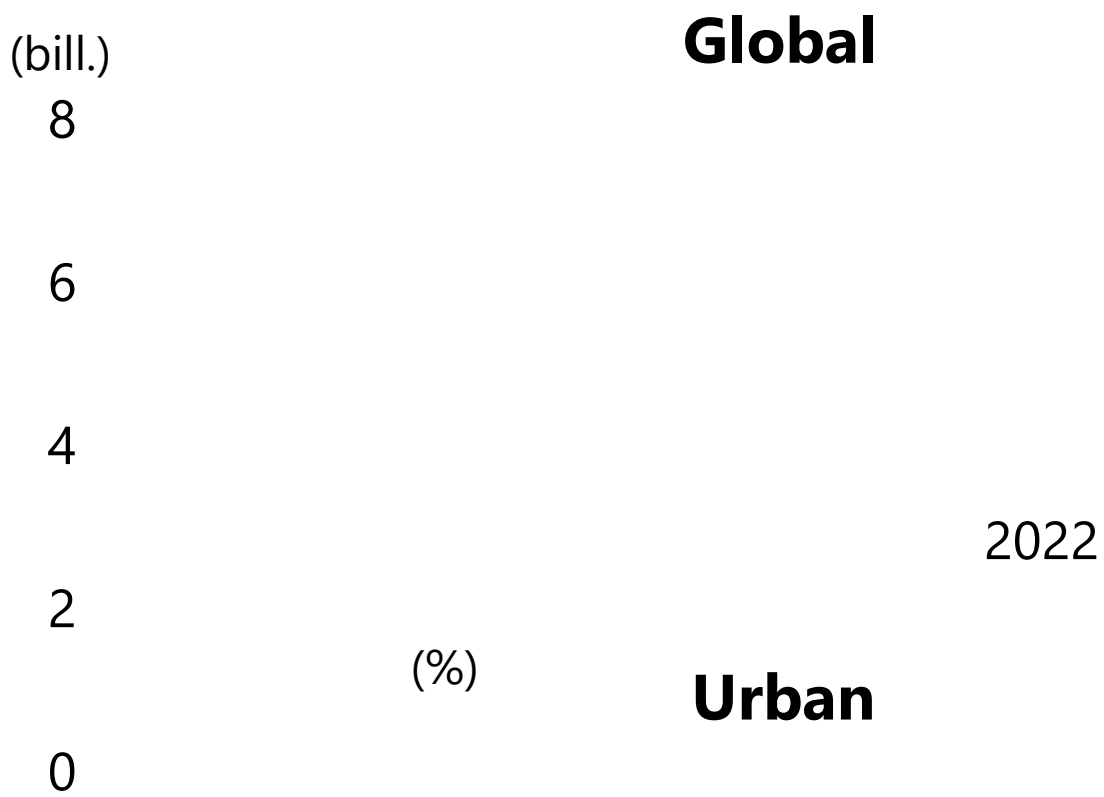
Desludging Challenges: Practices, Reasons, and Impacts in Asian countries

Hidenori Harada

Kyoto University

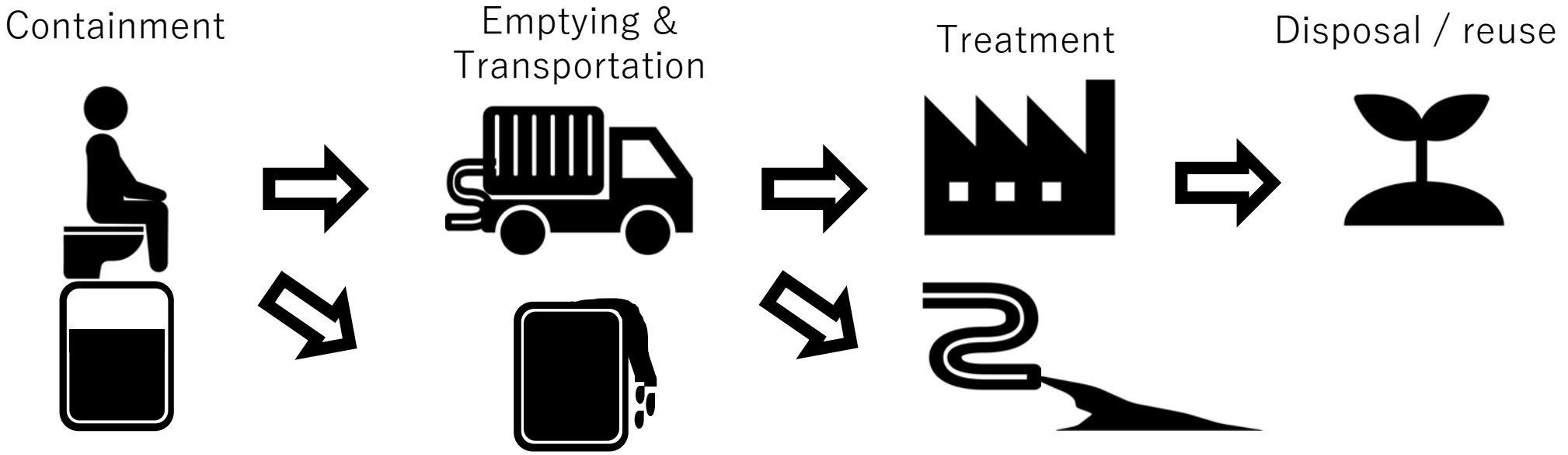
Background

- How do we secure sanitation for remaining 3.5 billion people?
- An increasing role of NSS
  - ✓ Globally, Non-sewered > Sewered since 2012
  - ✓ A higher increase rate in urban
- Expected roles for urban poor
  - ✓ Slum pop.: 25% in EA and SEA, 54% in SSA[1)]
  - ✓ Equity and City-Wide Inclusive Sanitation
- Septic systems as a major NSS to serve for 2.0 billion in 2024[2)].



1) UN Stats SDG Indicators Database; 2) WHO/UNICEF JMP

Desludging in Fecal sludge management



Desludging is a vital step for FSM.

