Climate Risks and Sanitation Challenges

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The Urban Sanitation Challenge

- **Asia and Pacific cities are growing rapidly**. By 2030 more than 55% of the region's population will live in urban areas.
- With higher population densities and urban expansion, **managing large amounts of human waste is becoming ever more challenging.**
- **Inadequate sanitation services have a significant impact** on
  - city and national economies
  - quality of life for all residents
  - public health
  - productivity and competitiveness
  - the environment and real estate values.


Mumbai, Maharashtra, India
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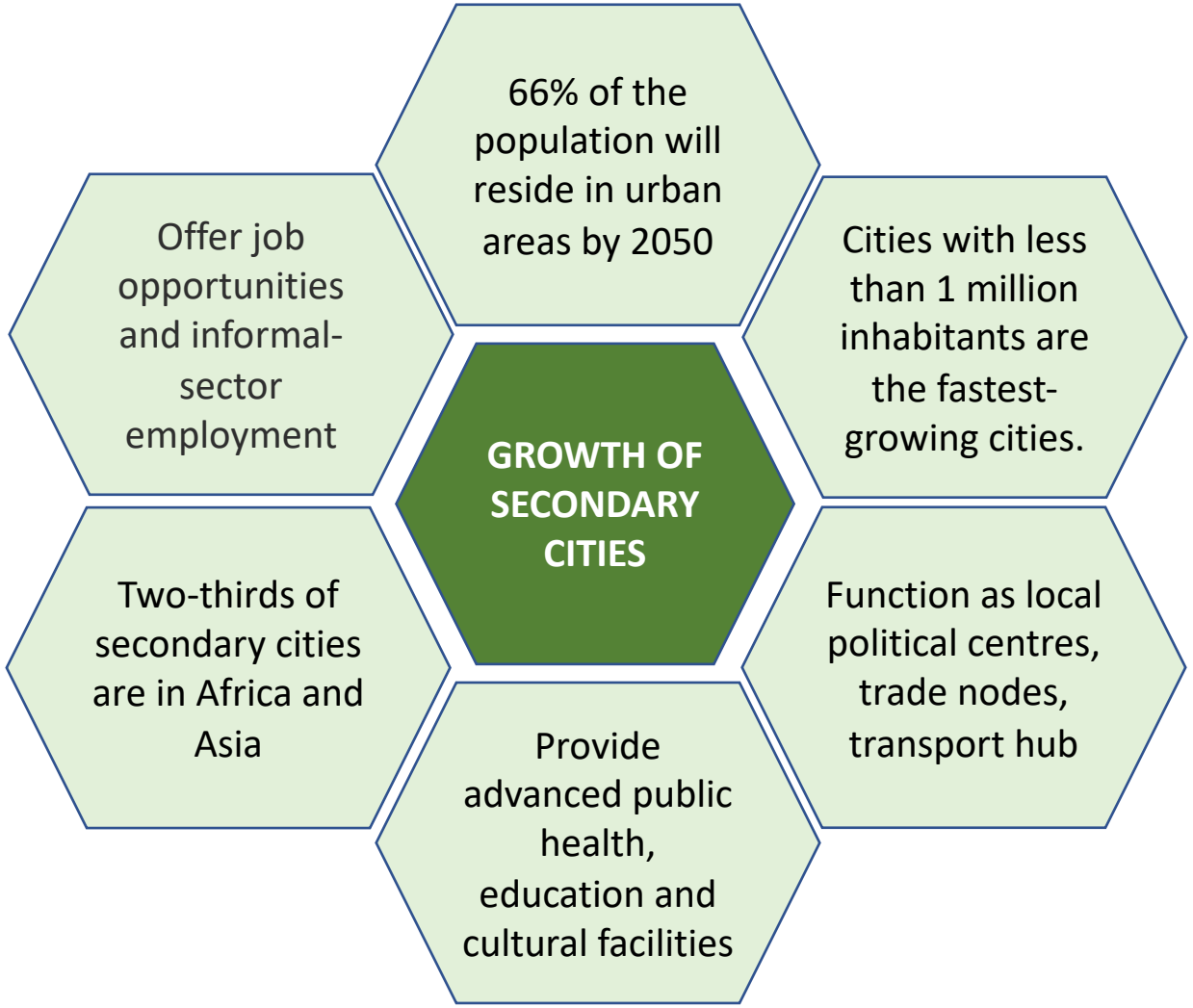
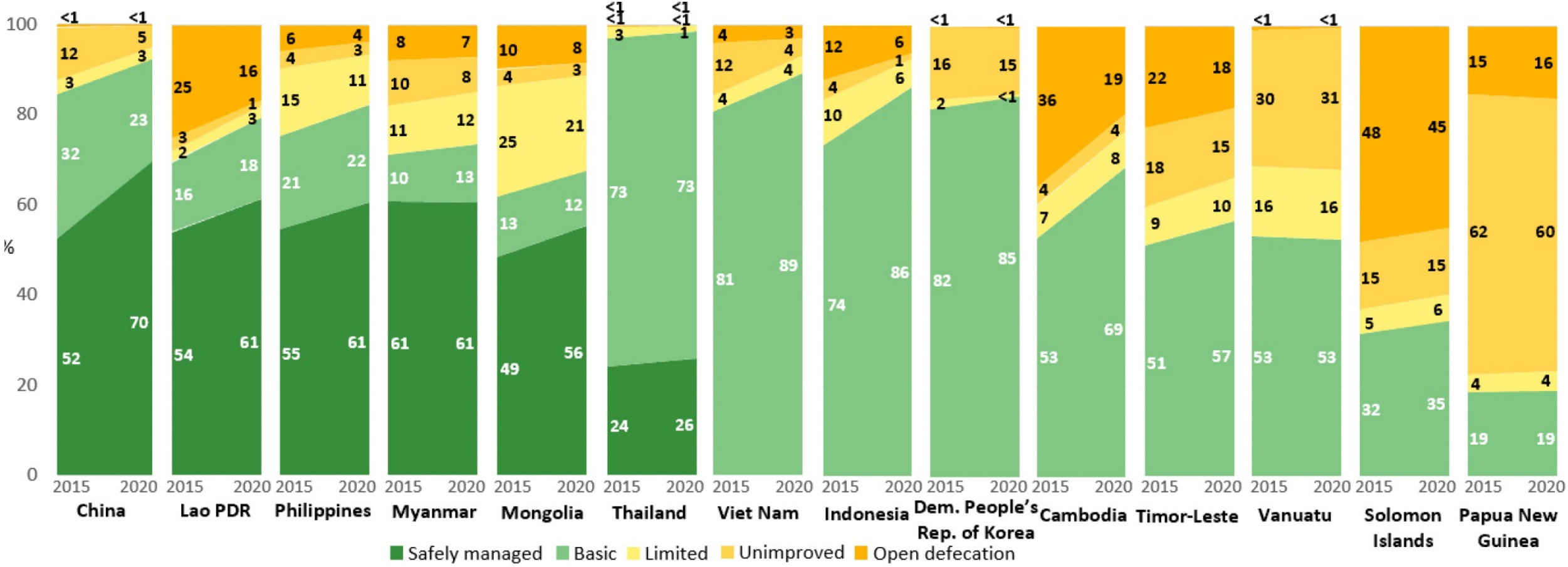
GROWTH OF SECONDARY CITIES



Source: United Nations, 2018; World Bank, 2009; UNHABITAT, 2020; World Cities Report, 2020; Chritiaensen, L., & Kanbur, R., 2016

EAST ASIA & PACIFIC: SANITATION STATUS

- Open defecation still practiced by people in, Papua New Guinea, Cambodia, Timor-Leste, Lao PDR and Solomon Islands

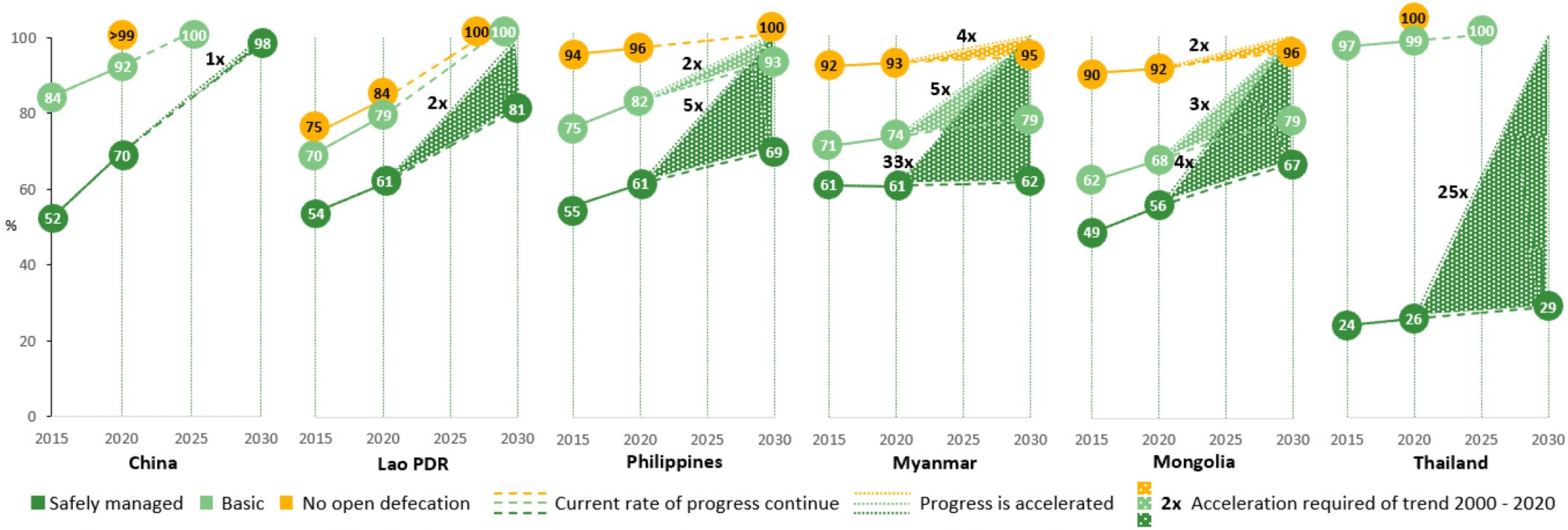


Sanitation Coverage, 2015 – 2020 (%)

