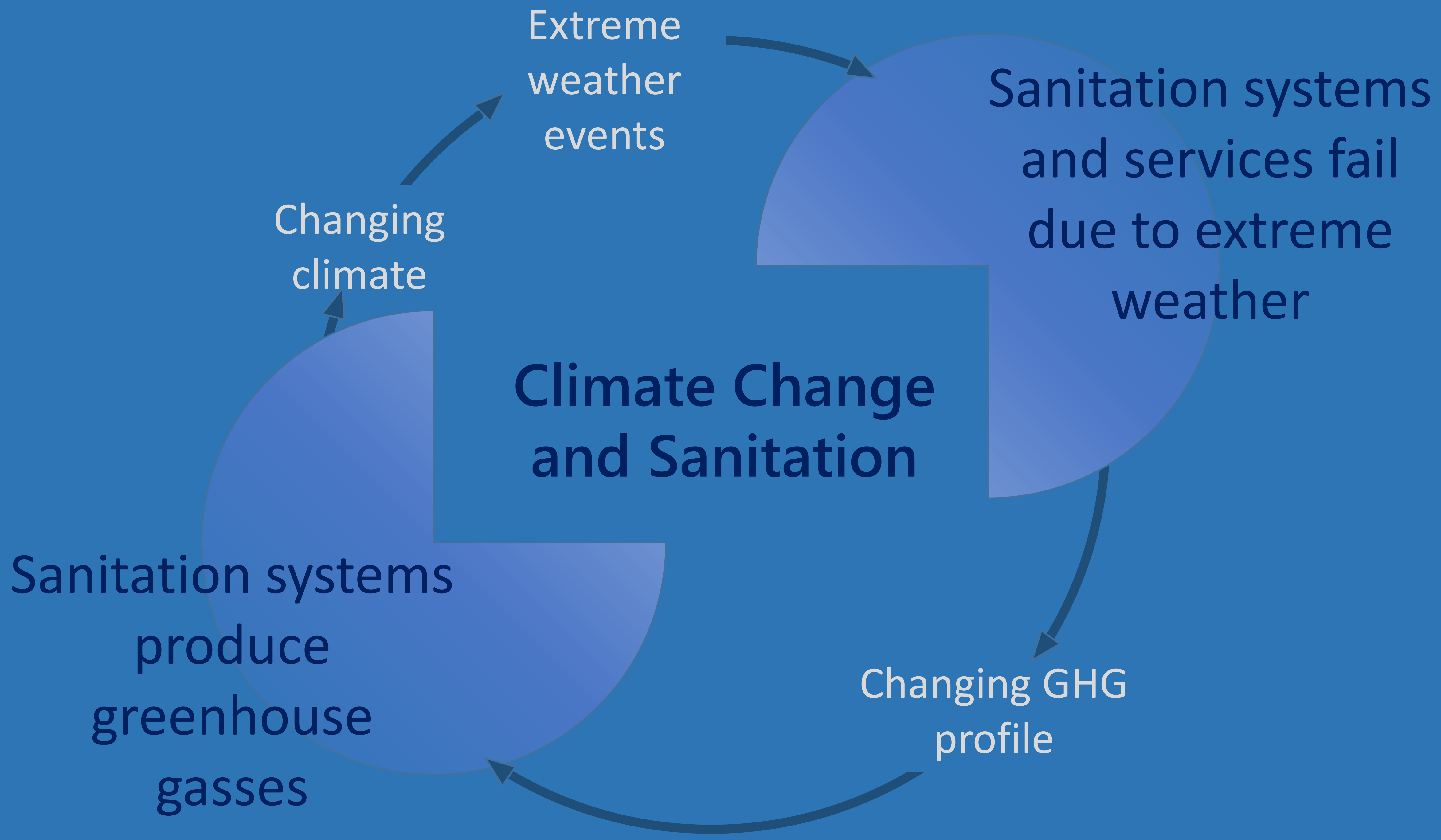
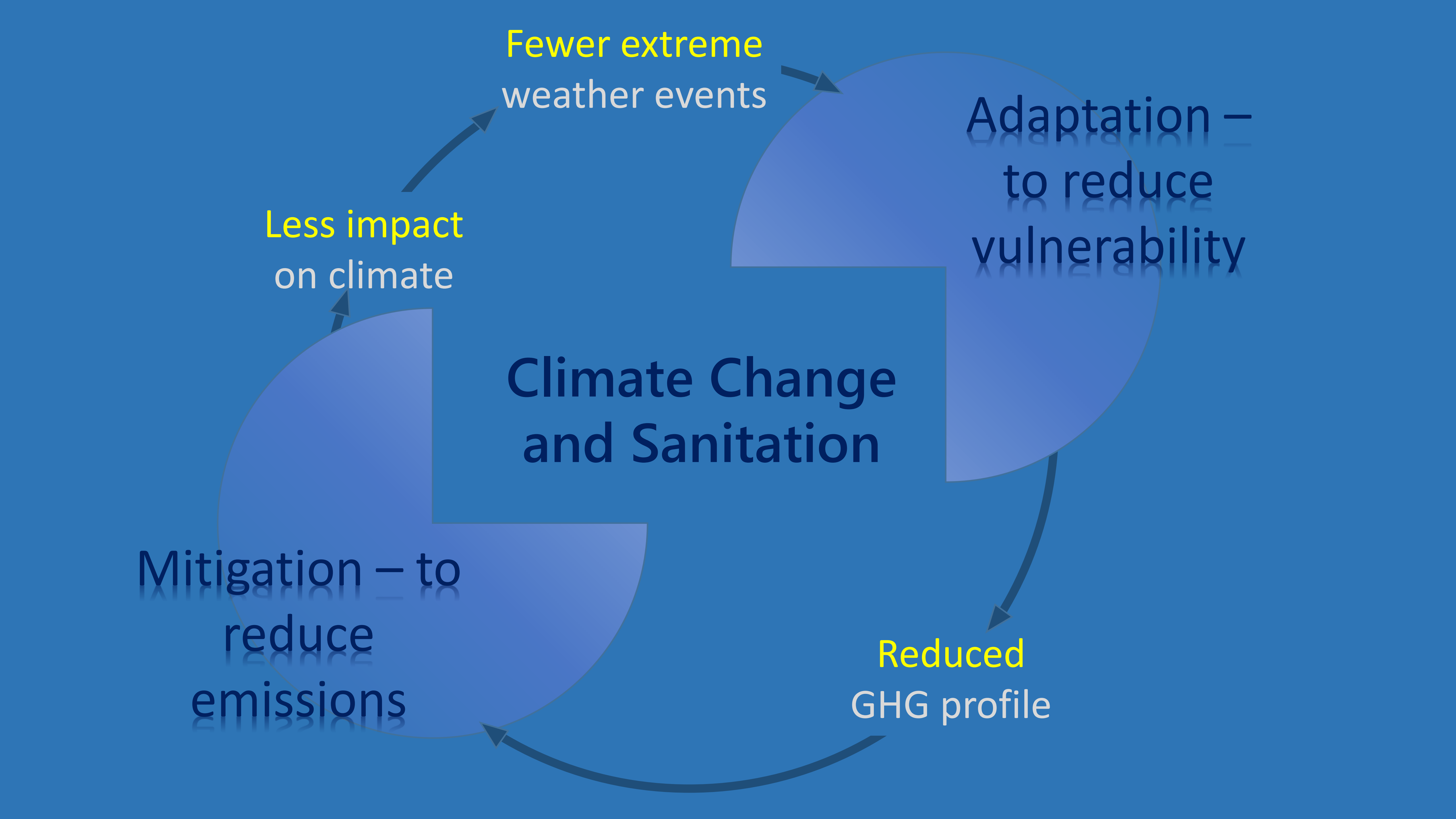
The climate and sanitation puzzle

Professor Barbara Evans, University of Leeds


Extreme weather events
Sanitation systems and services fail due to extreme weather
Changing climate
Climate Change and Sanitation
Sanitation systems produce greenhouse gasses
Changing GHG profile


Fewer extreme
weather events
Adaptation –
to reduce
vulnerability
Less impact
on climate
Climate Change
and Sanitation
Mitigation – to
reduce
emissions
Reduced
GHG profile

Mitigation

How big are emissions and where are they occurring?

What are the emissions from sanitation systems?