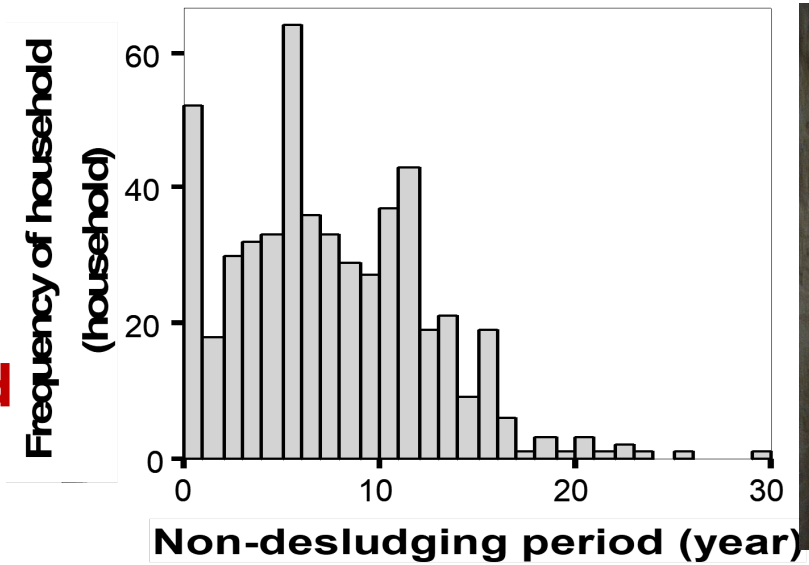
In reality,
it is challenging

What is the challenges of desluding in reality?

Not ready to be desludged: a case in Hanoi

- App. 90% of people in Hanoi, where effluent is mostly discharged, without leaching fields.
- Not really bad configurations:
  - Tank capacity ≥ 3.0 m^3: 83.0% (med. = 5.4 m^3)
  - HRT: app. 40 days

- **However, not ready to be desludged.**
  - **41.2% w/o any access holes**
  - **50.9% w/ cement-fixed holes**
  - **68.4% > 5 years not desludged**
  - **Also, physical difficulty**



Source: Harada, H. et al., (2008) *Water science and technology*, **58**(6): 1305–1311.

Tendencies to be desludged regularly : a case in Hanoi

- Older and smaller tanks more desludged
- Educated group with less desludging
- Emptied after experiencing troubles

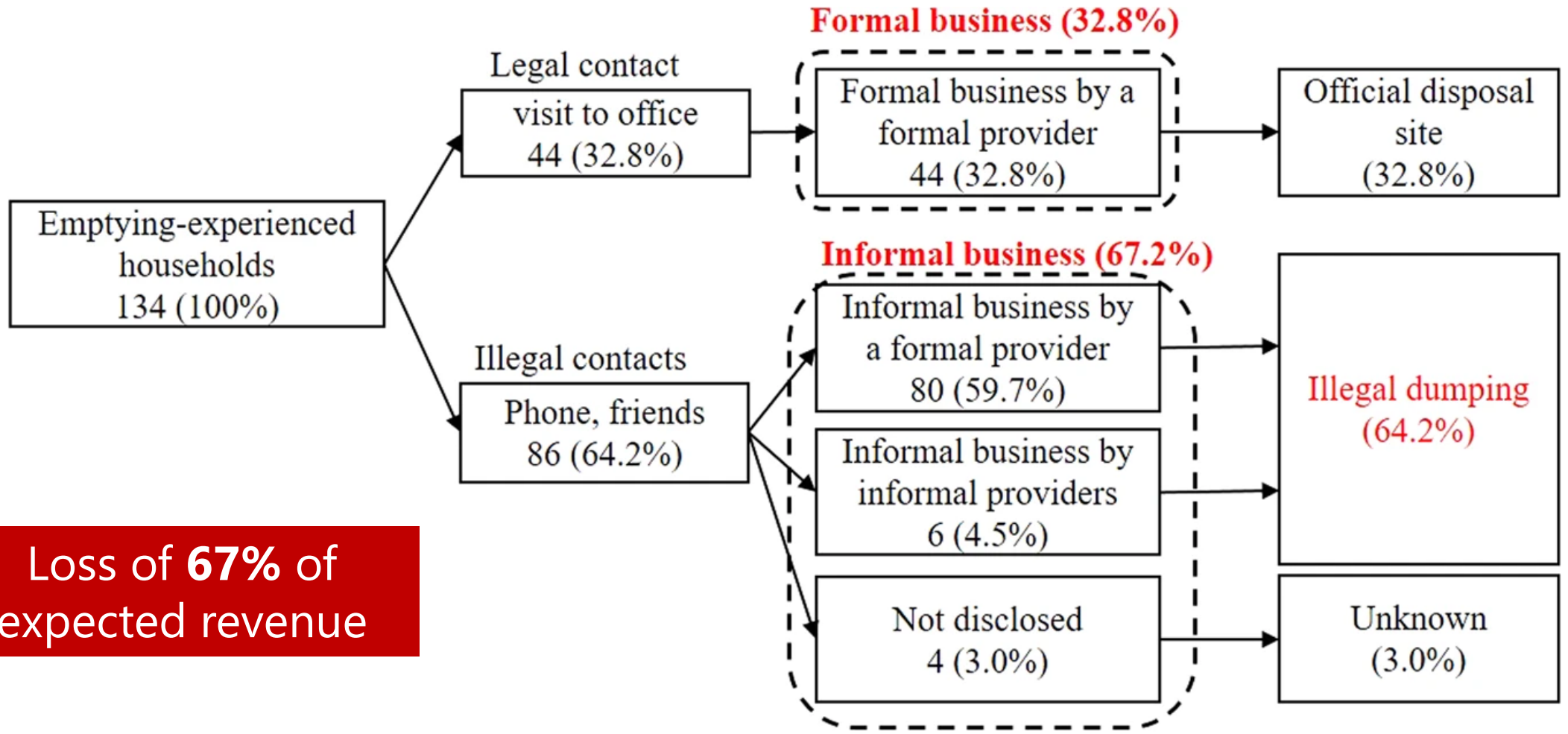
This is not a matter of poor or low education, but people do not empty without troubles

Table Differences in regular emptying practices by household conditions in Hanoi

Item	*n*	with regular emptying	without non-regular emptying
Median years after the tank installation	507	15 years	7 years
Tank volume	353	3.0 m^3	5.5 m^3
Education level			
Low	70	11.4%	88.6%
Middle	256	4.7%	95.3%
High	192	3.6%	96.4%
Experience of troubles of the tank			
Yes	29	48.3%	51.7%
No	489	2.9%	97.1%

How does informal desludging happen?