Source: UNICEF: Global sanitation and climate resilience, 2022

EAST ASIA & PACIFIC: TREND IN SERVICES

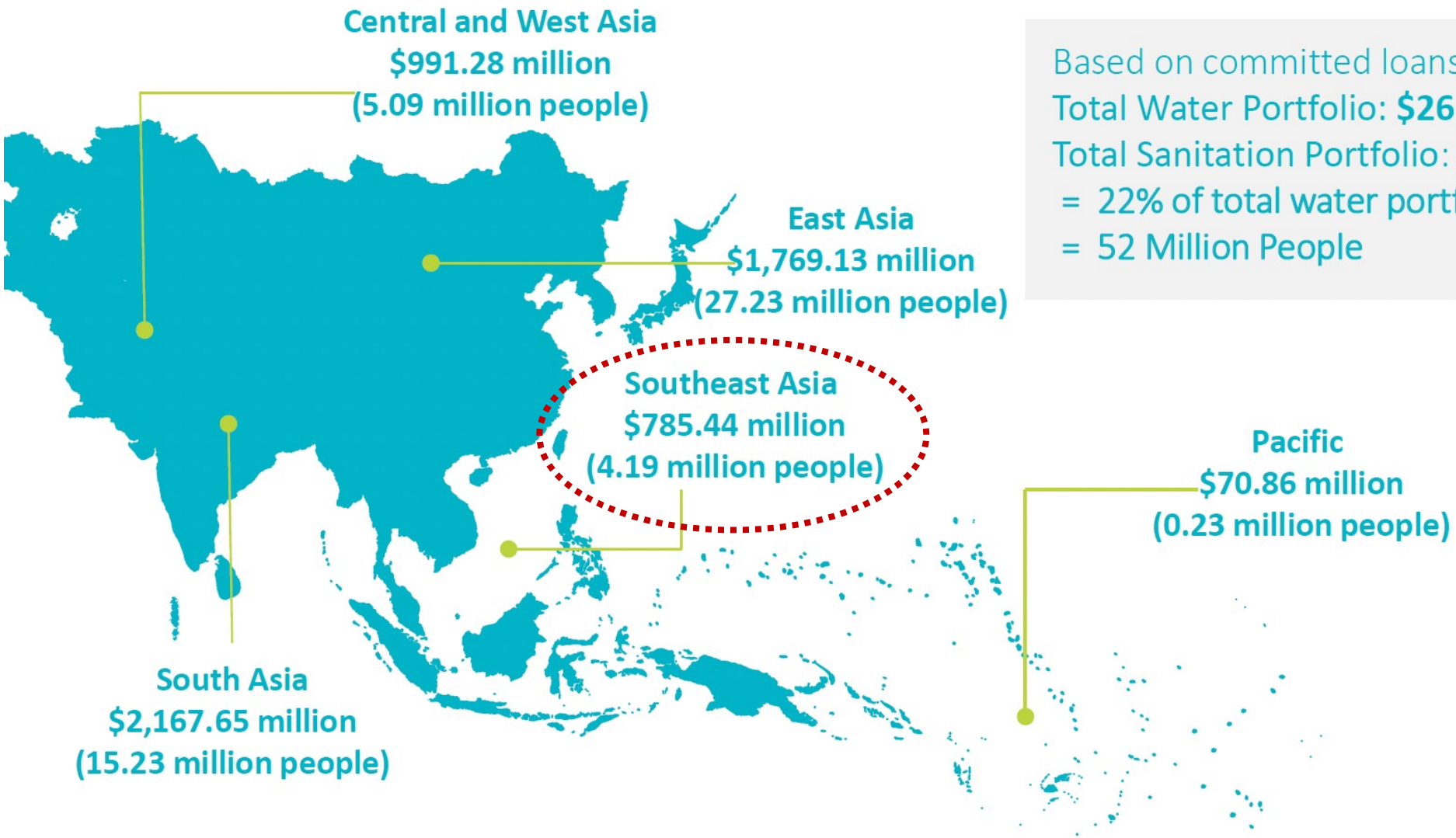
- Lao PDR is on track for ending open defecation and meeting universal access to basic sanitation services before 2030
- Needs a doubling efforts to meet the SDG target for safely managed sanitation services
- Philippines requires a five-fold increase in the provision of safely managed sanitation services



Coverage of sanitation services, 2015-2020 (%), and acceleration required to meet targets by 2030

Source: UNICEF: Global sanitation and climate resilience, 2022

INVESTMENTS IN SANITATION (2011-2022)

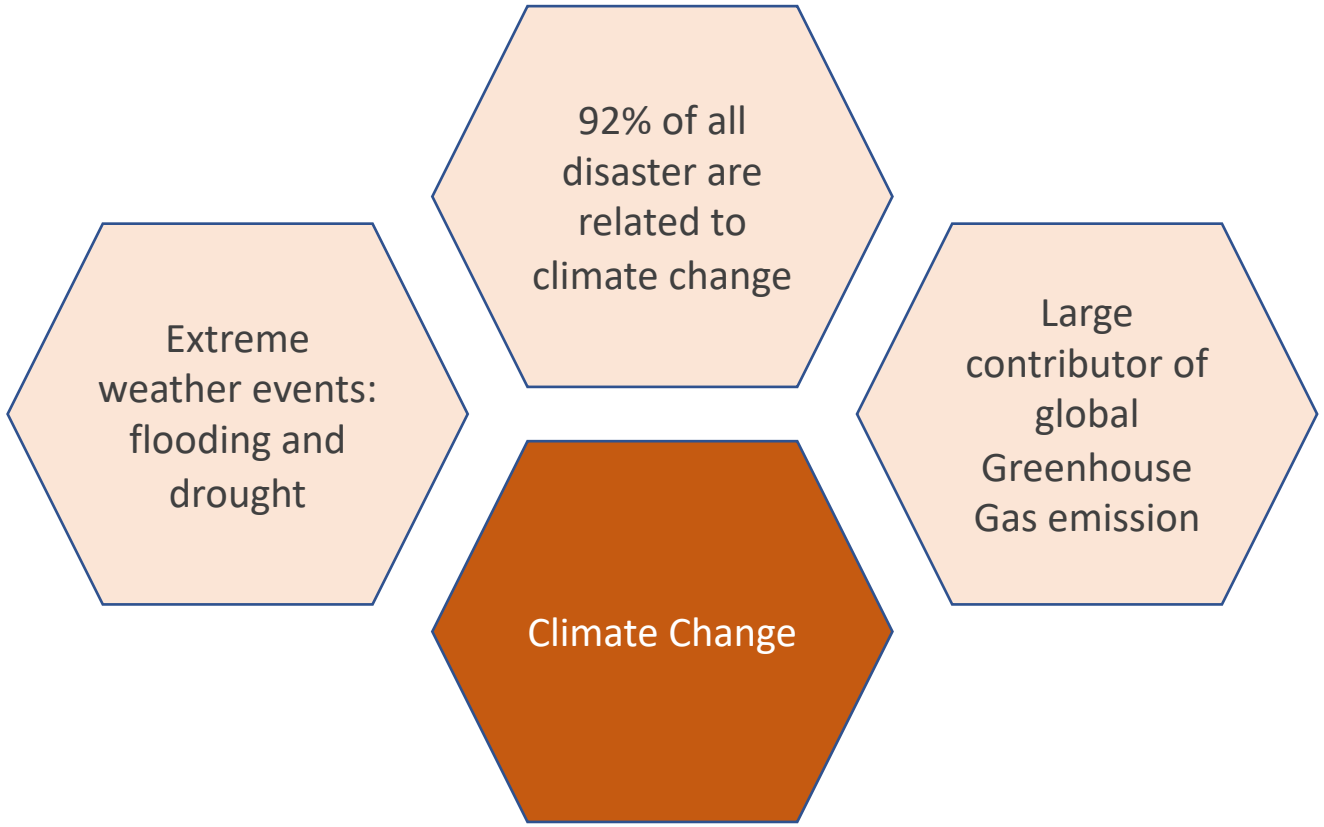


Based on committed loans (2011–2022):
Total Water Portfolio: **$26.5 Billion**
Total Sanitation Portfolio: **$5.8 Billion**
= 22% of total water portfolio
= 52 Million People