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Direct	Gasses that are produced from the system	- CH_4 and N_2O from contents of pits, tanks and sewers - CH_4 and N_2O from treatment plants

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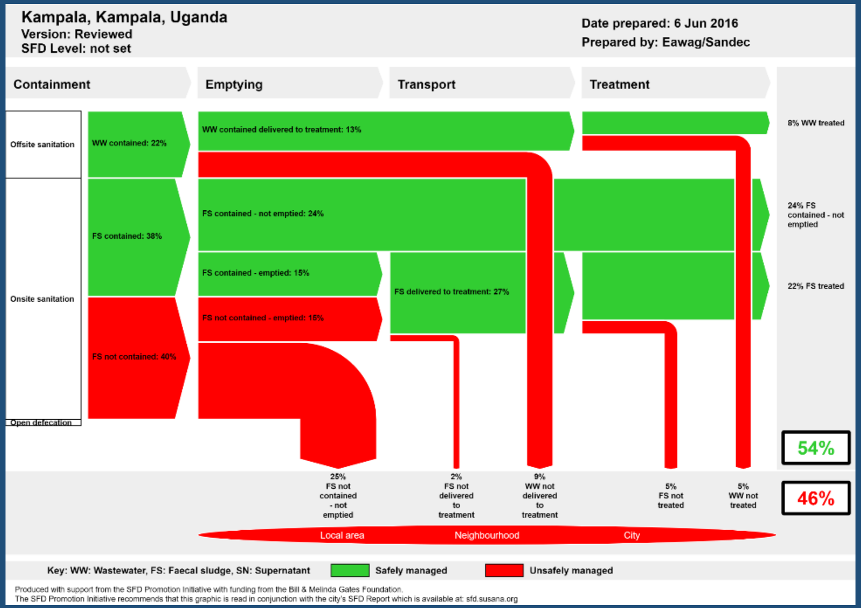
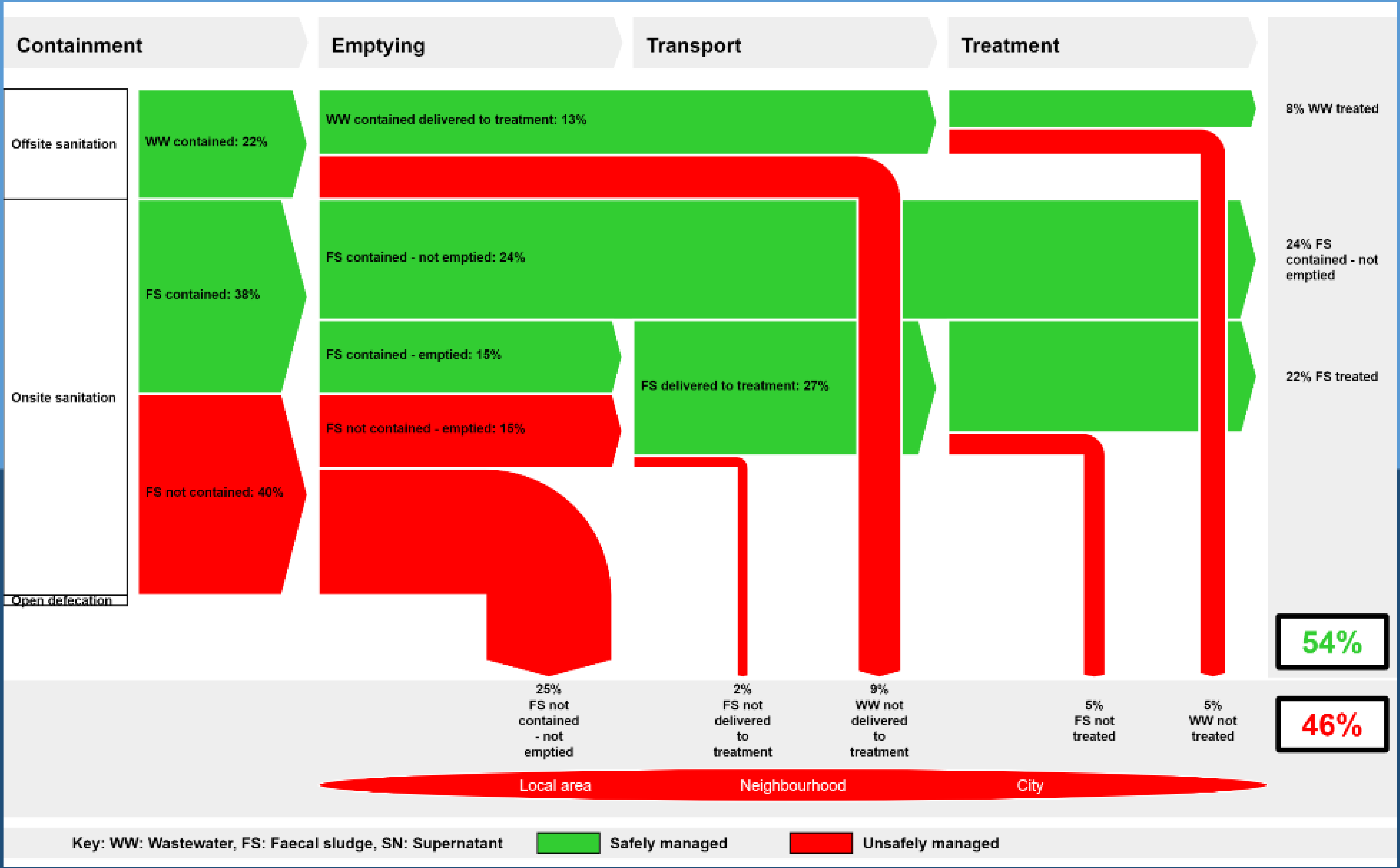
Embedded Carbon	Carbon that is produced during the production of the assets of WASH	- Concrete and steel in infrastructure - CO_2 associated with production and use of chemicals

Onsite and offsite systems

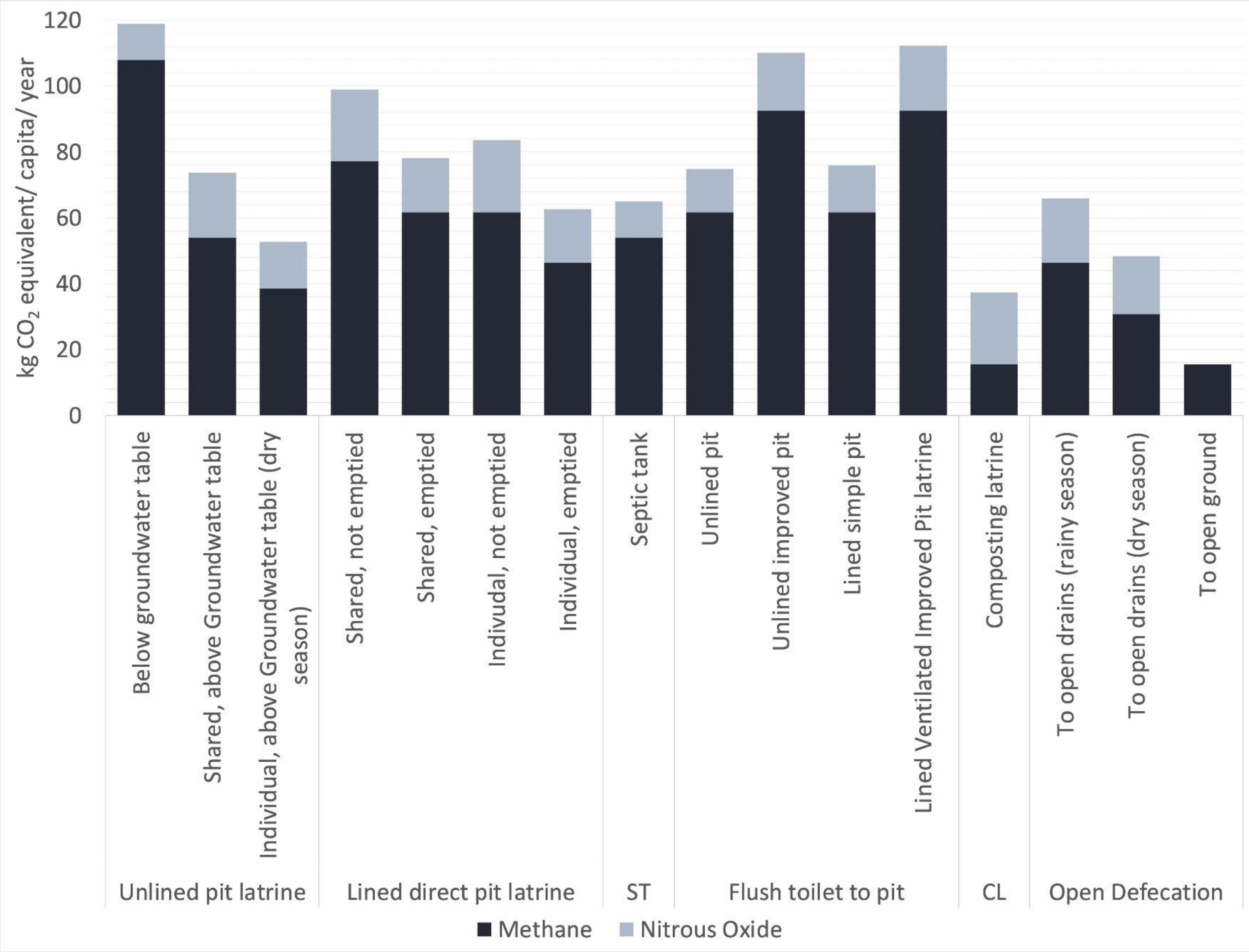
Containment, Emptying, Transport & Treatment

