtra to understand local level emissions with varying sanitation systems . . .

Selection of cities based on:

- **Large** town to **small** town
- Sanitation system coverage – (**onsite, offsite, combine system**)
- Type of sanitation **treatment** facilities – STP - (**anaerobic or aerobic**)
- Different **climatic conditions**

Sr. No.	Parameter	Pimpri Chinchwad (PCMC)	Ichalkaranji	Satara	Wai
1	Population	2.8 million	0.4 million	0.3 million	50 K
3	Area (Sq.Km.)	181	29.9	26.4	3.54
4	Sanitation system	95 % Sewered and 5 % onsite	Sewered (60 %) and onsite (40 %)	Fully onsite	Fully onsite
5	Sanitation treatment facility type	STP: SBR, ASP, extended aeration, and Biotower	STP: SBR (Sequential batch reactor)	FSTP (50 KLD)	FSTP (70 KLD)

Partially Sewered **Non-Sewered**

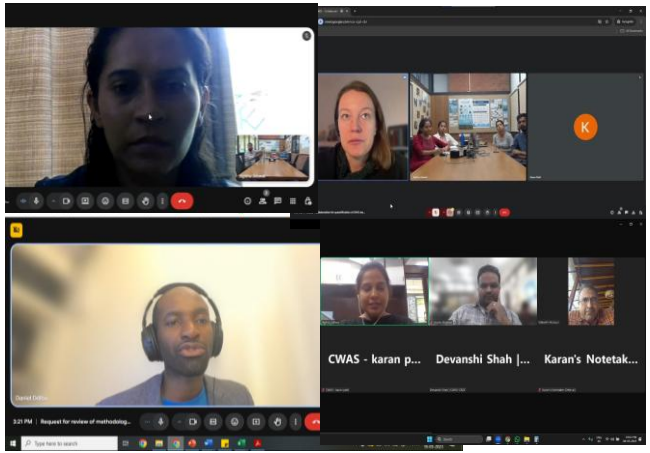


Developed a methodology for Methane quantification at local level. . .

Literature review and other allied sectors

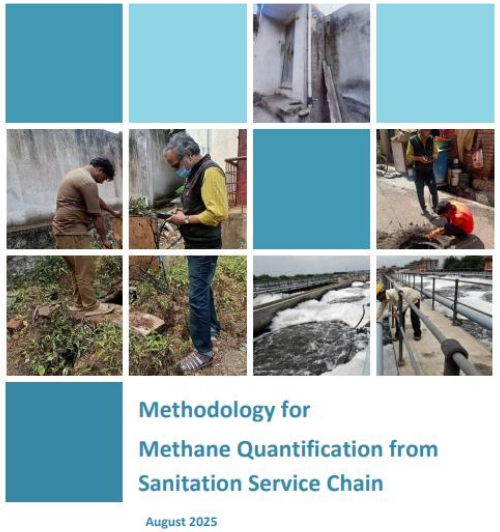
- Literature review to **understand current global practices** for methane quantification across different sanitation system
- Review focused on **methodologies, equipment used**, and **challenges** encountered in on-field quantification

Discussion with experts



- **Academic** institutions
- **Sector partners** and researchers
- **Professionals** working in remote sensing domain

Methodology Note



Scan to access

Sampling process followed to understand local level methane emissions . . .

On site Containment

- **Samples** Consideration of **17 samples across** 2 different cities with different characteristics
- **Sampling interval** **Continuous monitoring at a 2-hour interval** for **8-hour a day** was carried out during three season
- **Quality testing:** **Lab based sample test** for effluent and sludge samples are carried out on same interval

Sewer Network

- **Samples** **Maintenance holes** will be identified across 2 cities.
- **Sampling Interval** **continuous monitoring will be carried for 24 hour** across three seasons for day.
- **Quality testing :** **Lab based sample test** for effluent and sludge samples are carried out on same interval

Pumping station and Sewage treatment plant

- **Samples** **3 STPs with different technologies** are consider across 2 cities.
- **Sampling Interval** **Continuous monitoring at interval of 2 hour** by installing floating flux chamber at different STP units for **8 hours over peak and nonpeak hours** across three seasons for day
- **Quality testing** Sampling collection for **lab-based testing** of effluent and sludge sample are carried out on same interval

Discharge

- **Samples** **5 discharge locations of treated and untreated** usedwater will be selected.
- **Sampling Interval** Continuous monitoring using **open bottom flux chamber at 3 location (upstream, at discharge location and downstream**
- **Quality testing** Sampling collection for **lab-based testing** of effluent sample are carried out seasonally.