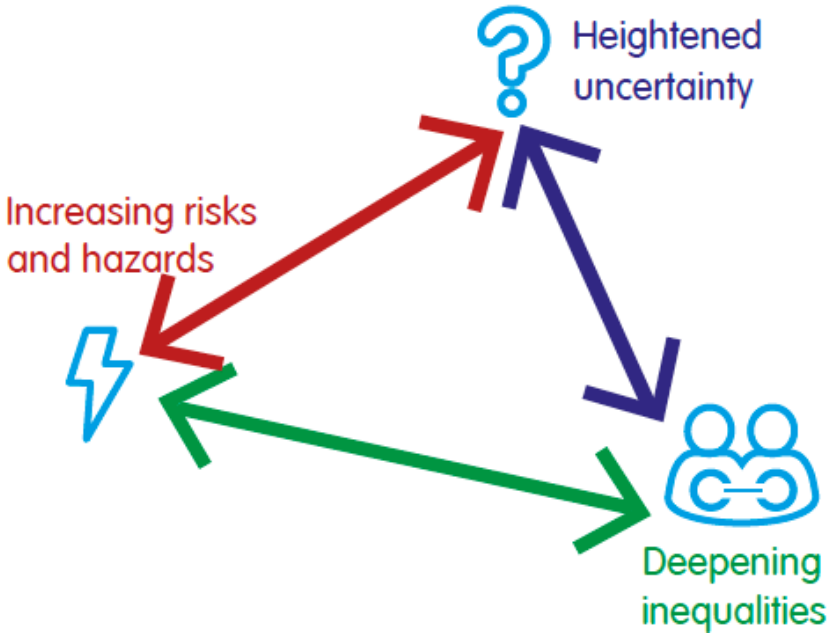
Source: ADB, 2022

CHALLENGES: CLIMATE CHANGE

Challenges in the Region

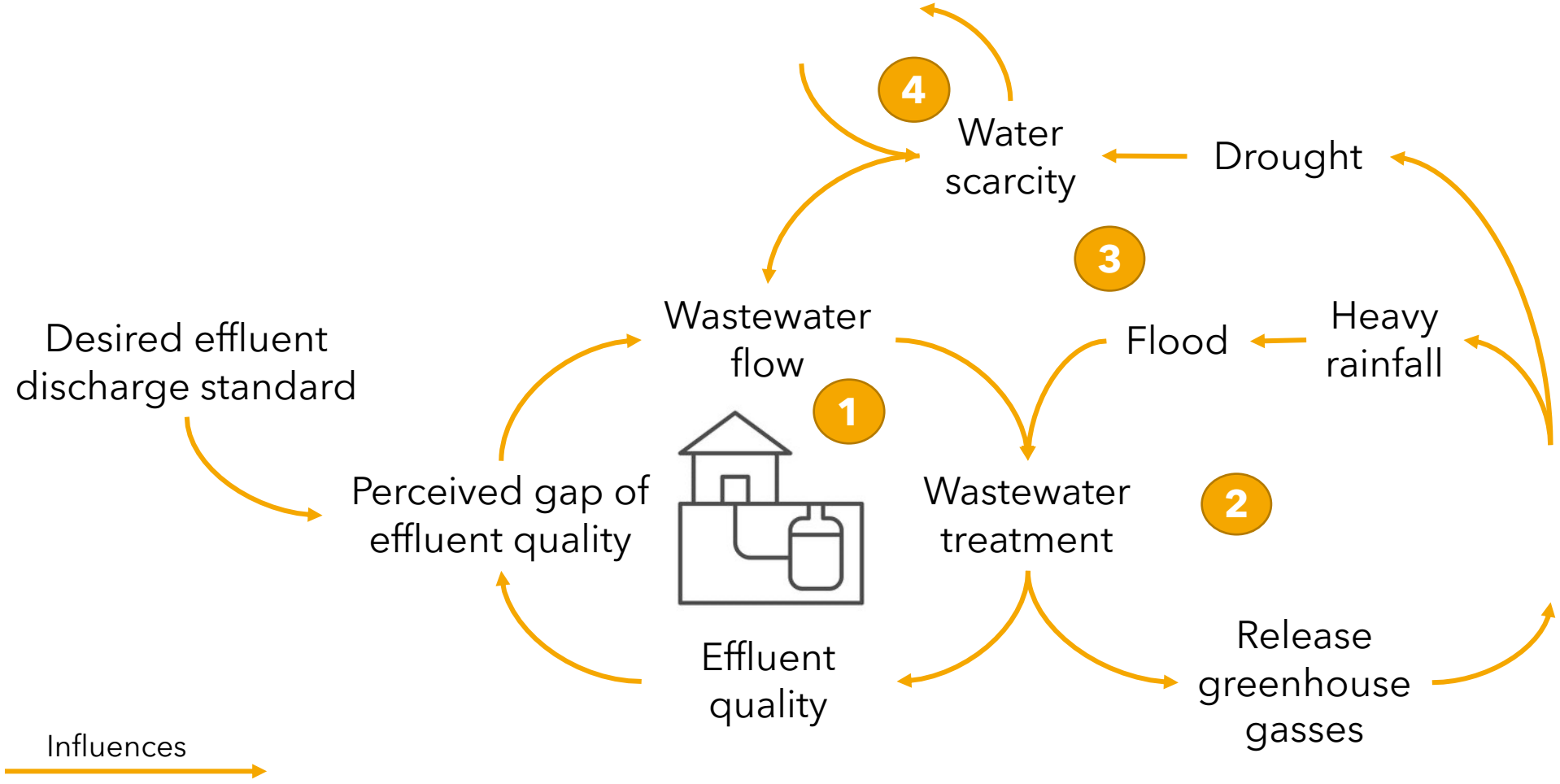


Climate Change Impacts



Source: UNICEF: Global sanitation and climate resilience, 2022 / ISF-UTS and SNV, 2019

CHALLENGES: CLIMATE VS TOILET: CAUSALITY



DIRECT ADVERSE EFFECTS ON VALUE CHAIN

Unskilled professionals

Impracticality of planning tools

Household level users not being able to **afford** professional emptying services

Operators not able to afford the transport of FS over large distances to treatment facilities

Lack of market opportunities

Containment | Emptying | Transport | Treatment | Reuse/disposal

no practice or abidance to regular desludging

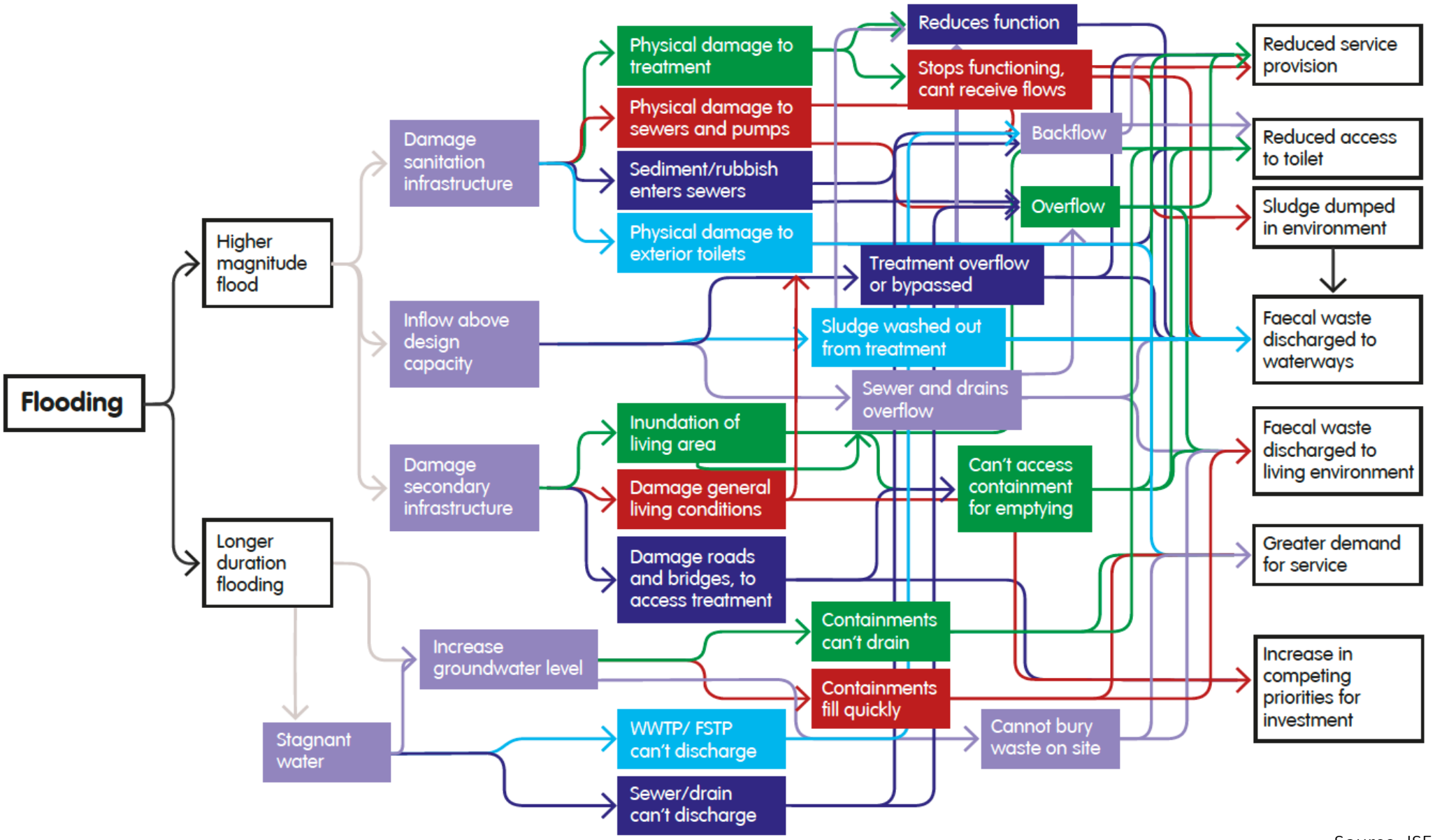
the lack of legitimate FS discharge locations or treatment facilities