Different forms in informal emptying: a case in Mandalay

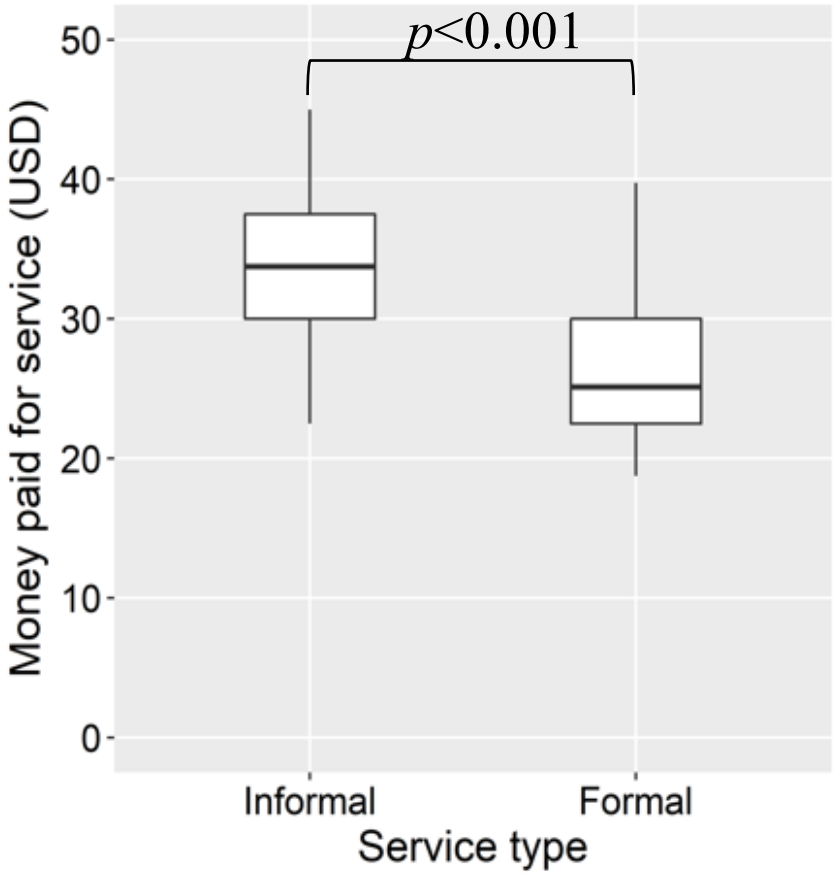


Loss of **67%** of expected revenue

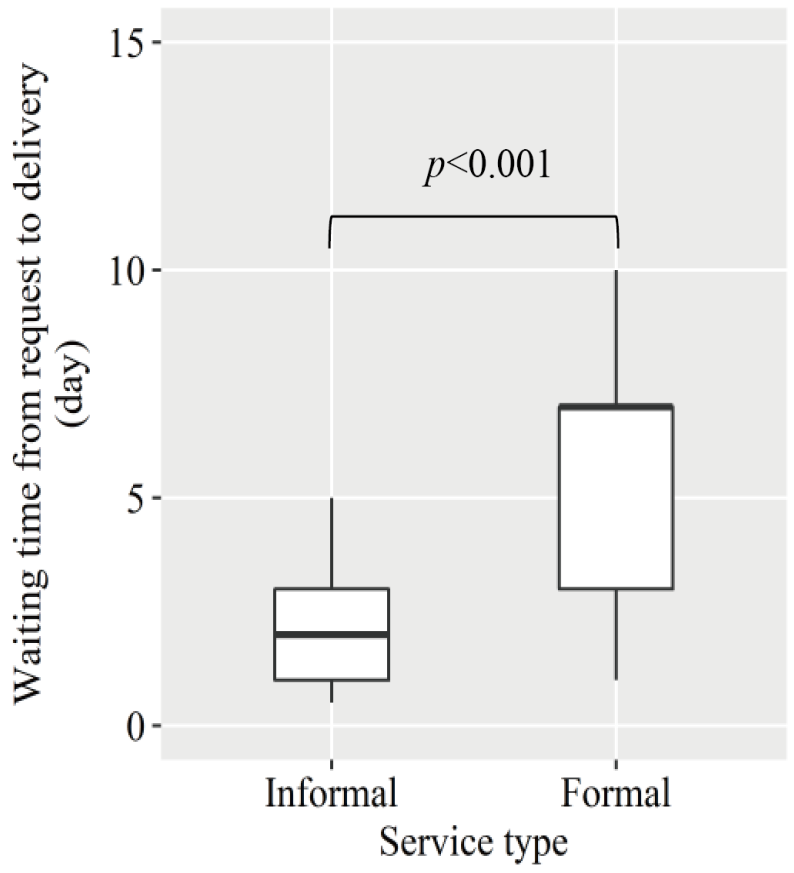
Fig. Choice of fecal sludge emptying services. Data obtained from emptying-experienced household (n = 134). The number indicate household numbers and their proportions