Lab tests of samples are done to establish empirical relationship between lab results and emissions that are recorded

As on date : activities as per this approach have been completed at containment systems and STPs

Exploring different approaches for on field quantification . . .

Flux chamber

Septic tank	Sewer network & Pumping station	STPs
		Discharge

Built an in-house open bottom flux chamber for collecting flux readings at 4 septic tanks.

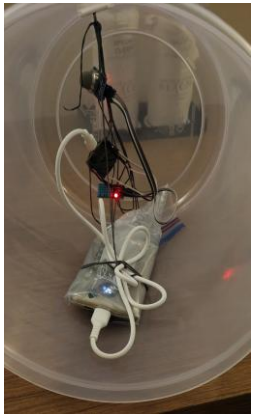


IOT based sensor

Septic tank	Sewer network & Pumping station

IOT based sensor solutions for estimating the methane concentration across sanitation service chain.

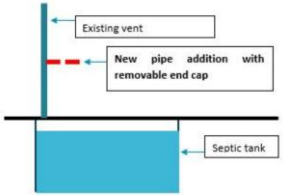





Stack based approach

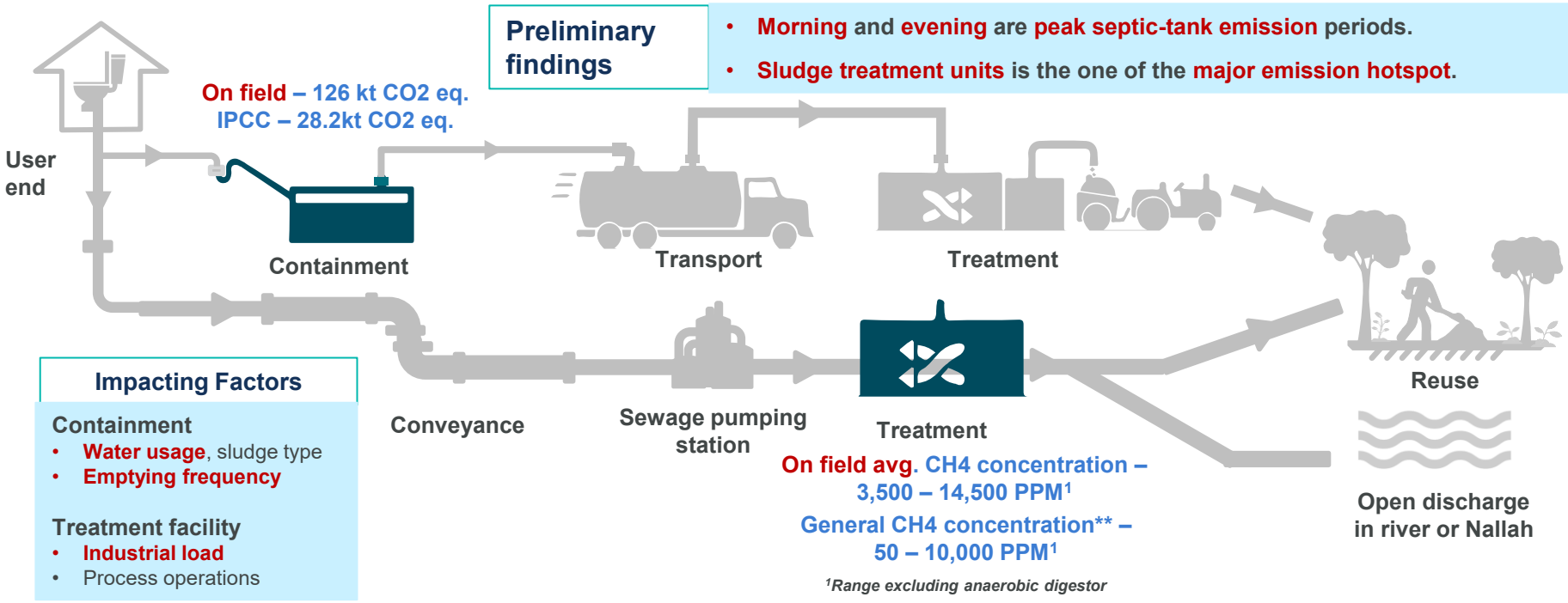
Septic tank

Methane concentration in stacks carried out at 17 septic tanks at 2 hours interval.