Lack of clear policies & enforcement mechanisms **awareness**

Lack of stakeholder **awareness**

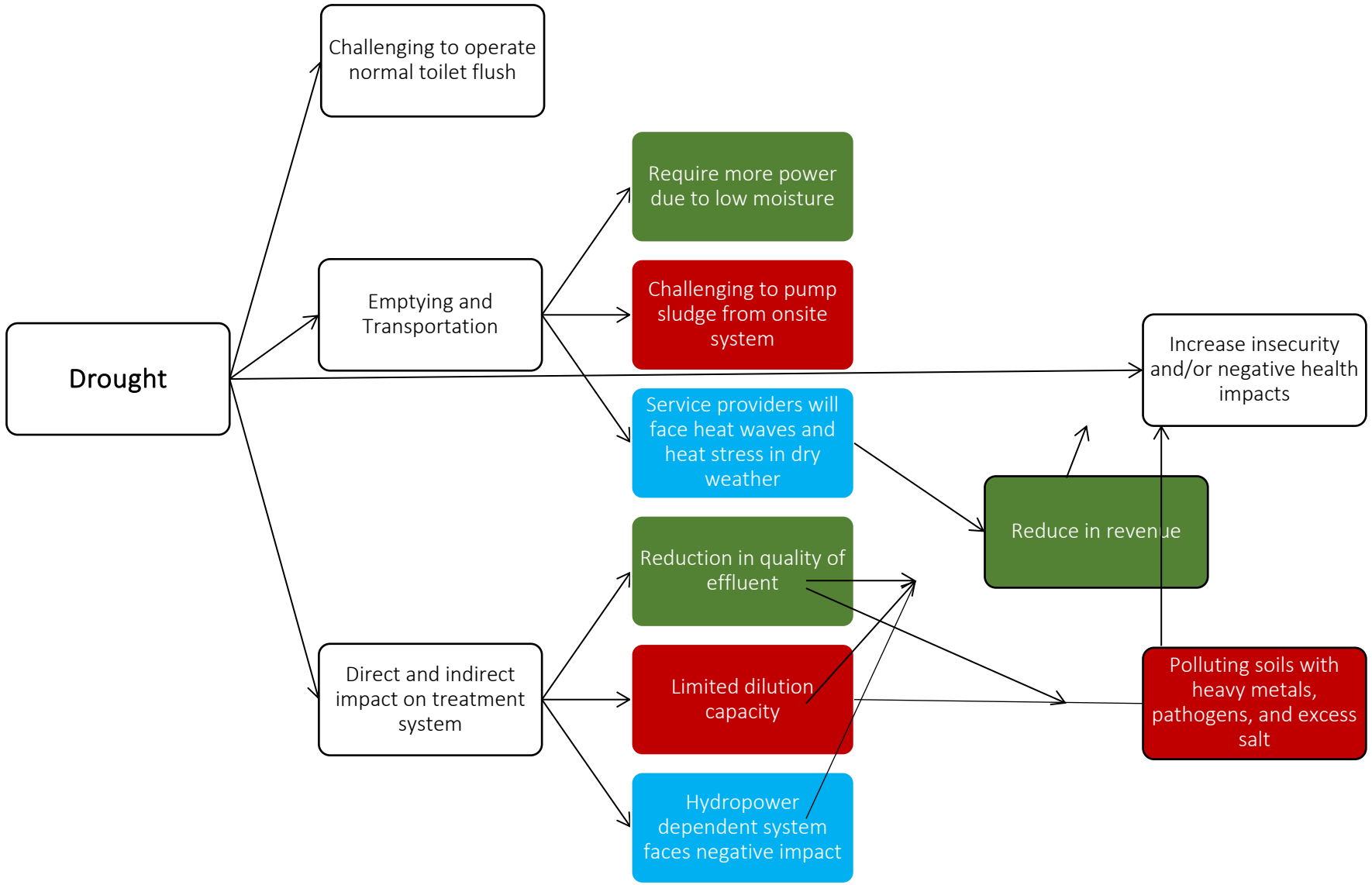
Inefficient assessment procedures

EXAMPLE: HOW DISASTER IMPACT SANITAION



Source: ISF-UTS and SNV (2019)

System Diagram Example: **Drought**



Climate Resilient Urban Sanitation (2021)

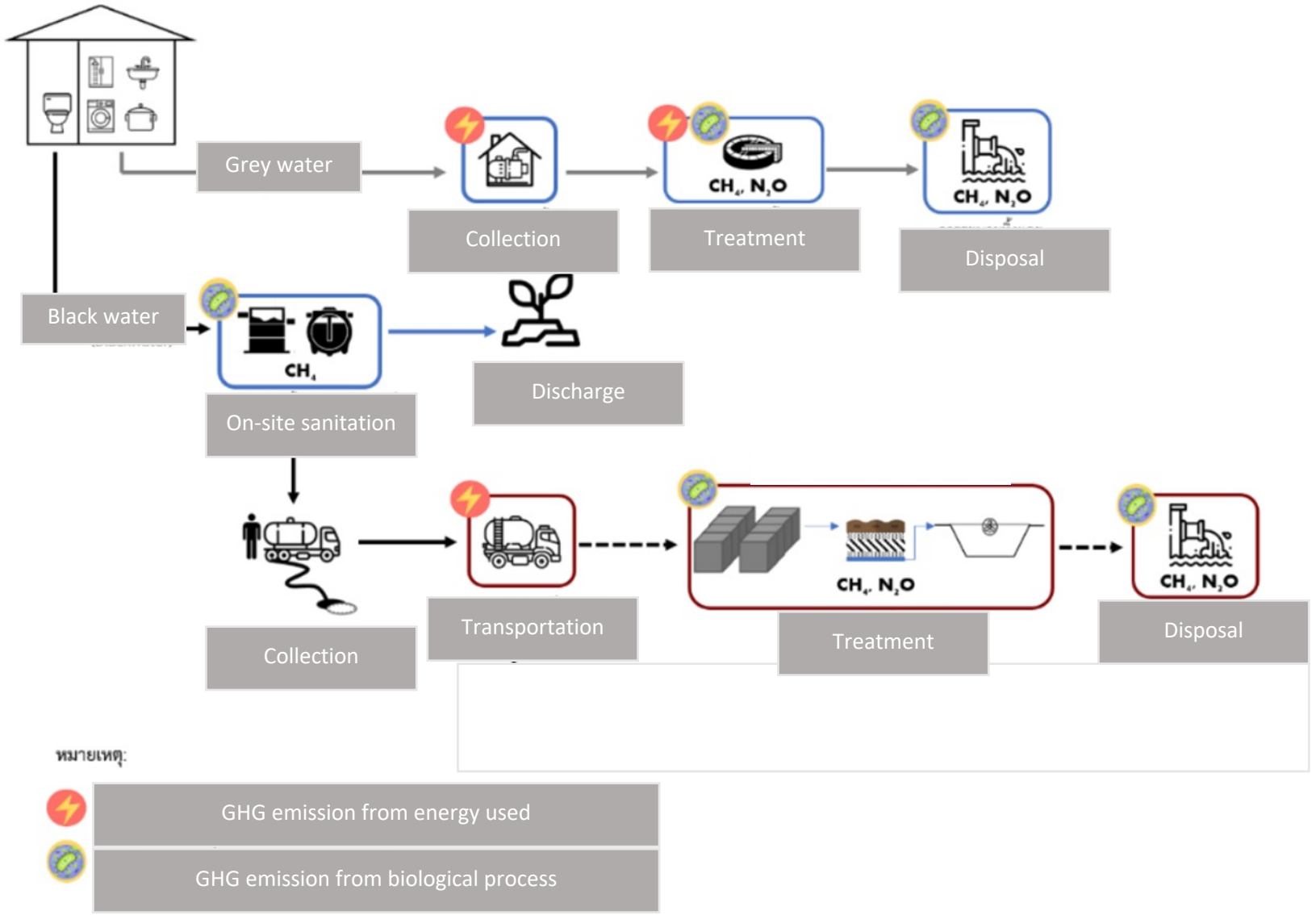
What Should We Do?

Assessment, Mitigation, Adpatation, Resilience on Climate Risks

VS.