Source: Naing W, Harada H et al., (2020) Environmental Management, 65:122–130

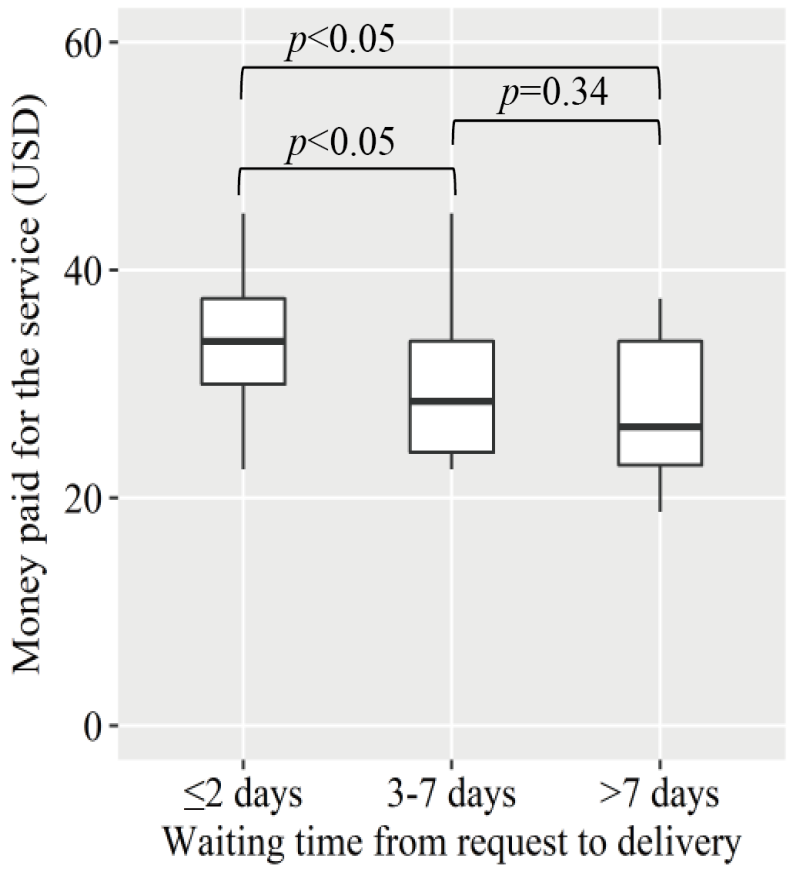
Why did they choose the informal? : a case in Mandalay



The informal was more expensive.



The informal was faster.



People paid more for faster.

The formal needs quick service delivery to have sound desludging.

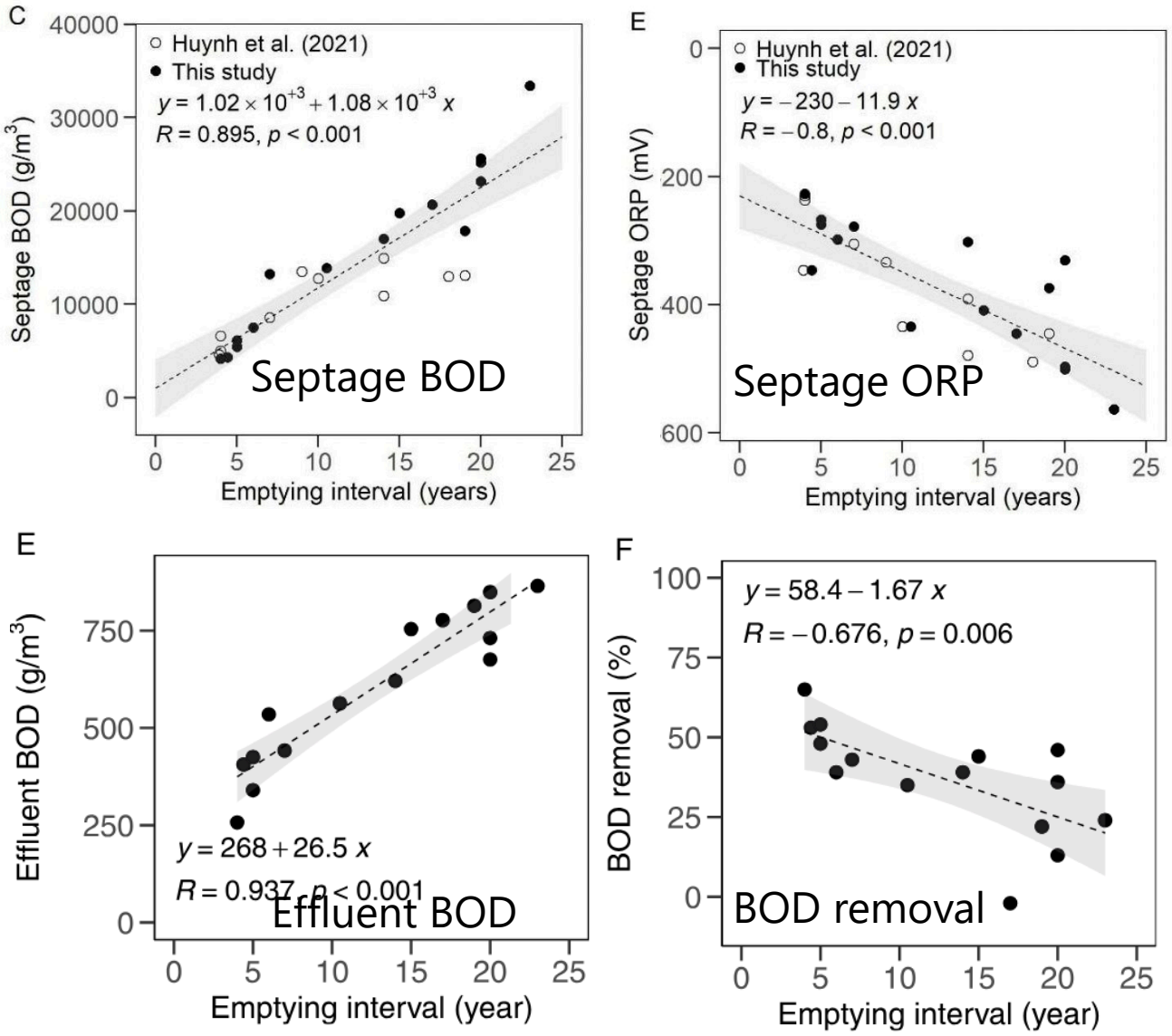
Source: Naing W, Harada H et al., (2020) Environmental Management, 65:122–130

What does overdue desludging cause?