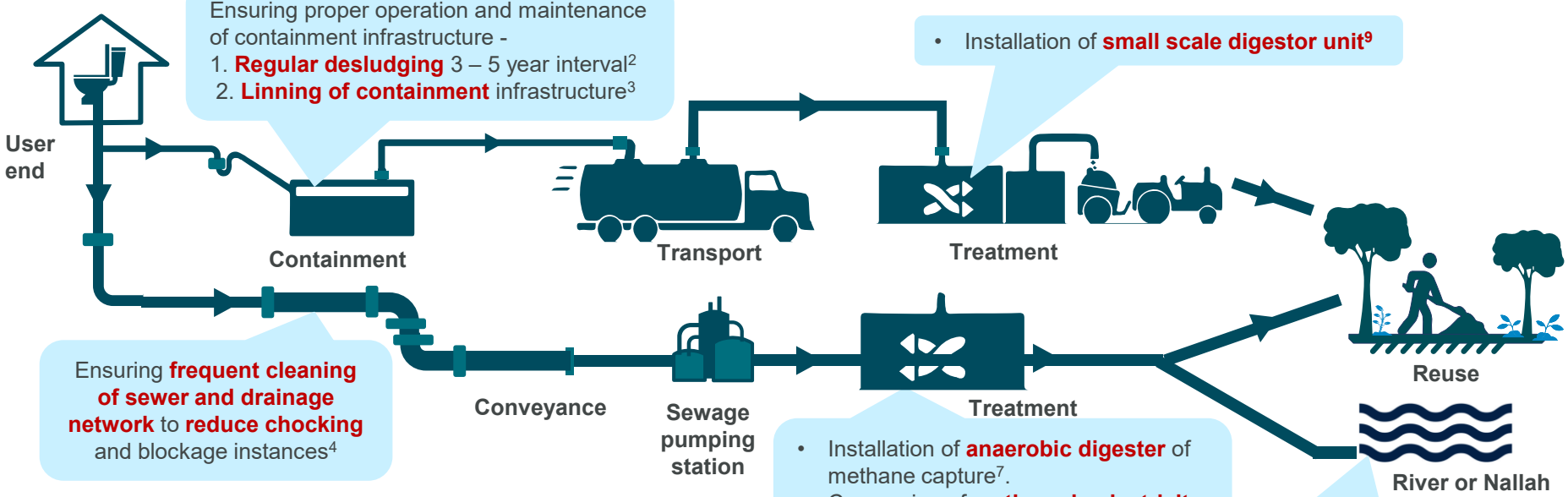

Methane emission varies across sanitation service chain, with higher emissions at treatment facilities . . .



On field methane emissions from septic tanks are 4x compared to tier 2 emission estimates for Ichalkaranji city*

* Based on preliminary analysis with limited data set and point source emission readings using flux chamber

Existing efforts being undertaken to mitigate methane emissions / resource recovery across sanitation service chain . . .