Sustainable, Efficient, or Profitable Sanitation Systems

GHG Emission Factors and Sanitation Technology



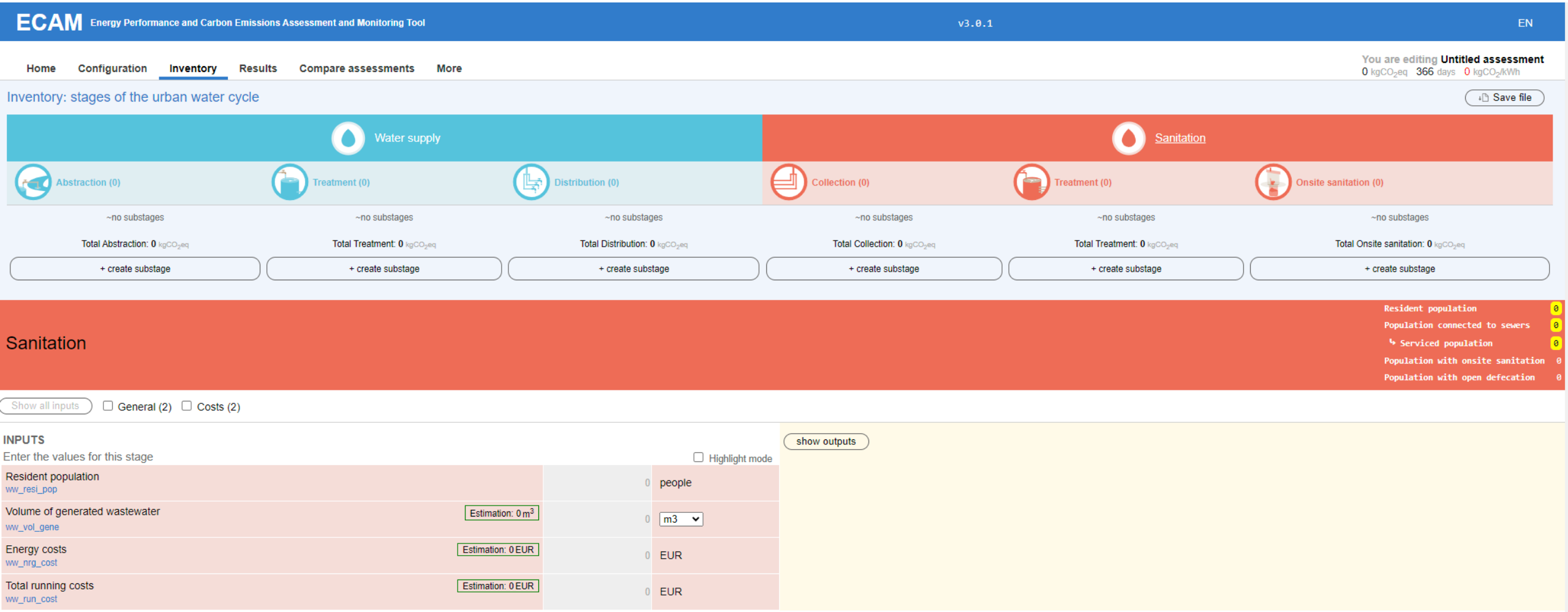
Mitigation Scope 1&2

Mitigation:

The mitigation defined with the Scopes 1 and 2 emissions (https://plana.earth/academy/what-are-scope-1-2-3-emissions/), which categorizes in direct emission from the process as Scope 1 (treatment process and disposal), indirect emission from the generation of purchased energy as Scope 2.

Application of ECAM

"https://climatesmartwater.org/ecam/"



Review methodologies ☑

List key parameters

Survey design

Conduct analytical study

Analyze the results

Make comparison of methane??

Recommend for National GHG Emission Factor

Onsite Treatment System

Sampling Methods

Analytical Methods

Wastewater

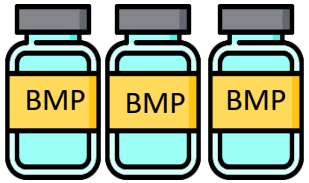
Sludge

Gas

BMP method

Experimental design
(Characteristic and condition)

Gas analysis
(Gas composition and Gas generation)



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Parameters	Method
tBOD	In-house method based on AWWA-2017, Part 4500-O G.
tCOD	In-house method based on AWWA-2017, Part 5220 D.
sCOD	In-house method based on AWWA-2017, Part 5220 D.
TKN	In-house method based on AWWA-2017, Part 4500-N_{org} C.
NH_3	In-house method based on AWWA-2017, Part 4500-NH_3 C.
NO_2^-	Ferrous sulfate method by HACH DR 3900
NO_3^-	Cadmium Reduction method by HACH DR 3900
TVS	In-house method based on AWWA-2017, Part 2540 E.
TSS	In-house method based on AWWA-2017, Part 2540 D.
VSS	In-house method based on AWWA-2017, Part 2540 D.
pH	pH meter
VFA	In-house method based on AWWA-2017, Part 5560 C.
Temperature	Thermometer
Gas generation (Volume of gas)	Gas analyzer
Gas composition (CH_4, CO_2, etc.)	Gas chromatography (GC) with TCD detector

Review methodologies ☑

List key parameters ☑

Survey design ☑

Conduct analytical study

Analyze the results

Make comparison of metha

Recommend for National GHG Emission Factor

Selection Criteria

Criterion 1: Klong Luang, Pathumthani and Nakhonsawan

Criterion 2: Source of pollution (Greenhouse gases)

Criterion 3: Variables

Criterion 4: Cooperation

Scope of Questionnaire preparation

Member

Type of toilet

Type of system

Desludging

Treatment

Gas Releasing

Review methodologies ☑

List key parameters ☑

Survey design ☑

Conduct analytical study

Analyze the results

Make comparison of methane??

Recommend for National GHG Emission Factor

Installation and sampling for onsite treatment system

Review methodologies ☑

List key parameters ☑

Survey design ☑

Conduct analytical study

Analyze the results

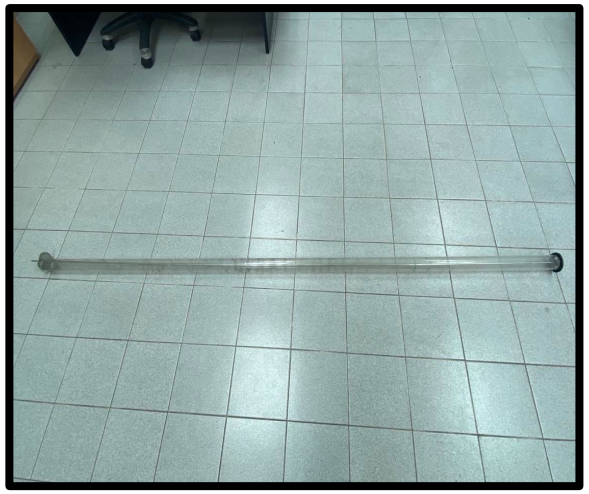
Make comparison of methane??