Impact of overdue desluding: inside septic tanks

- **Septage changed along desluding interval length**
  - More organic mass
  - More strongly reducing
  - More polluted effluent
  - Less BOD removal

- **Poor treatment with long interval**
  - **Annual emptying could remove 71% of BOD load compared to the current.**
- **More favorable for CH_4 emission**



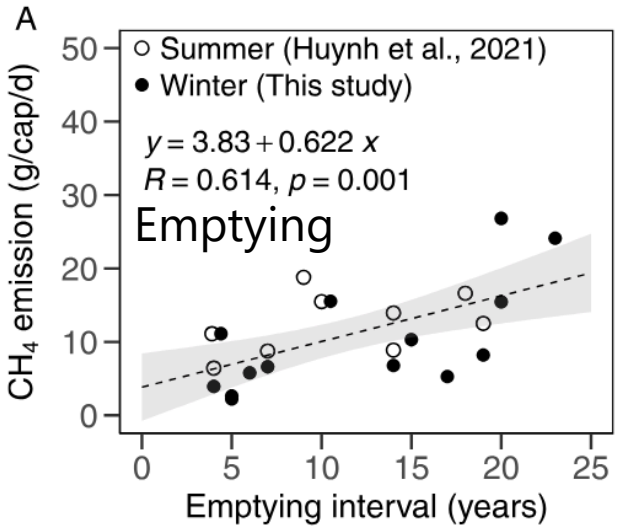
Source: Moonkawin et al. (2023), ES&T; Harada, H. et al., (2008), Water science and technology.

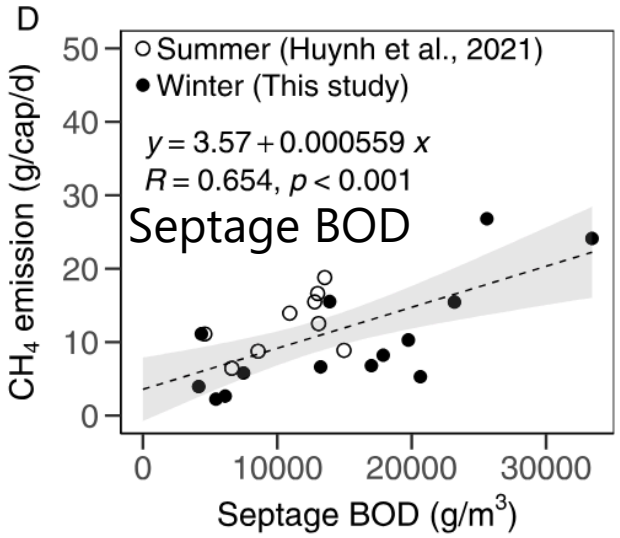
Impact of overdue desludging: GHG emission

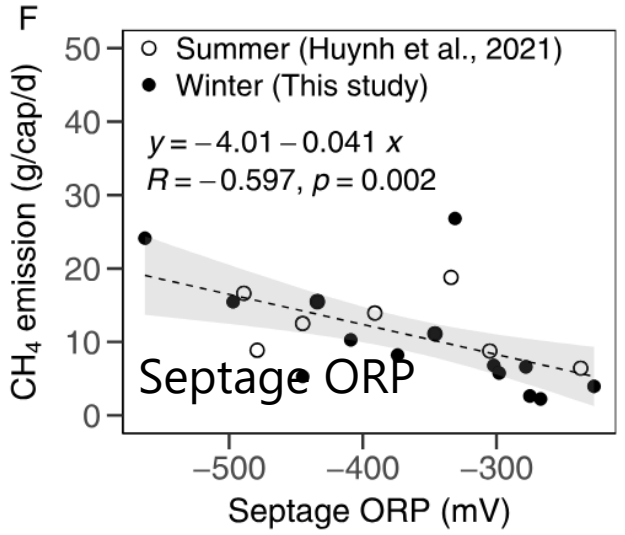
- **CH_4 emission rates correlated with:**
  - Emptying intervals (+)
  - Septage BOD (+)
  - Septage ORP (-)

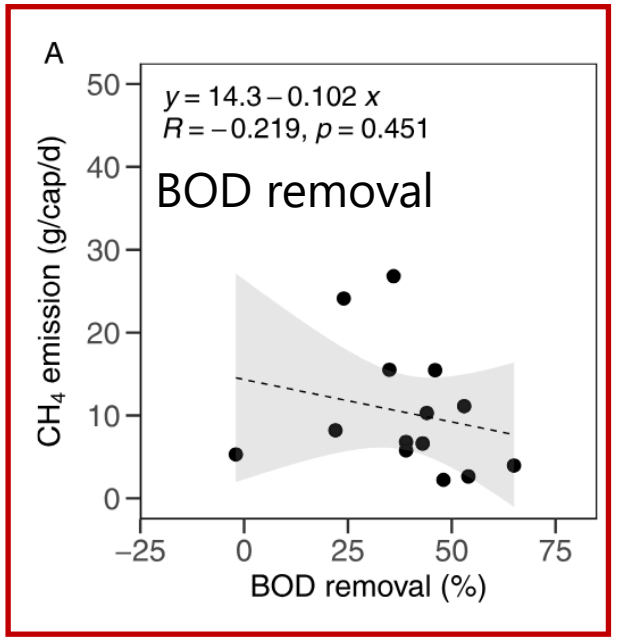
- **Malfunctioning STs**
  - Still produced CH_4 w/o BOD removal
  - Much accumulated organics under strong reducing conditions

The IPCC method assume that CH_4 positively proportional to BOD removal.
->Potential discrepancy to IPCC for poorly-maintained STs









Source: Moonkawin, … Harada (2023), ES&T.

