Greenhouse Gas Emissions from Sanitation Systems and their Global Impact

GHG emissions from the Sanitation Service Chain

- Direct Emissions
  CH_4 and N_2O, some CO_2
- Operational Emissions
  CO_2 (e.g. trucks/pumps)
- Embedded Carbon
  (e.g. from construction)

All sections of the Sanitation Service Chain can release emissions, with **methane** appearing to be the primary sanitation GHG of concern

Text adapted from: Johnson (2022). Images from: Bottom Left: UNICEF https://www.unicef.org/esa/sanitation-and-hygiene , Bottom Right: Ben S-R (Brazil), Top Left: https://en.wikipedia.org/wiki/Blair_toilet#/media/File:Blair_VIP_Toilet.jpg
Top Right: https://upload.wikimedia.org/wikipedia/commons/thumb/1/17/Vacuum_tanker_for_pit_emptying.jpg/1280px-Vacuum_tanker_for_pit_emptying.jpg

How accurate are global emissions estimates? Case study of: Kampala, Uganda

IPCC methods may underestimate emissions:

- Emissions from Kampala may be underestimated by 1/3
- Safely managed ≠ low emissions
- Highest emissions: WWTPs, storage & treatment of faecal sludge, & unsafe discharges

Johnson et al. (2022)

Global emissions: "Non-Sewered Sanitation Systems" (NSSS*)

Cheng et al. (2022)

- Average global CH_4 emissions from NSSS: ~377 Mt CO_2e/year in 2020 *(using the IPCC accounting method)*
- This is <u>4.7% of global anthropogenic CH_4 emissions</u>, equal to ~60% of WWTP CH_4 emissions
- Moving from OD to NSSS adds ~111 kg CO_2e/pp/year, an increase of 55 Mt CO_2e/year at ODF

WWTPs = 632 Mt CO_2e/year for 2020
ODF: Open Defecation Free - SDG 6.2 [2030]

What effects would these emissions have globally?

Author's own work, created using: FaIR version 1.6.4 (Smith et al., 2018)

Climate modelling can show the potential global effects of inaccurately estimated Road-Based Sanitation System (RBSS) GHGs

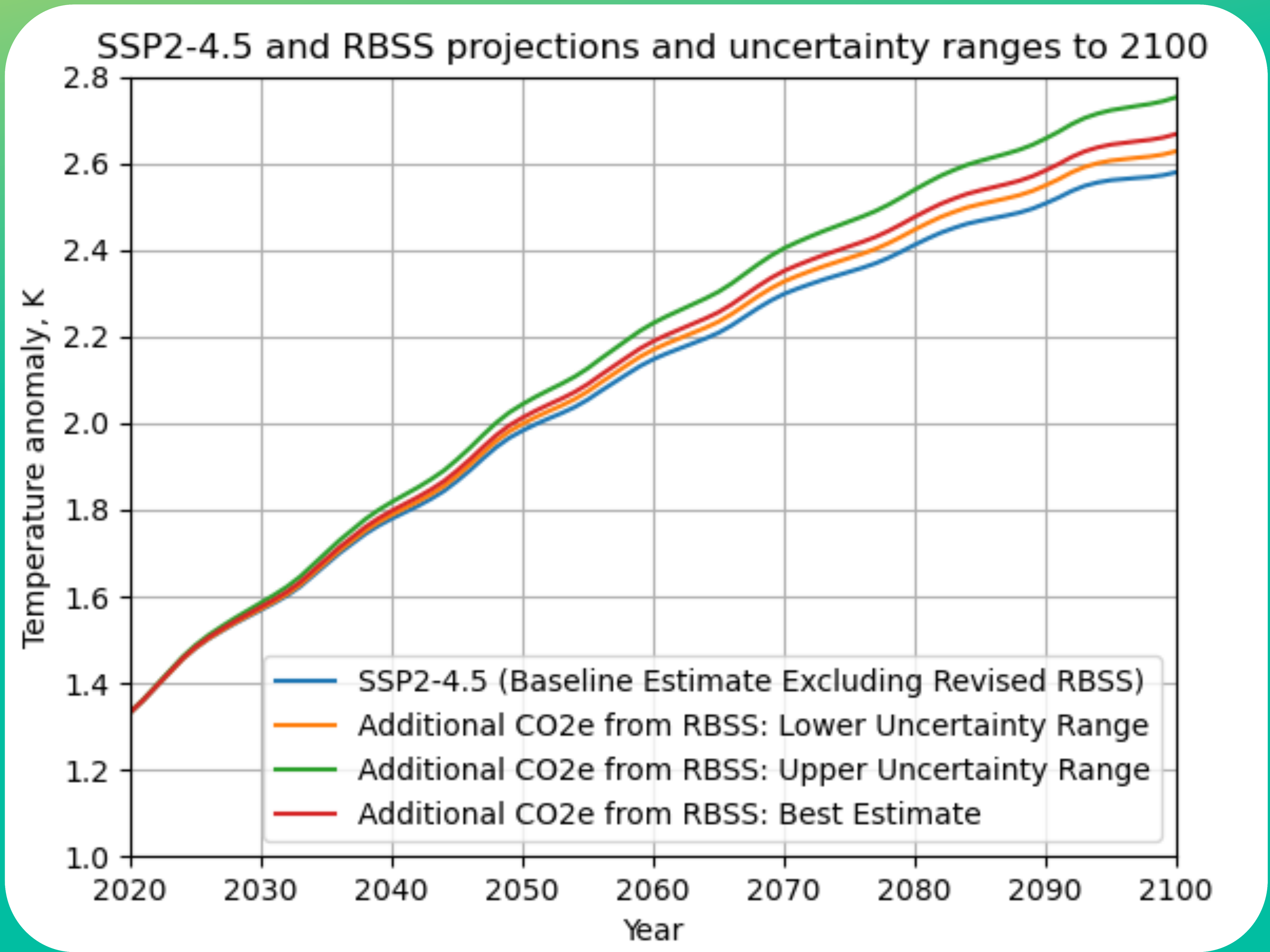
OD population to RBSS* scenario:

- Adds 111 kg CO_2e/pp/yr until ODF & a pulse of 377 Mt CO_2e in 2020 for historically unaccounted for RBSS GHGs
- …plus upper & lower uncertainty range scenarios for 2020: 88 to 1003 Mt CO_2e
- Produces a *best estimate* temperature difference of 0.088°C in 2100
- Upper range of uncertainty produces <u>0.059°C in 2050 and 0.173°C in 2100</u>

Underlying data adapted from: Cheng et al. (2022)

Some example Future Research:

- Improved climate projections using the new version of FaIR v2.1.0
- Lab/field work to gain empirical data
- Site improvements to reduce emissions



**N.b. "NSSS" is taken from Cheng et al. (2022) but this term may not capture all relevant on-site systems (e.g. septic tanks using effluent sewers). Hence, "Road-Based Sanitation Systems" has been used instead*

Key References:
"FAIR v1.3: a simple emissions-based impulse response and carbon cycle model" – Smith et al. (2018)
"Non-negligible greenhouse gas emissions from non-sewered sanitation systems: A meta-analysis" – Cheng et al. (2022)
"Whole-system analysis reveals high greenhouse-gas emissions from citywide sanitation in Kampala, Uganda" – Johnson et al. (2022)

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