Direct, Operational, Embedded Carbon



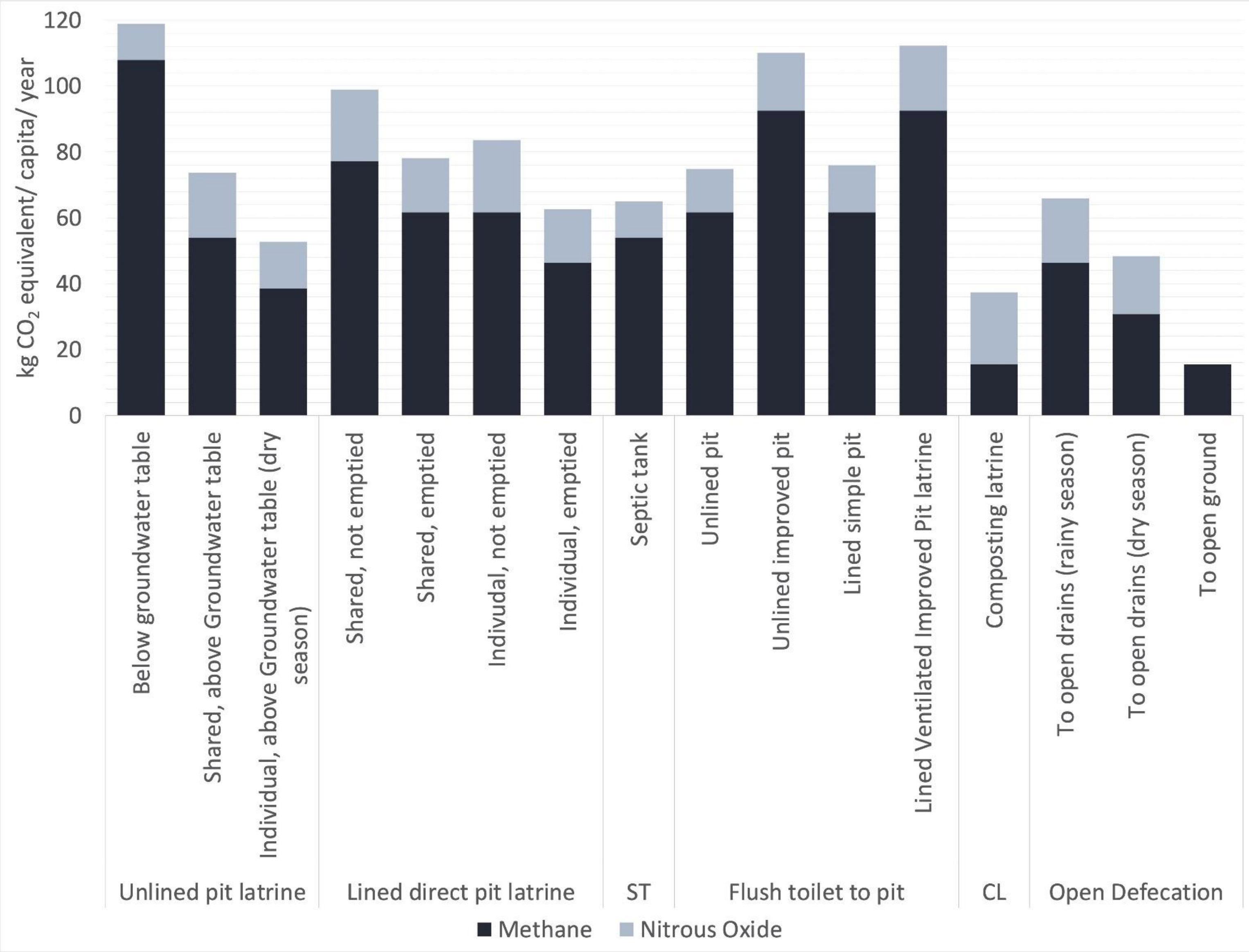

Containment
Emptying
Transport
Treatment
Offsite sanitation
Onsite sanitation
Open defecation
WW contained: 22%
FS contained: 38%
FS not contained: 40%
WW contained delivered to treatment: 13%
FS contained - not emptied: 24%
FS contained - emptied: 15%
FS not contained - emptied: 15%
FS delivered to treatment: 27%
8% WW treated
24% FS contained - not emptied
22% FS treated
54%
46%
25% FS not contained - not emptied
2% FS not delivered to treatment
9% WW not delivered to treatment
5% FS not treated
5% WW not treated
Local area
Neighbourhood
City
Key: WW: Wastewater, FS: Faecal sludge, SN: Supernatant
Safely managed
Unsafely managed

Direct emissions from pits and tanks were modelled on a 'population' scale from empirical data



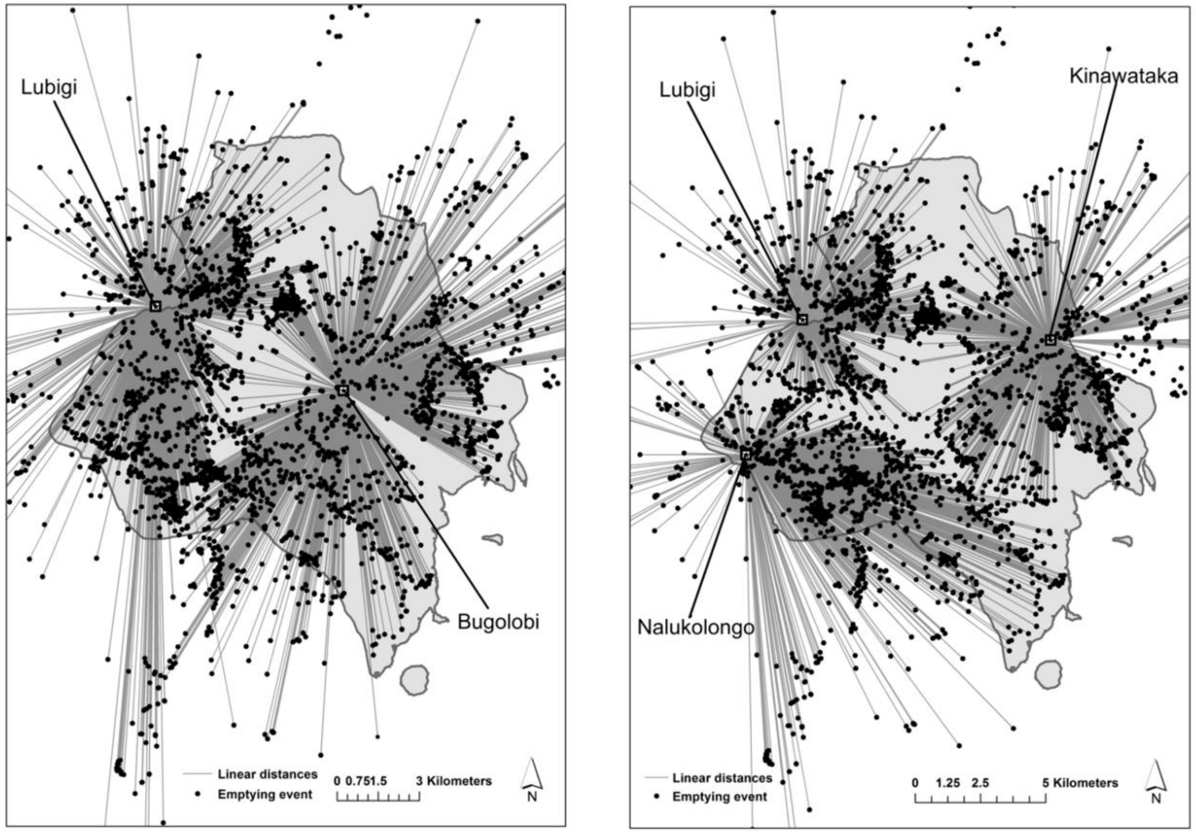
Wet anaerobic systems have the highest emissions