City-wide GHG emission from sanitation services

Primary Sources:

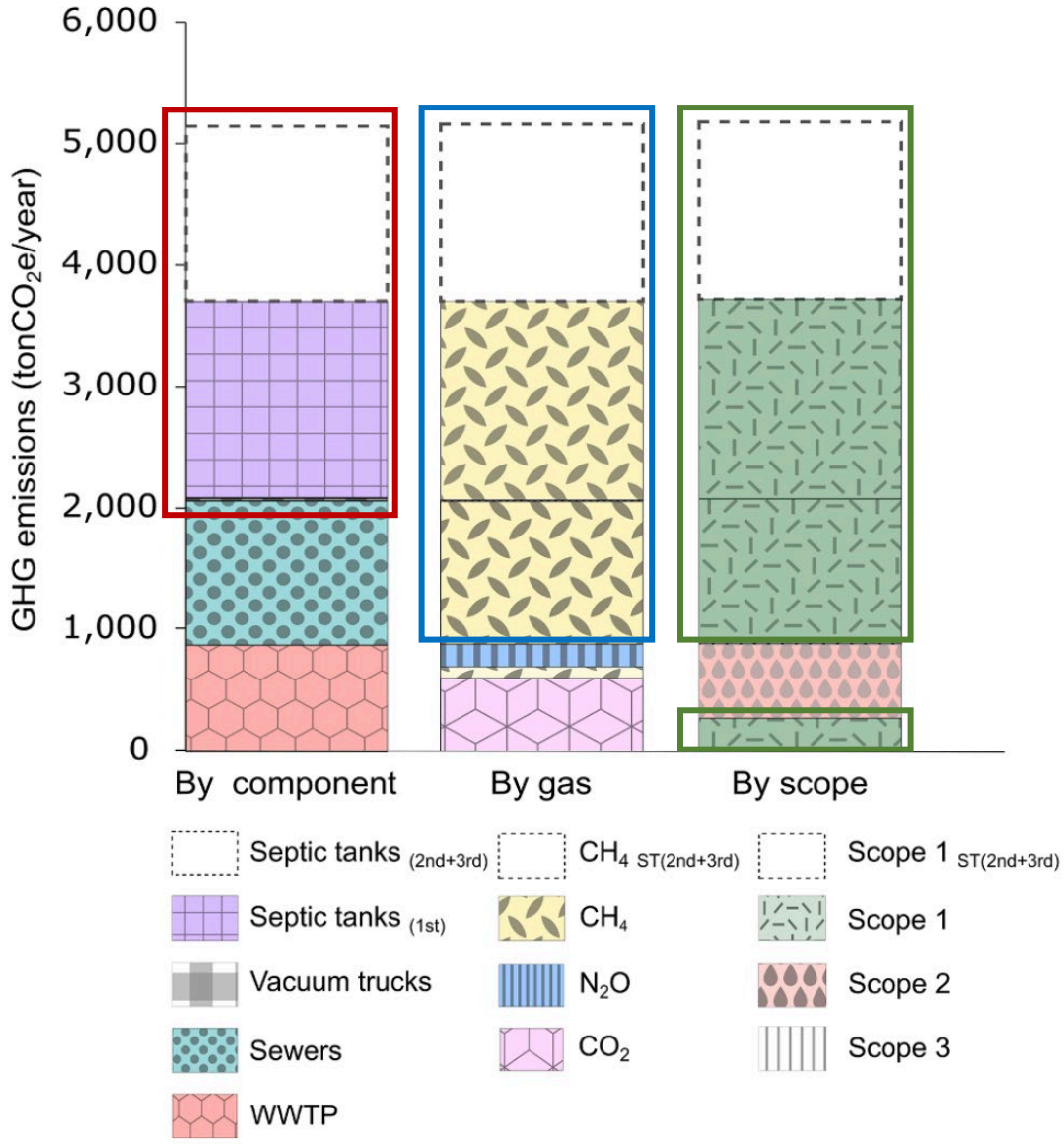
Poorly-maintained septic tanks (44-60%) and stagnant sewers (23-32%).

Gas type:

A methane-dominated system; CH_4 accounted for 78-85%.

Scope Analysis:

Direct emissions from wastewater decomposition (Scope1) vastly outweighed electricity-related emissions (Scope2).



Septic tank emission based on the own empirical equation by emptying intervals

Source: Moonkawin, … Harada (2023), ES&T.