Recommend for National GHG Emission Factor

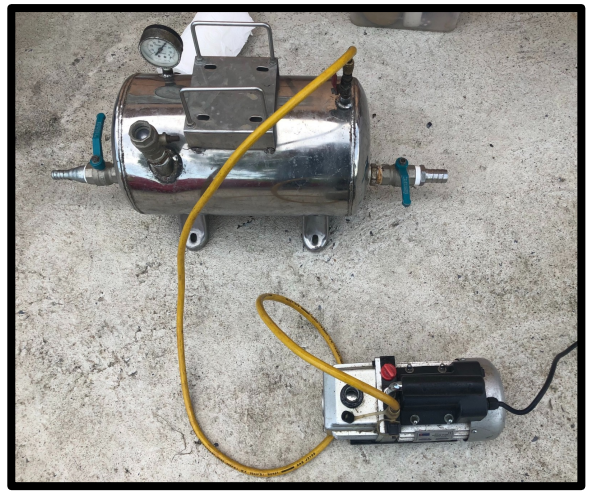
Sample bottle

Gas bag

Sludge sampling equipment



Sludge sampling equipment



Review methodologies ☑

List key parameters ☑

Survey design ☑

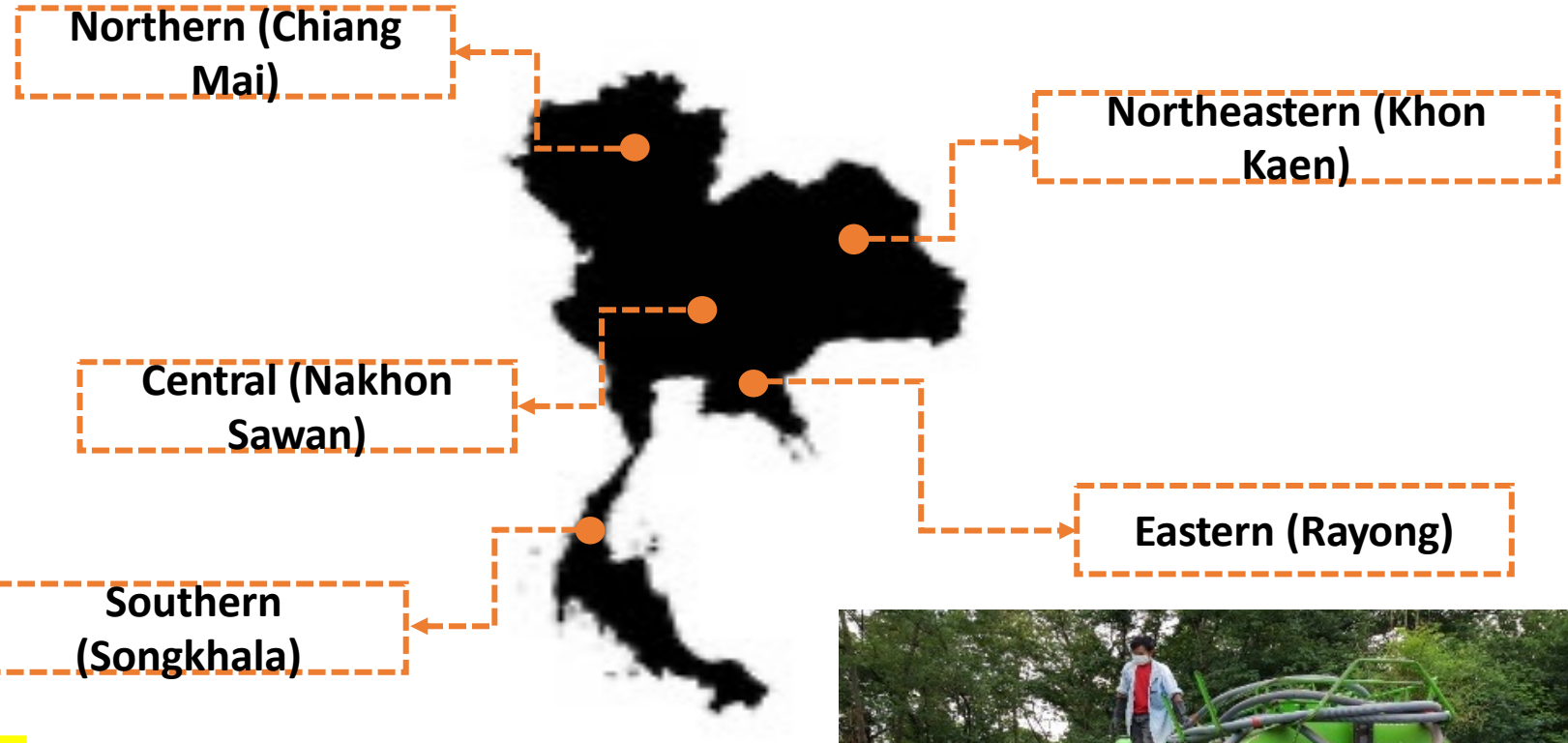
Conduct analytical study

Analyze the results

Make comparison of methane??

Recommend for National GHG Emission Factor

Sampling of Vacuum truck



Review methodologies ☑

List key parameters ☑

Survey design ☑

Conduct analytical study

Analyze the results

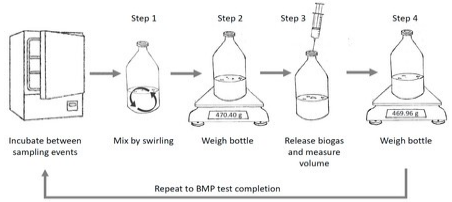
Make comparison of methane??

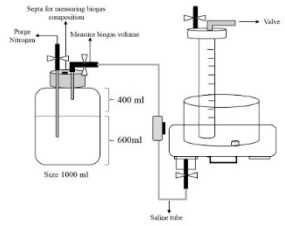
Recommend for National GHG Emission Factor

Gas bag

Gas composition

Gas generation





☑ Accuracy ☑ Suitability

☑ Compare with GC ☑ Standard and Reference

Review methodologies ☑

List key parameters ☑

Survey design ☑

Conduct analytical study

Analyze the results

Make comparison of methane??

Recommend for National GHG Emission Factor

Biochemical Methane Potential Test

1. Characteristic of sludg

2. Prepare BMP test bottle

3. Add sludge / Adjust volume

☑ Parameters

- ☞ BOD ☞ TVS ☞ Other
- ☞ Gas Generation
- ☞ Gas Composition

4. Incubate at 30-40 ๐C

5. Daily gas generation

6. Gas Composition

☑ Compare

- ☞ BMP (Optimum condition)
- ☞ BMP (Actual condition)
- ☞ Actual onsite treatment system

Application and Function of ECAM Tool (Version 2.2)

Water Treatment Utility

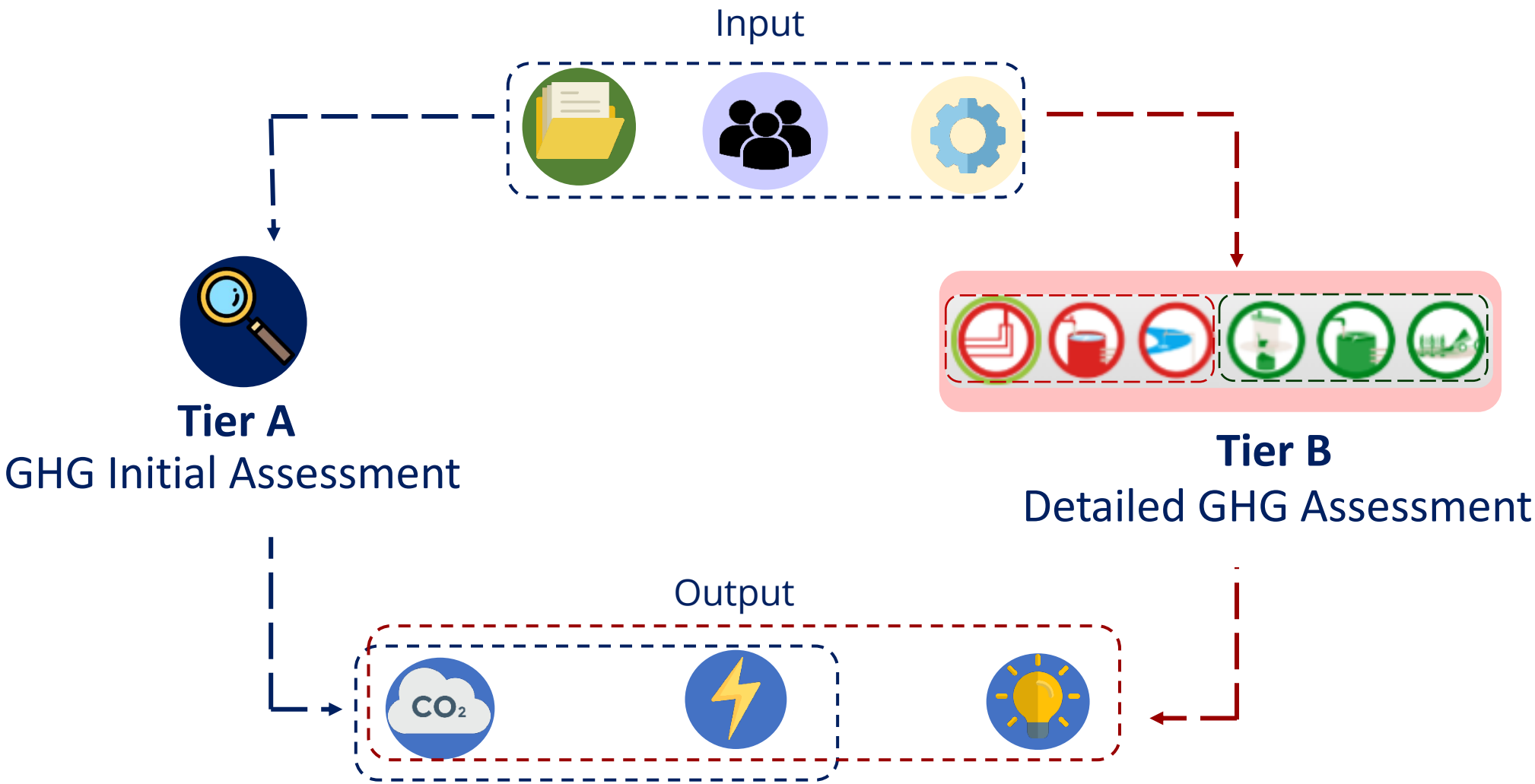
Central Wastewater Treatment Utility

Fecal Sludge Management

- GHG Emission assessment
- Energy performance assessment
- GHG emission reduction measure

- Benefit to municipality for improving the effective wastewater management planning
- Support GHG emission information to the National GHG Inventory report/ NDC

Function and Input Data for ECAM Tool



Tier A: GHG Initial Assessment

Input Data

Type of Treatment Process

Energy consumed from grid (kWh)

Volume of treated wastewater (m^3)

TN in treated ww (mg/L)

Volume of discharged effluent to water body (m^3)