Our estimates are more realistic than IPCC



Operational emissions from trucks were MUCH lower than we expected

*Also true for treatment and sewerage pumps



(a) (b)

Linear distance of FSM trucks (Schoebitz et.al. 2017)

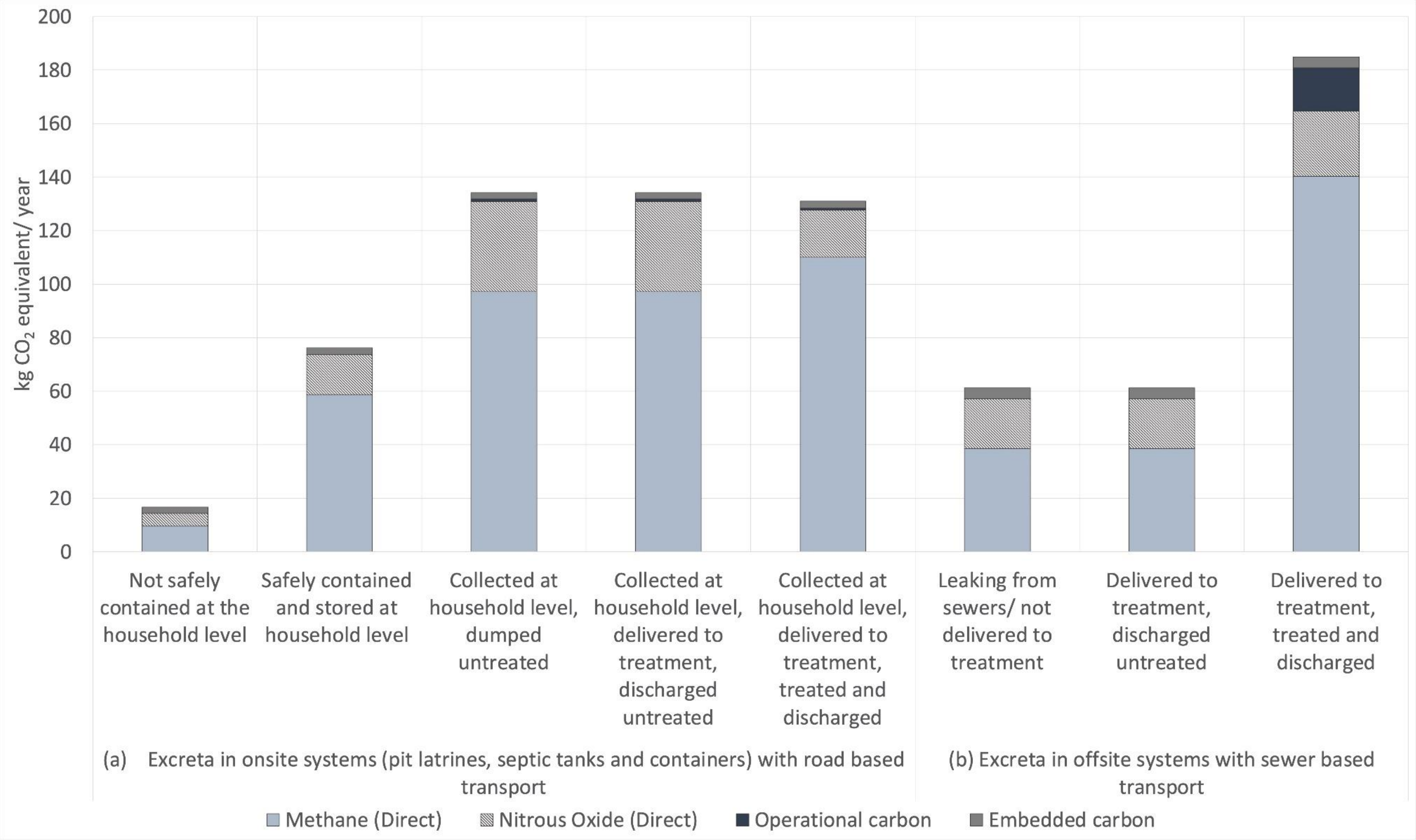
Table 4 Per capita annual emissions rates from sanitation system elements in Kampala ($kgCO_2e$/capita/year).

Sanitation service element	Direct CH_4	Direct N_2O	Operational CO_2	Embedded carbon	Total
Containment	58.63	15.13	–	2.43	76.18
Transport of faecal sludge in trucks	–	–	0.85	–	0.85
Treatment of faecal sludge	51.35	2.49	–	0.12	53.96
Transport of wastewater in sewers	–	–	–	4.06	4.06
Treatment of wastewater	140.27	24.34	16.16	0.02	180.79
Unsafe discharges to the environment	22.84	11.02	–	–	33.85

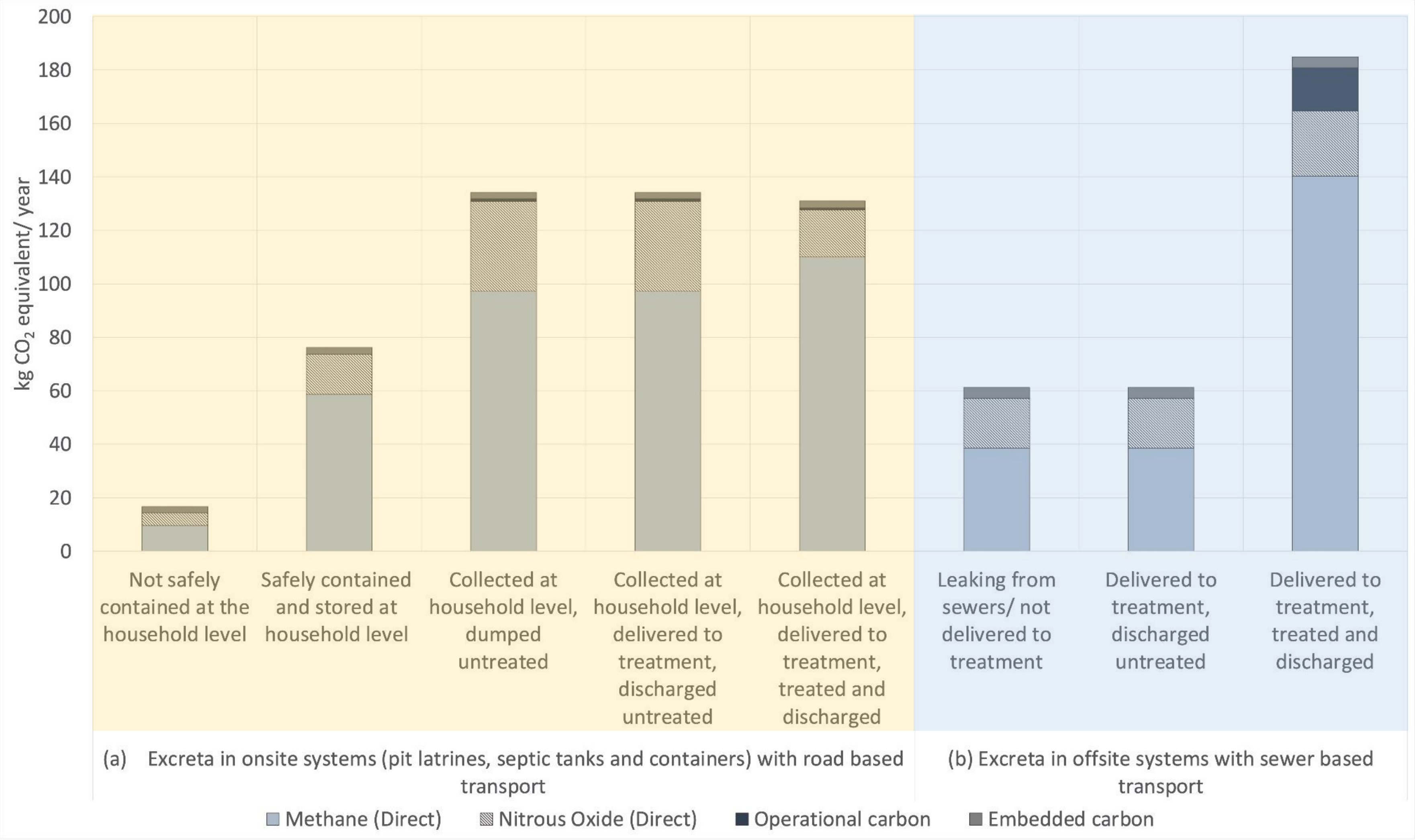
Direct methane accounts for the highest share of emissions for all systems