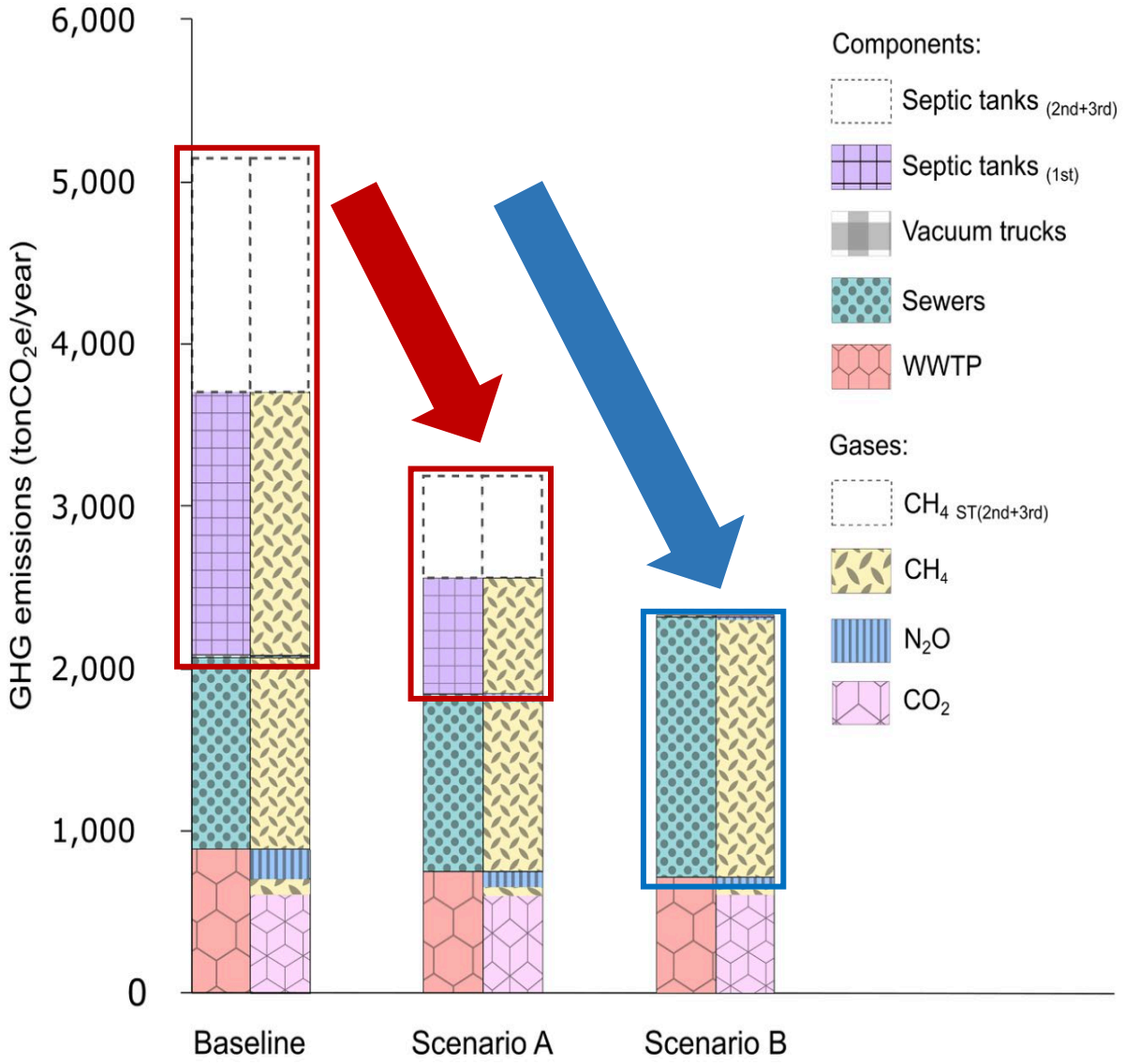
GHGs Mitigation by proper desludging

☐ Annual desludging (A)

- Decreased by 31-38%,
- An effective, non-disruptive strategy w/o infrastructure overhaul.
- Still, septic tanks remained as a significant source.

☐ Septic tank removal (B)

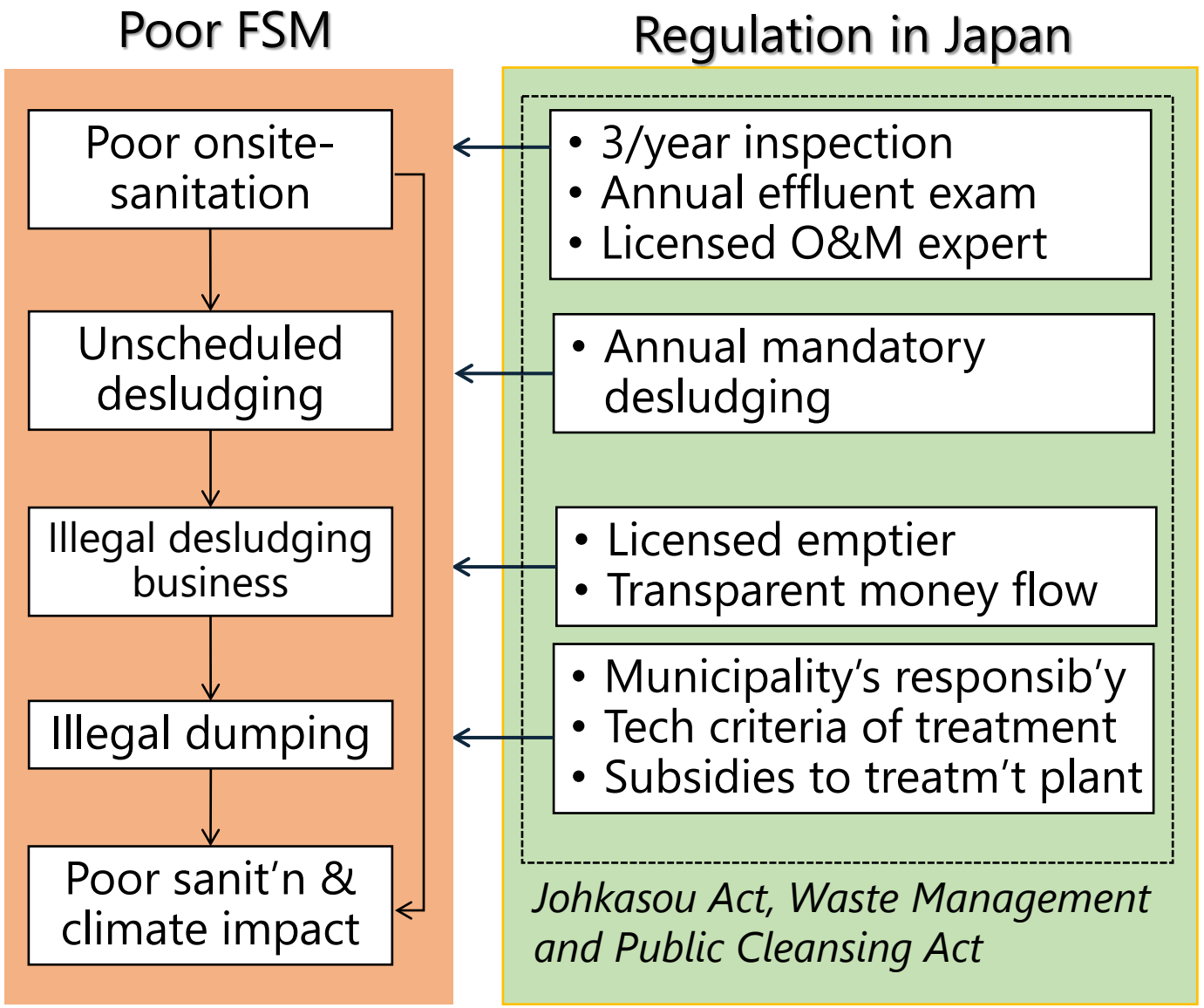
- Increased emission from sewers but reduced in total (37–55%).
- May face high social and financial implementation barriers (e.g., by-pass work inside private property).