Energy costs

Running costs

producing biogas

Energy consumed from the grid

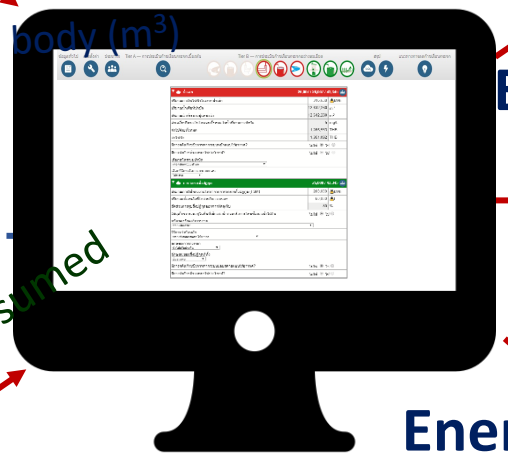
OSS type

Treatment type

% Containments emptied

Volume of fuel consumed

Type of faecal sludge disposed

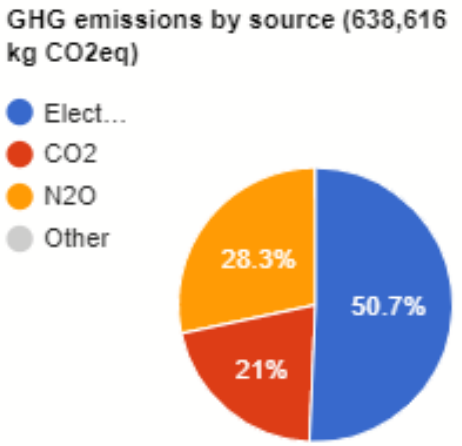


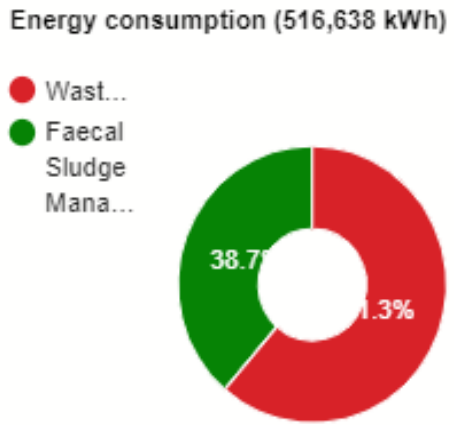
Output

GHG Emission by source

Energy Consumption

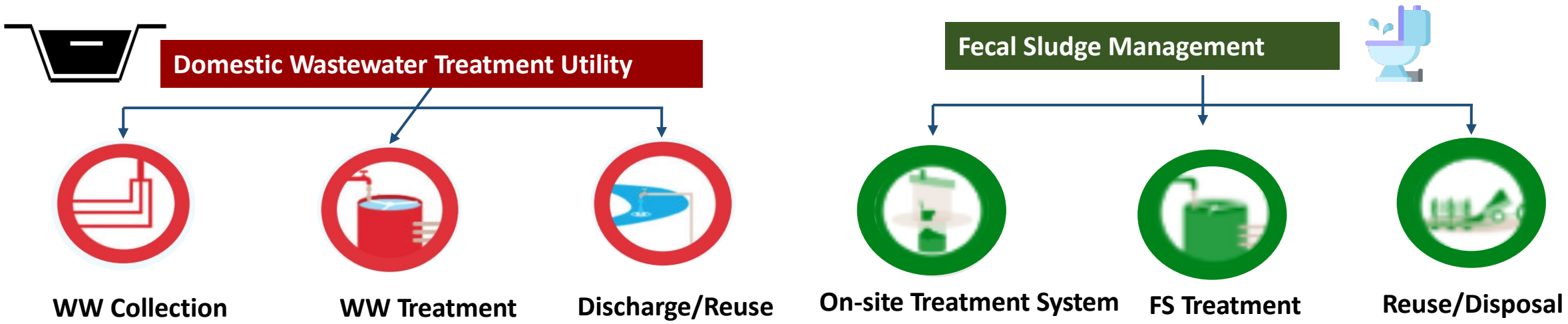
Energy performance and Service Level indicators





Total GHG Wastewater	Total GHG Faecal Sludge Management	Serviced population in Faecal Sludge Management
14.5	10.46	57.68 %
kg CO_2eq/year/serv.pop.	kg CO_2eq/year/serv.pop.	

Tier B : Detailed GHG Assessment



Additional Assessment

- ✓ Pumping Efficiency Assessment
- ✓ Pump Efficiency Opportunity Assessment for Improvement
- ✓ Biogas Production Assessment
- ✓ GHG emission reduction from Reuse

Benefit to municipality for improving the effective wastewater management planning


CLIMATE-SMART WASH
TECHNOLOGY
CATALOGUE WITH
MODELING
UNICEF x AIT

List of the technologies

WATER 

HYGIENE 

SANITATION 

Water	Hygiene	Sanitation
1 Title: Hybrid Ion Exchange system	7 Title: Foot-operated handwashing station	11 Title: Solar Septic Tank (SST)
2 Title: Solar-Powered water supply system	8 Title: Splash handwashing and drinking stations	12 Title: Aerated septic tank
3 Title: Community well with handpump	9 Title: Solar Powered Automated Hand Washer	13 Title: ECO-SAN Toilet
4 Title: Household Sand Filter	10 Title: Autarky handwashing station (AHWS)	14 Title: ZYCLONE CUBE
5 Title: Household Membrane Filters		15 Title: Vermicomposting toilet
6 Title: Complete water filtration system		16 Title: Omni Processor
		17 Title: Planted Drying Bed
		18 Title: The Black Soldier fly (BSF)
		19 Title: Co-composting
		20 Title: Anaerobic Digestion

20 technologies and each contribution to Mitigation Scope 1&2 and Adaptation

TECHNOLOGIES	SECTOR	MITIGATION Scope 1	MITIGATION Scope 2	ADAPTATION	CROSS-CUTTING
1 Title: Hybrid Ion Exchange system	Water	-	+	+	✓
2 Title: Solar-Powered water supply system	Water	-	+	-	✓
3 Title: Community well with handpump	Water	+	-	+	✗
4 Title: Household Sand Filter	Water	-	-	+	✗
5 Title: Household Membrane Filters	Water	-	-	+	✓
6 Title: Complete water filtration system	Water	-	-	+	✓
7 Title: Foot-operated handwashing station	Hygiene	-	-	-	✓
8 Title: Splash handwashing and drinking stations	Hygiene	-	-	+	✓
9 Title: Solar Powered Automated Hand Washer	Hygiene	-	-	-	✓
10 Title: Autarky handwashing station (AHWS)	Hygiene	+	+	+	✓

20 technologies and each contribution to Mitigation Scope 1&2 and Adaptation

TECHNOLOGIES	SECTOR	MITIGATION Scope 1	MITIGATION Scope 2	ADAPTATION	CROSS-CUTTING
11 Title: Solar Septic Tank (SST)	Sanitation	+	+	+	✓
12 Title: Aerated septic tank	Sanitation	+	+	+	✗
13 Title: ECO-SAN Toilet	Sanitation	-	-	+	✓
14 Title: ZYCLONE CUBE	Sanitation	-	+	+	✓
15 Title: Vermicomposting toilet	Sanitation	-	-	+	✓
16 Title: Omni Processor	Sanitation	+	-	+	✓
17 Title: Planted Drying Bed	Sanitation	+	-	+	✗
18 Title: The Black Soldier fly (BSF)	Sanitation	-	+	+	✓
19 Title: Co-composting	Sanitation	+	-	+	✓
20 Title: Anaerobic Digestion	Sanitation	+	-	+	✗

Total GHG emission

3,050 kg CO_2 eq./annum

Cost estimate

- 2,500 USD/system
- 50 USD/year (O&M)

Cross-cutting

Yes

11 Solar Septic Tank (SST)

An innovative decentralized wastewater treatment system was constructed and tested at the household scale in a community in central Thailand and southeast asia.

The SST is a modified conventional septic tank with a solar-heated water system from solar panal to create higher temperature than ambient inside the septic tank. The enhancement of temperature promotes the biodegradation of organic matter and methane formation. Furthermore, temperature also has a significant effect on the settleability and degradation of biological solids and pathogen inactivation.

Advantages

SST is suitable to apply for blackwater with high strength organic content due to it is high rate degradation system. Advantages of this system are reduction of sludge accumulation, high removal efficiency and high pathogen inactivation.

Disadvantages

There are some disadvantages which are it requires energy to heat up the system and demands large rooftop area for installation of solar heating device.

Climate-resilient

This technology can be resilient to cold climate because the system can be well performed with external heated supply to facilitate organic degradation inside the system. Adaptation to flood might be optional which can constructs the system in elevated form.

Adaptation

Drought
Securing sufficient volumes of water for flushing and operation.
Regular maintenance to avoid pipe blockage.
Construction of system with hand washing station and recycling water for flushing.

Total GHG emission

634 kg CO_2 eq./annum

Cost estimate

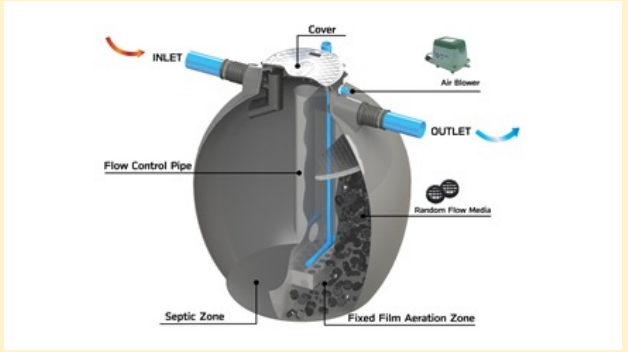
- 950 USD/system
- 30 USD/year (O&M)

Cross-cutting

No

12 Aerated septic tank

Aerobic treatment system is the modern option which is similar to septic systems in that both treat wastewater using natural processes. However, the aerobic system supplies oxygen into the tank using air pump or blower to facilitate the microbial activities in septic system. The compartment of tank can be both concrete structure and fiber glass.



Advantages

The benefits of this systems are odor avoiding, able to remove organic mattet and nutrients under standard meeting and reducing methane gas.

Climate-resilient

This technology can be resilient to flood which might be coustructed the system in elevated form.

Disadvantages

Most of treatment needs power supply to operate air pump. There are some companies that can provide air pump using energy from solar panal which can be environment-friendly alternative for human waste treatment.

Adaptation

Drought
Securing sufficient volumes of water for flushing and operation.
Regular maintenance to avoid pipe blockage.

Extreme cold
Providing thick Insulator for maintaining warm temperature

Total GHG emission

1460 kg CO_2 eq./annum

Cost estimate

- N/A
- 4745 USD/year (O&M)

Cross-cutting

Yes

14 ZYCLONE CUBE

Zyclone cube" is a novel on-site sanitation technology manufactured by SCG company, Thailand. This system relied on mechanical and biological processes for treating the fecal waste from toilets.