Treatment processes have the highest per capita emission rates

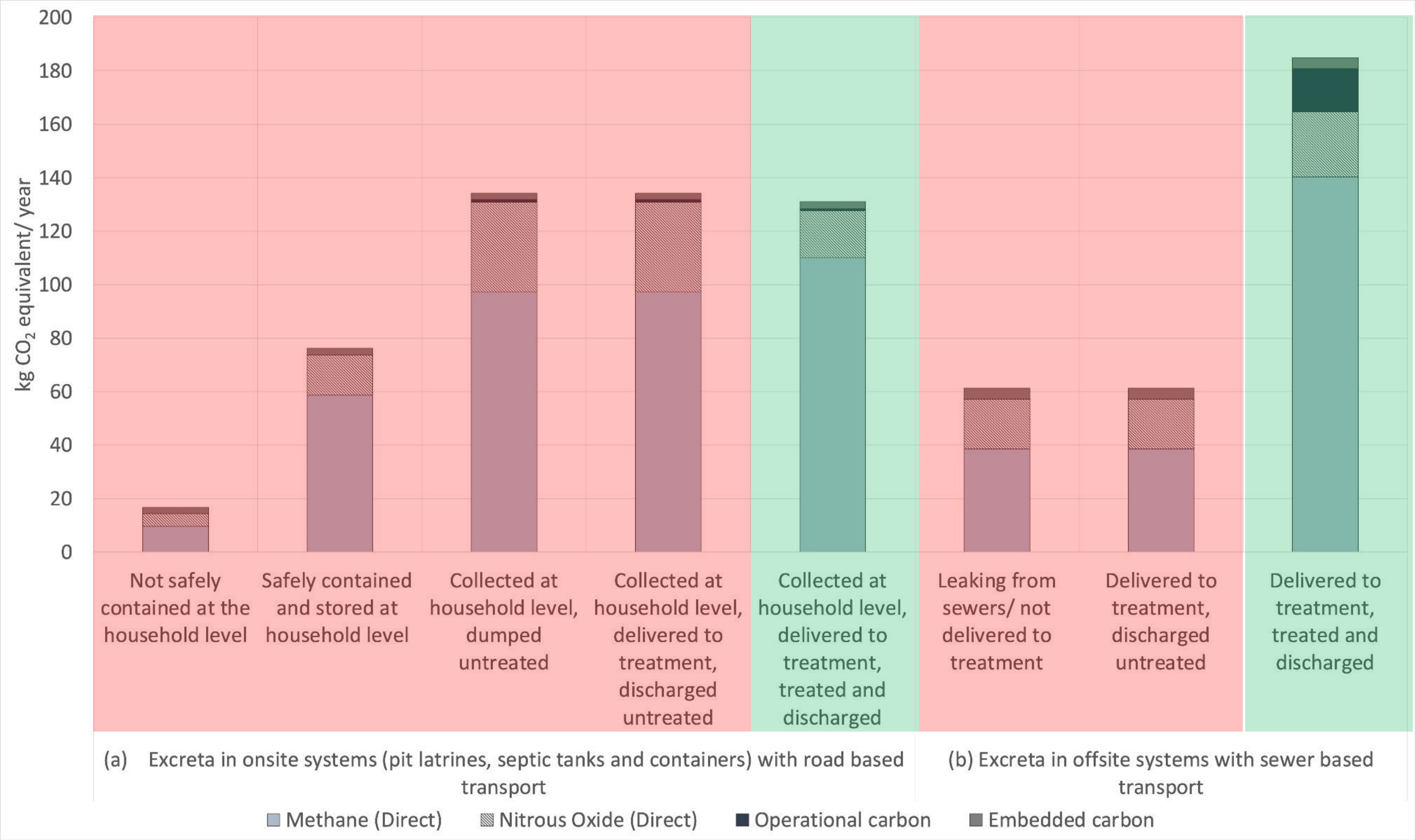
Different sanitation pathways have different per capita emission rates



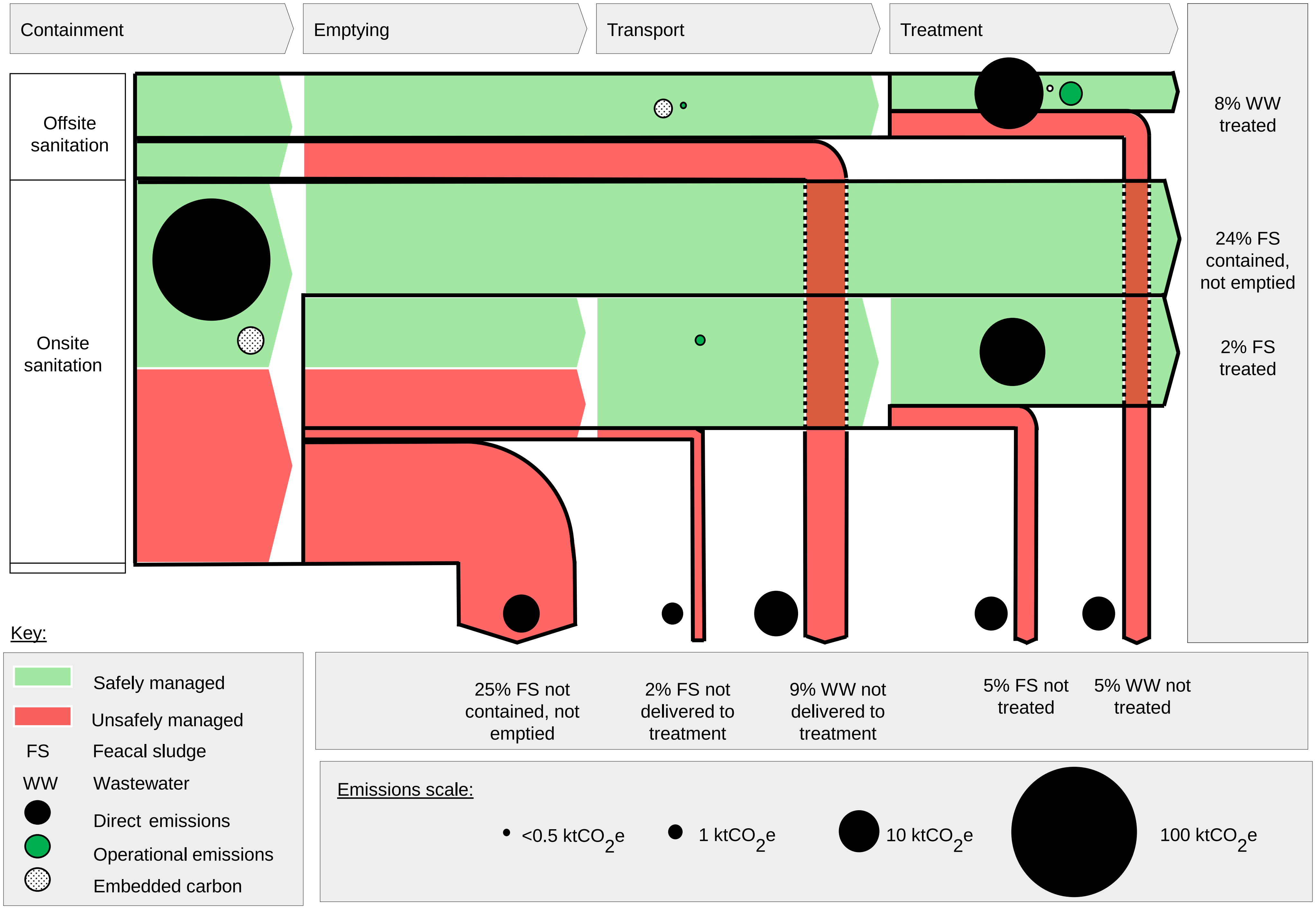
'Onsite/ FSM' systems are not inherently better or worse than offsite/ sewer systems



‘Safely managed’ sanitation pathways do not have inherently lower per capita emission rates