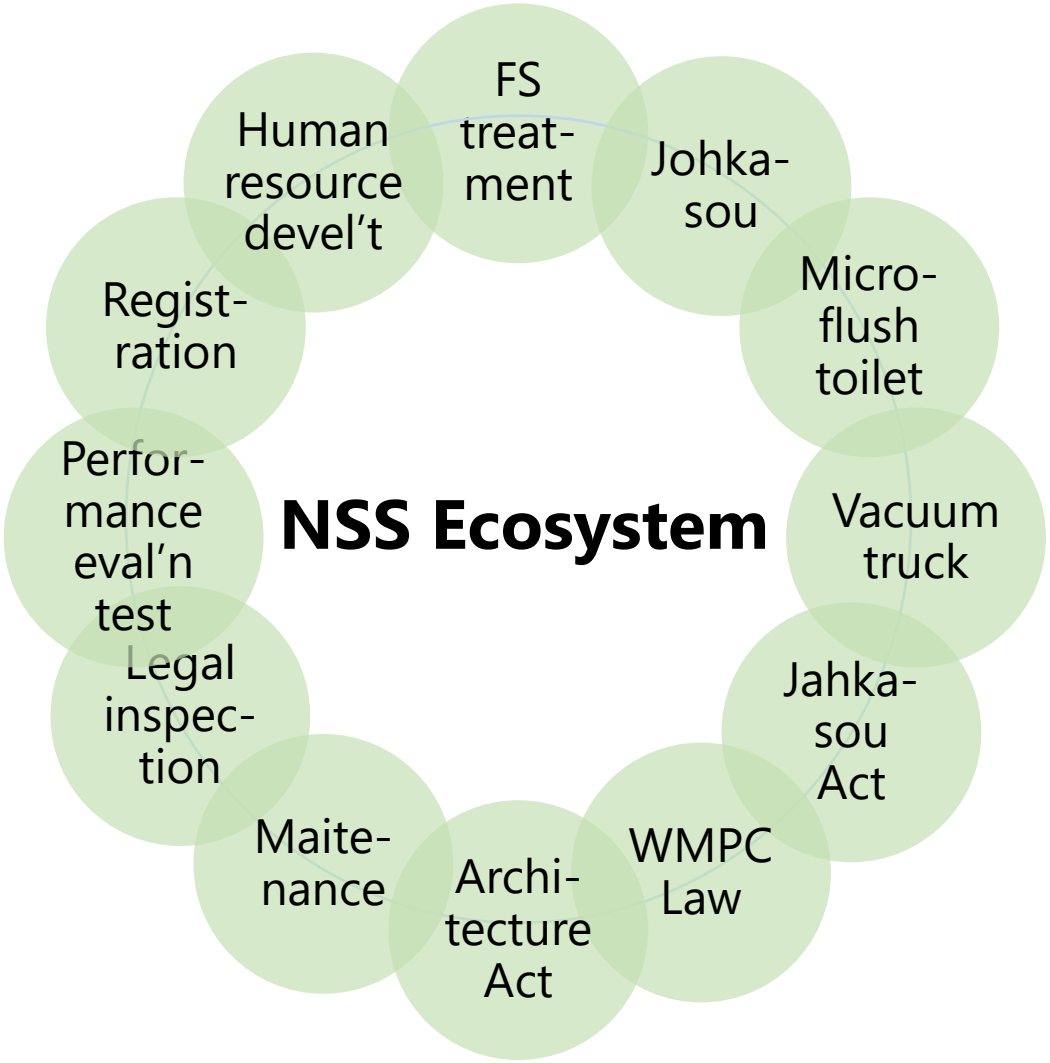


Source: Moonkawin, … Harada (2023), ES&T.

Implications

Needs of NSS Ecosystem





Conclusions

- **Regular desludging is vital but not always implemented in proper manners.**
- **Co-benefit of the betterment of septic tank desludging**
  - Proper emptying can achieves both water environment protection and climate change mitigation.
  - Reduced GHGs can be a potential incentive to improve NSS and FSM.
- **Ecosystem of NSS, to sustain sound continuous operation**
- **Holistic pictures of NSS and SS in integrated and cooperated manners**

Key reference

- Moonkawin, J., …, Harada, H. Impact of GHG mitigation measures in sanitation service chains: a focus on septic tanks and sewers, *Water Research*. 288(A), 124618 (2025). doi: 10.1016/j.watres.2025.124618
- Moonkawin, J., …, Harada, H. Challenges to Accurate Estimation of Methane Emission from Septic Tanks with Long Emptying Intervals. . *Environ. Sci. Technol.* 57 (43): 16575–16584 (2023). doi: 10.1021/acs.est.3c05724
- Huynh, T.L., Harada H., et al. Greenhouse Gas Emissions from Blackwater Septic Systems. *Environ. Sci. Technol.* 55, 1209–1217 (2021). doi: 10.1021/acs.est.0c03418
- Naing, W., Harada, H., Fujii, S. & Hmwe, C. S. S. Informal Emptying Business in Mandalay: Its Reasons and Financial Impacts. *Environ. Manage.* 122–130 (2019). doi:10.1007/s00267-019-01228-w
- Harada, H., Dong, N. T. & Matsui, S. A measure for provisional-and-urgent sanitary improvement in developing countries: septic-tank performance improvement. *Water Sci. Technol.* 58, 1305–1311 (2008). doi: 10.2166/wst.2008.715

Thank you for your kind attention.

Water Env Lab Sanitation Hygiene

https://wash.africa.kyoto-u.ac.jp

@HHarada_KU