Solid part in wastewater was separated by cyclone unit using centrifugal force. Separated solid then flow into unit of screw-heater drying and disinfection to produce dry solid as reusable by-product. Liquid part was flowed into different biological treatment chambers including filtration, anaerobic, aerobic and anoxic processes. Ultimately, treated wastewater was therefore disinfected in electrochemical chambers before discharging.

Advantages

-

Disadvantages

-

Climate-resilient

This system can be employed both drought and flooding areas because solid and liquid parts of wastewater from toilets are not affected from hot climate and it can be constructed flooding areas using elevated form.

Adaptation

Extreme cold
Providing thick Insulator of seperator for keeping warm temperature.

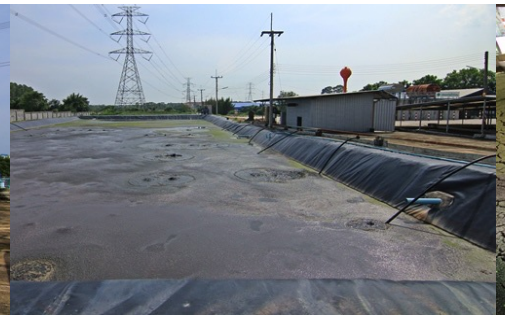
A Review of Profitable FSM Business Case

But “Sustainable” and “Efficient”??

CASE STUDY THAILAND: Thongthawil Service Co,.Ltd

General Information	
Service area	~ 440 km^2
Population	398,656
Working day	365 Days/year
FSM structure	Licensed private company
Permission duration	1-3 years (*based on agreement)
Licensing duration	1 Year (*renew annually)
FS collection and transportation	
No. of truck	15 Truck (*10-12 trucks serve daily)
Truck size	6 m^3/truck
Average age of truck	~ 6-7 Years
Average investment per truck	~ 3-4 Million Baht/truck
Current Collection Capacity	~250-350 m^3/day

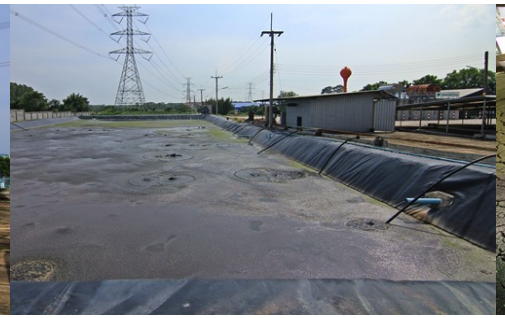





CASE STUDY THAILAND: Thongthawil Service Co,.Ltd

FS collection and transportation (continue)	
Service hour	8 AM – 5 PM *employees can work overtime if there are requests
No.of employee	~ 40
No. of truck driver and assistant per truck	1 Driver and 2 Assistants per truck
No.of customer	Average 54600 household/year
Customer segment	Base on no. of customers; approximately 40% industrial estate*, and 60% households. Based on amount of collected FS; approximately 70% industrial estate, and 30% households. *The company collects FS from toilet of industrial estate. Note: Amount of FS from 1 industrial factory are much higher than 1 household.
Average waiting time (Days)	Average 2 days






CASE STUDY THAILAND: Thongthawil Service Co,.Ltd

Covered Lagoon

FS truck emptying

Covered lagoon

CH_4

Electricity generator from biogas

Solids

Liquid

Drying bed

Aerobic pond

Bamboo farm

Constructed wetland

Storage pond

RO+UV plant

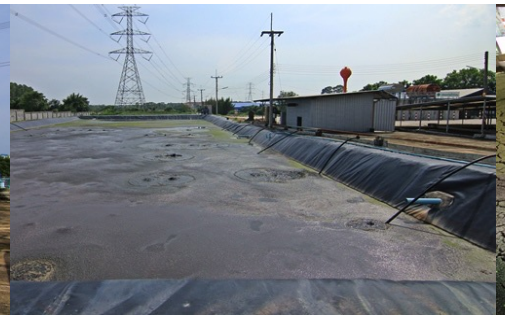
Tap water storage

Flow diagram

CASE STUDY THAILAND: Thongthawil Service Co,.Ltd

General Information	
Technology	Integrated system – Covered lagoon, sand drying bed, pond, and constructed wetland
Operated year	2006
Area	0.048 km^2 (30 Rai)
Investment	6,500,000 Baht (Year 2006)
Maximum capacity	500 m^3/day
Current capacity	250-350 m^3/day
Treatment retention time	36-40 days (Overall plant design criteria)
Products and by-products	Dried sludge, water, bamboo shot, biogas, electricity
No. of operators	~2-3 persons
Treatment fee	1200 Baht/m^3 (**Only industrial sector is charged as per Factory Act)






CASE STUDY THAILAND: Thongthawil Service Co,.Ltd

Cost (operation)	
Total cost	FS collection truck 17,497,699 Baht/year (~583,000 USD/year) (Administrative 43.62%, Personnel 30.62%, Fuel 19.75%, Maintenance 5.69% and License 0.31%) FS treatment plant 774,600 Baht/year (~25,820 USD/year) (Personnel 60.61%, Maintenance 16.67%, Plant performance monitoring 10.33% and Other 12.39%)
Revenues	
Total Revenue	FS Collection Revenue: 27,375,000 Baht/year (~912,500 USD/year) FS Treatment Revenue: 91,980,000 Baht/year (~3,066,000 USD/year) (**Note: Treatment fee were collected from industrial sector only)
Net Profit (Exclude Depreciation)	~ 101,082,701 Baht/year (~3,369,000 USD/year)

KEY TAKEAWAYS

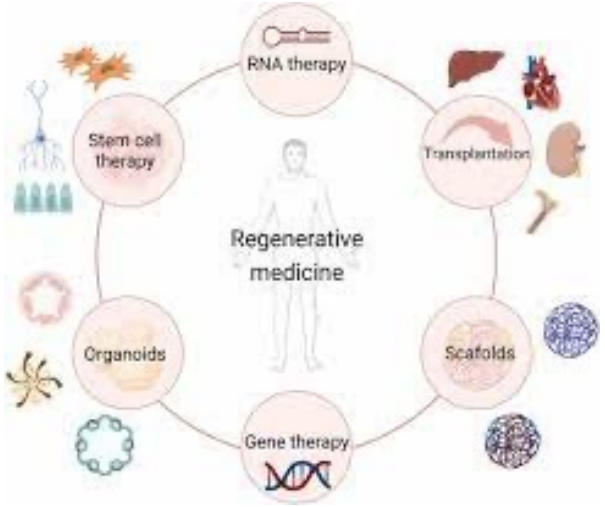
- Emerging challenges in urban/rural sanitation
  - Fecal Sludge Management
  - Climate risks, adaptation, resilience, mitigation
- Inclusive Planning
  - How to integrate low-income communities?
  - Including solid wastes, greywater?
- Sustainable Model & Innovation
  - Life Cycle Cost vs. Financing?
  - Advanced vs. Nature-based solutions?
  - C-sequestration of FS:
    - Biochar vs. Reforestation
  - Integrating into Digital Public Infrastructure
  - **IOT** "Internet of Toilet"?

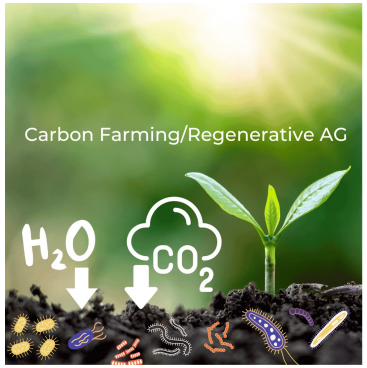
Beyond SDG

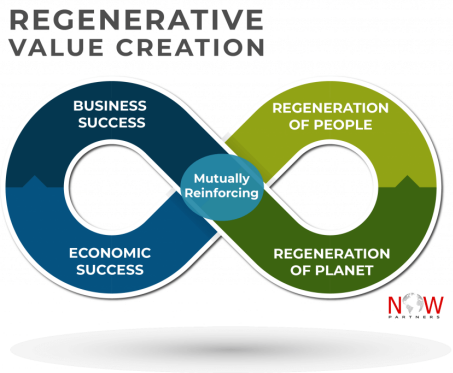
- Should we revisit ”Sustainable or Inclusive” Sanitation?
- Should we create ”Positive Impacts” out of sanitation systems rather than preventing negative ones?
- Should we consider “Regeneration” of the existing sanitation systems?

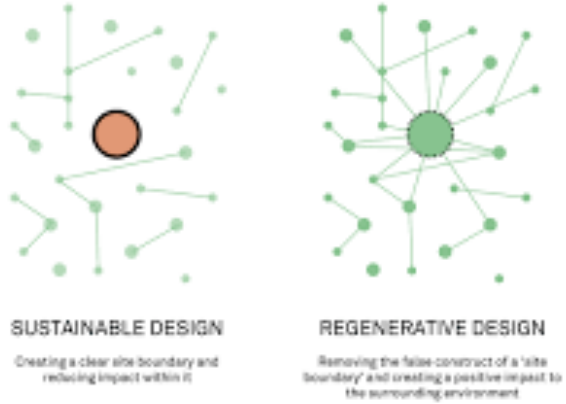
Regenerative Sanitation

- Regenerative Medicine
- Regenerative Agriculture
- Regenerative Business
- Regenerative Design









May the Toilet Be With You