Total emissions dominated by storage, treatment and informal discharges



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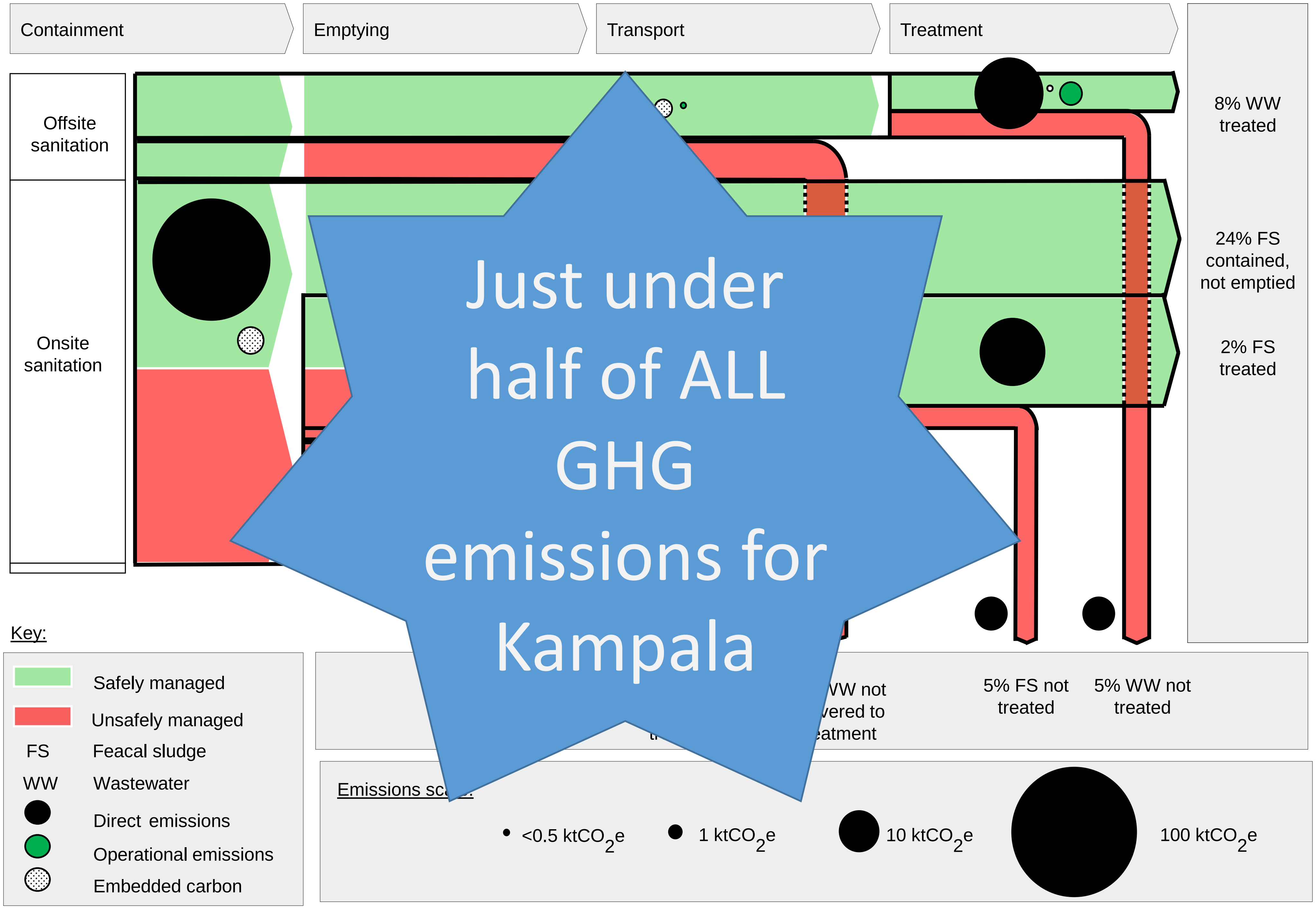
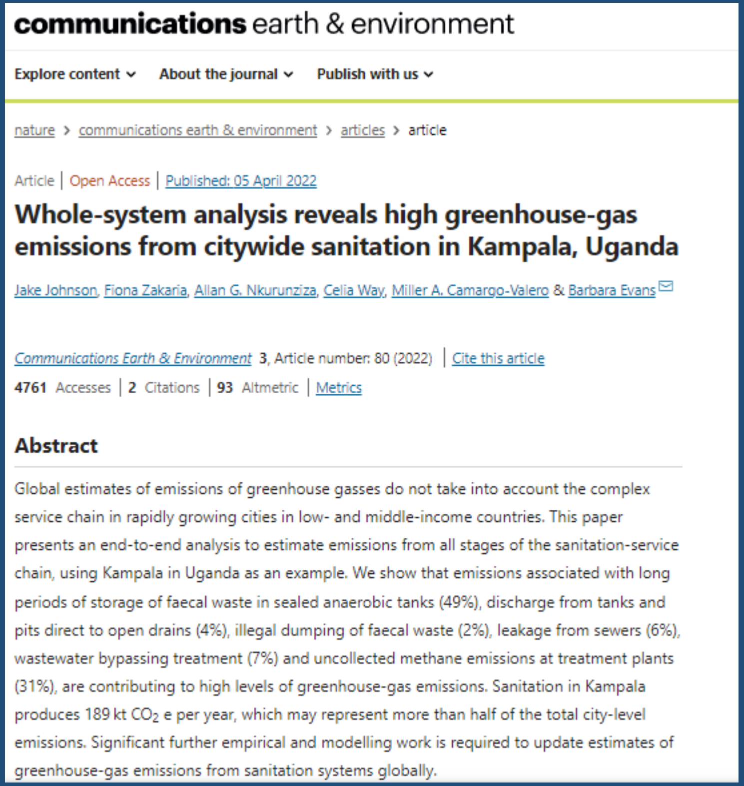


Johnson, J., Zakaria, F., Nkurunziza, A. G., Way, C., Camargo-Valero, M. A., & Evans, B. (2022). Whole-system analysis reveals high greenhouse gas emissions from citywide sanitation in Kampala, Uganda. *Communications Earth & Environment*, 3. doi: 10.1038/s43247-022-00413-w



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Whole-system analysis reveals high greenhouse-gas emissions from citywide sanitation in Kampala, Uganda

Jake Johnson, Fiona Zakaria, Allan G. Nkurunziza, Celia Way, Miller A. Camargo-Valero & Barbara Evans

Communications Earth & Environment 3, Article number: 80 (2022) | Cite this article

4761 Accesses | **2** Citations | **93** Altmetric | Metrics

Abstract

Global estimates of emissions of greenhouse gasses do not take into account the complex service chain in rapidly growing cities in low- and middle-income countries. This paper presents an end-to-end analysis to estimate emissions from all stages of the sanitation-service chain, using Kampala in Uganda as an example. We show that emissions associated with long periods of storage of faecal waste in sealed anaerobic tanks (49%), discharge from tanks and pits direct to open drains (4%), illegal dumping of faecal waste (2%), leakage from sewers (6%), wastewater bypassing treatment (7%) and uncollected methane emissions at treatment plants (31%), are contributing to high levels of greenhouse-gas emissions. Sanitation in Kampala produces 189 kt CO_2 e per year, which may represent more than half of the total city-level emissions. Significant further empirical and modelling work is required to update estimates of greenhouse-gas emissions from sanitation systems globally.

Song, C. et al (2023). Methane Emissions from Municipal Wastewater Collection and Treatment Systems *Environ. Sci. Technol. 2023, 57, 2248-2261* doi: https://doi.org/10.1021/acs.est.2c04388