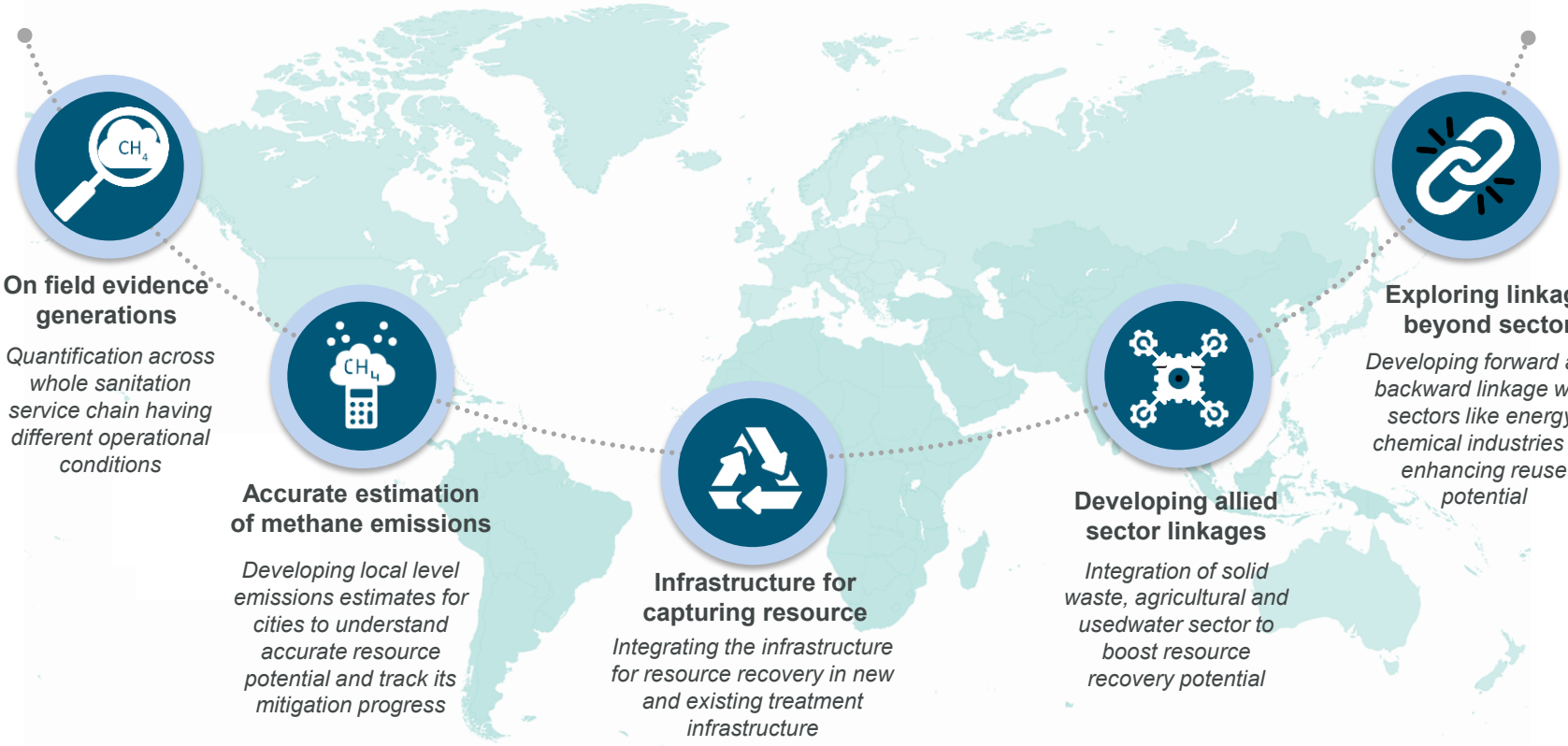


Usedwater sector holds potential of reducing 504 Mt CO2 eq by 2050.

Overall waste sector emissions can increase up to 56 % by 2050 if no actions are taken[1].

Source:1. United Nations Environment Programme (2025). *Global Methane Status Report*. Paris. https://www.unep.org/resources/report/global-methane-status-report-2025; 2. Greenhouse Gas Emissions from Blackwater Septic Systems; 3. Greenhouse gas emissions from different containment system in Dhulikhel Municipality in Nepal; 4. Reducing methane emissions from gravity sewer pipelines by ultrasonication; 5. Investigating high methane emissions from urban areas detected by TROPOMI and their association with untreated wastewater ; 6. Wastewater-effluent discharge and incomplete denitrification drive riverine CO_2, CH_4 and N_2O emissions ;7. Reduction of energy consumption and greenhouse gas emissions in wastewater treatment plant: A case study of utilizing anaerobic sludge digestion ; 8. Turning Human Waste into Renewable Energy: Scope and Options for India; 9. Omission of emissions: the untapped potential of sanitation for climate mitigation in Nepal

Key Takeaways : To do tackle methane emissions and convert into resource . . .



On field evidence generations

Quantification across whole sanitation service chain having different operational conditions

Accurate estimation of methane emissions

Developing local level emissions estimates for cities to understand accurate resource potential and track its mitigation progress

Infrastructure for capturing resource

Integrating the infrastructure for resource recovery in new and existing treatment infrastructure

Developing allied sector linkages

Integration of solid waste, agricultural and usedwater sector to boost resource recovery potential

Exploring linkage beyond sector

Developing forward and backward linkage with sectors like energy, chemical industries for enhancing reuse potential

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About us

The Center for Water and Sanitation (CWAS) is a part of CEPT Research and Development Foundation (CRDF) at CEPT University. CWAS undertakes action-research, implementation support, capacity building and advocacy in the field of urban water and sanitation. Acting as a thought catalyst and facilitator, CWAS works closely with all levels of governments - national, state and local to support them in delivering water and sanitation services in an efficient, effective and equitable manner.

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