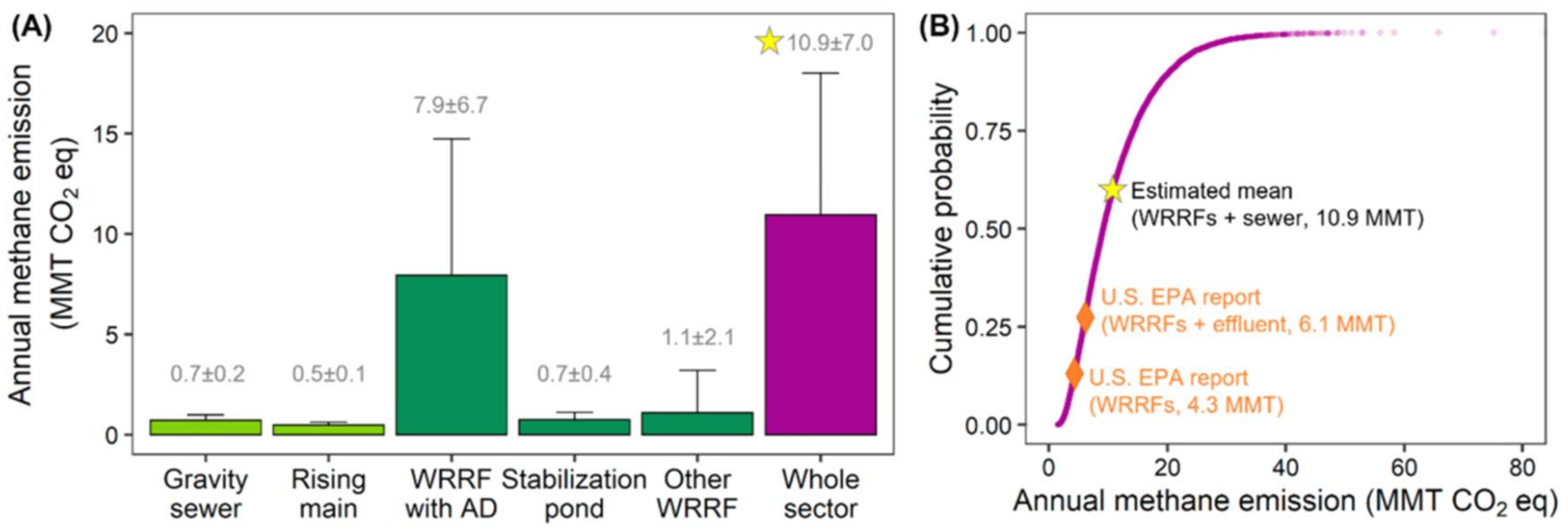
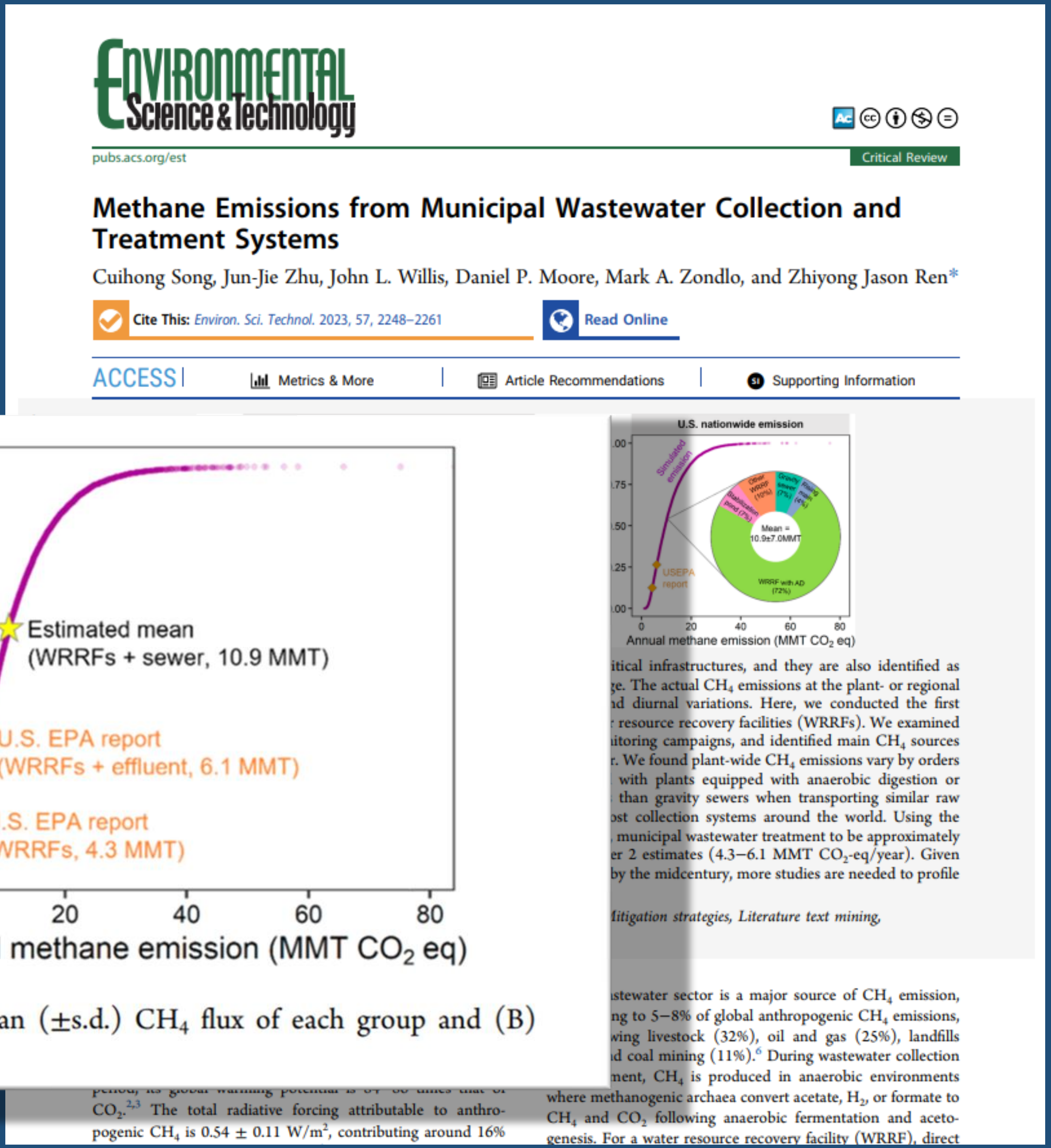
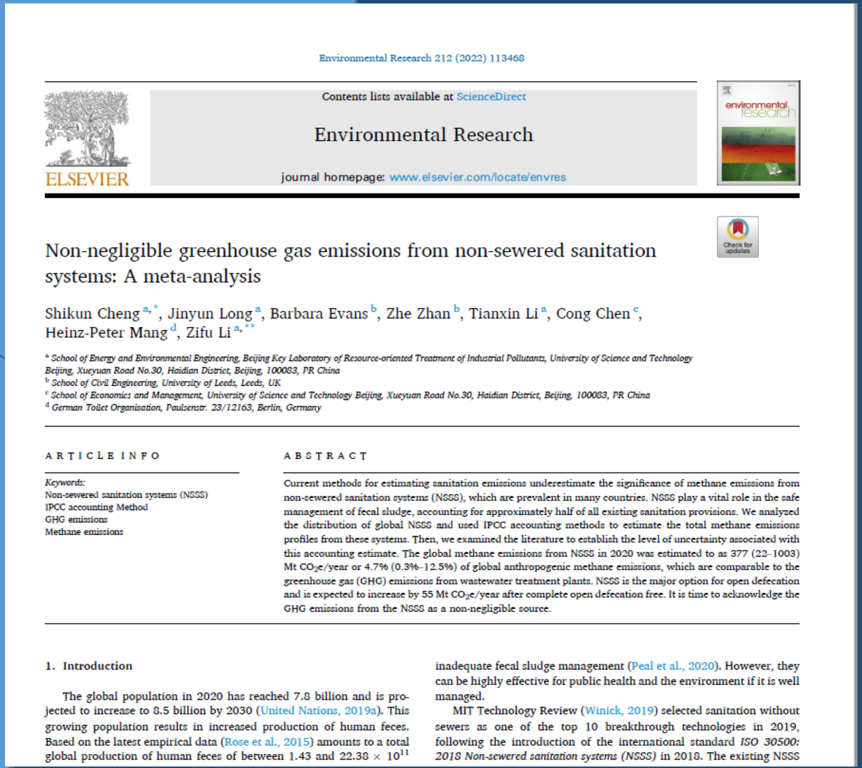


Figure 7. Nationwide CH_4 emissions from the U.S. wastewater sector. (A) Estimated annual mean (±s.d.) CH_4 flux of each group and (B) accumulative probability of CH_4 emissions from the whole wastewater sector.



Global methane emissions from onsite containers 2020

- 377 (22–1,003) Mt CO_2e/year
- 4.7% (0.3%–12.5%) of anthropogenic methane emissions
- Comparable to emissions from wastewater treatment plants.
- Significant in India, Indonesia, China, USA….



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Non-negligible greenhouse gas emissions from non-sewered sanitation systems: A meta-analysis

Shikun Cheng [a,*], Jinyun Long [a], Barbara Evans [b], Zhe Zhan [b], Tianxin Li [a], Cong Chen [c], Heinz-Peter Mang [d], Zifu Li [a,**]

[a] School of Energy and Environmental Engineering, Beijing Key Laboratory of Resource-oriented Treatment of Industrial Pollutants, University of Science and Technology Beijing, Xueyuan Road No.30, Haidian District, Beijing, 100083, PR China
[b] School of Civil Engineering, University of Leeds, Leeds, UK
[c] School of Economics and Management, University of Science and Technology Beijing, Xueyuan Road No.30, Haidian District, Beijing, 100083, PR China
[d] German Toilet Organisation, Paulsenstr. 23/12163, Berlin, Germany

ARTICLE INFO

Keywords:
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GHG emissions
Methane emissions

ABSTRACT

Current methods for estimating sanitation emissions underestimate the significance of methane emissions from non-sewered sanitation systems (NSSS), which are prevalent in many countries. NSSS play a vital role in the safe management of fecal sludge, accounting for approximately half of all existing sanitation provisions. We analyzed the distribution of global NSSS and used IPCC accounting methods to estimate the total methane emissions profiles from these systems. Then, we examined the literature to establish the level of uncertainty associated with this accounting estimate. The global methane emissions from NSSS in 2020 was estimated to as 377 (22–1003) Mt CO_2e/year or 4.7% (0.3%–12.5%) of global anthropogenic methane emissions, which are comparable to the greenhouse gas (GHG) emissions from wastewater treatment plants. NSSS is the major option for open defecation and is expected to increase by 55 Mt CO_2e/year after complete open defecation free. It is time to acknowledge the GHG emissions from the NSSS as a non-negligible source.

1. Introduction

The global population in 2020 has reached 7.8 billion and is projected to increase to 8.5 billion by 2030 (United Nations, 2019a). This growing population results in increased production of human feces. Based on the latest empirical data (Rose et al., 2015) amounts to a total global production of human feces of between 1.43 and 22.38 × 10^{11}

inadequate fecal sludge management (Peal et al., 2020). However, they can be highly effective for public health and the environment if it is well managed.

MIT Technology Review (Winick, 2019) selected sanitation without sewers as one of the top 10 breakthrough technologies in 2019, following the introduction of the international standard *ISO 30500: 2018 Non-sewered sanitation systems (NSSS)* in 2018. The existing NSSS

Glo l methane em f e

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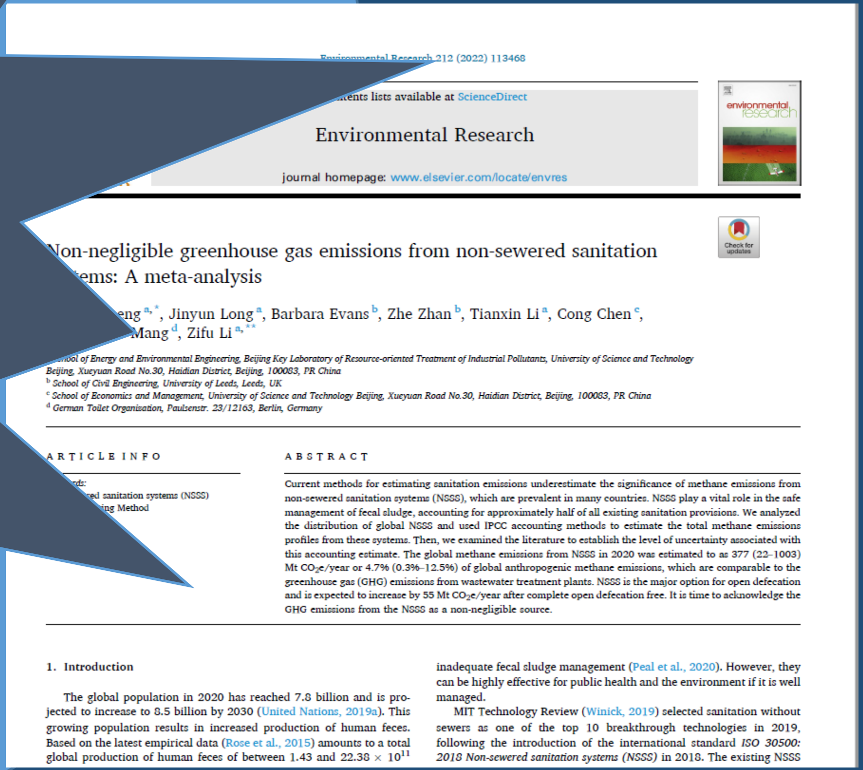
Could be more than 10% of anthropogenic methane emissions



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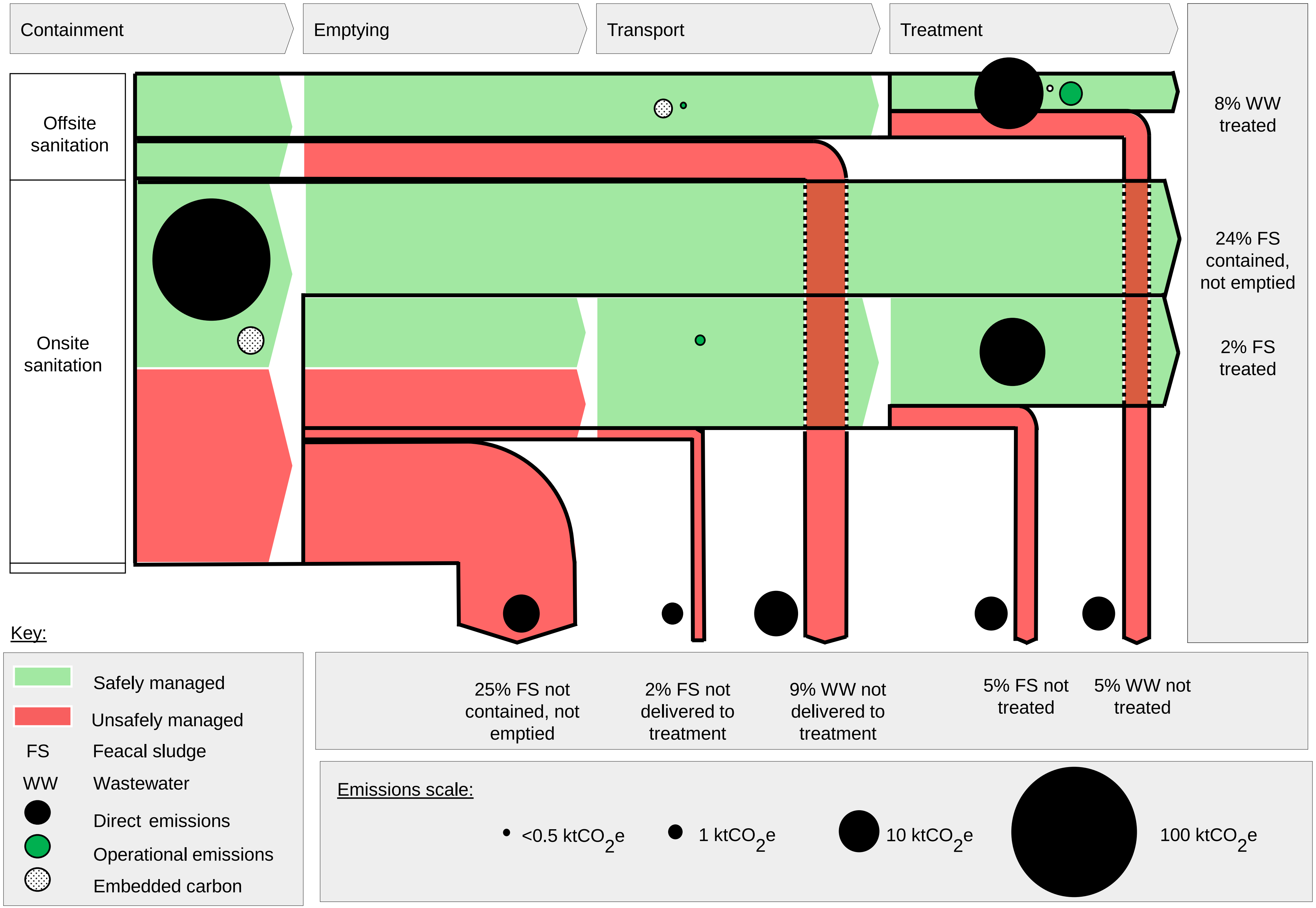
Mitigation (also in India)

What might this mean for Implementation?

Total emissions dominated by storage, treatment and informal discharges



- Greenhouse gas emissions along the sanitation value chain are dynamic and interrelated – the best interventions are context specific

- Reducing emissions is associated with management of storage systems onsite – including pits and tanks – but also management of supernatant, or the liquid fraction

- Being thoughtful about treatment – thinking about end products (including biogas/ methane) and designing treatment appropriately

- Methane from anaerobic parts of the system (storage in pits and tanks, illegal dumping, treatment), is the major contributor to overall emissions
- Reducing emissions for sanitation NOT about specific technologies (ie onsite versus sewers) but about systems
- Reducing emissions IS about 'actively-managed WASH' - moving fecal waste quickly and maintaining infrastructure – both of which are also good for resilience

Thankyou