Fecal Sludge Management (FSM)

Lessons learned from Cox's Bazar Bangladesh

14th February 2023

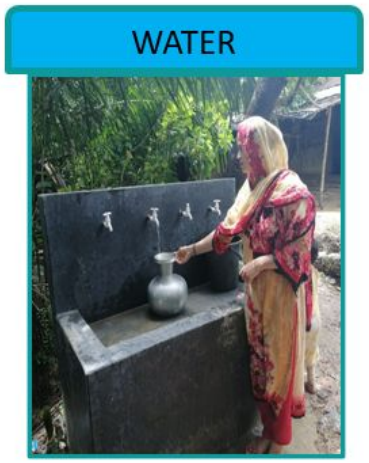
Julien Graveleau
WASH sector Coordination
jgraveleau@unicef.org

Agenda

- **Introduction /context** – Julien (WASH sector Coordinator)
- **Overview FSM strategy** – Sojib (UNICEF – Sanitation Officer)
- **Different FSTP technologies** - Jafar (WASH sector Engineer)
- **Decentralized approach: case study of DEWATS** – Alessandro (IOM – WASH Manager) + Baudouin (IOM – WASH Officer – Global)
- **Mega FSTPs/ centralized approach** – Grover (UNHCR – WASH officer)
- **Pit Intelligent Tracker (PIT)-** Niloy (OXFAM – WASH Coordinator)
- **The FSTP monitoring dashboard** – Siam (FS Lab Manager) + Tanvir (WASH sector IM)
- **Challenges and Way forward** – Julien (WASH sector)

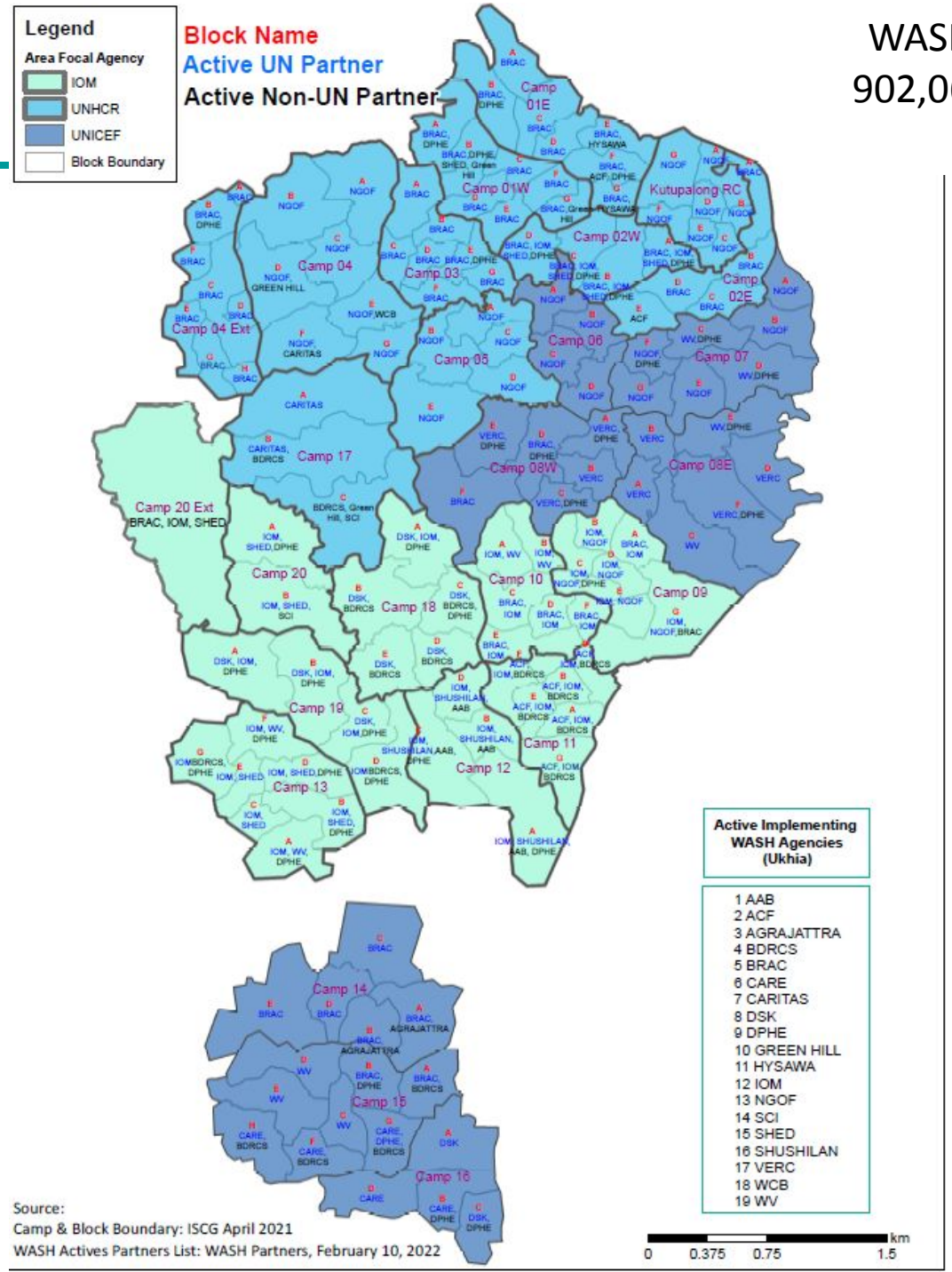
Overview of the crisis & context

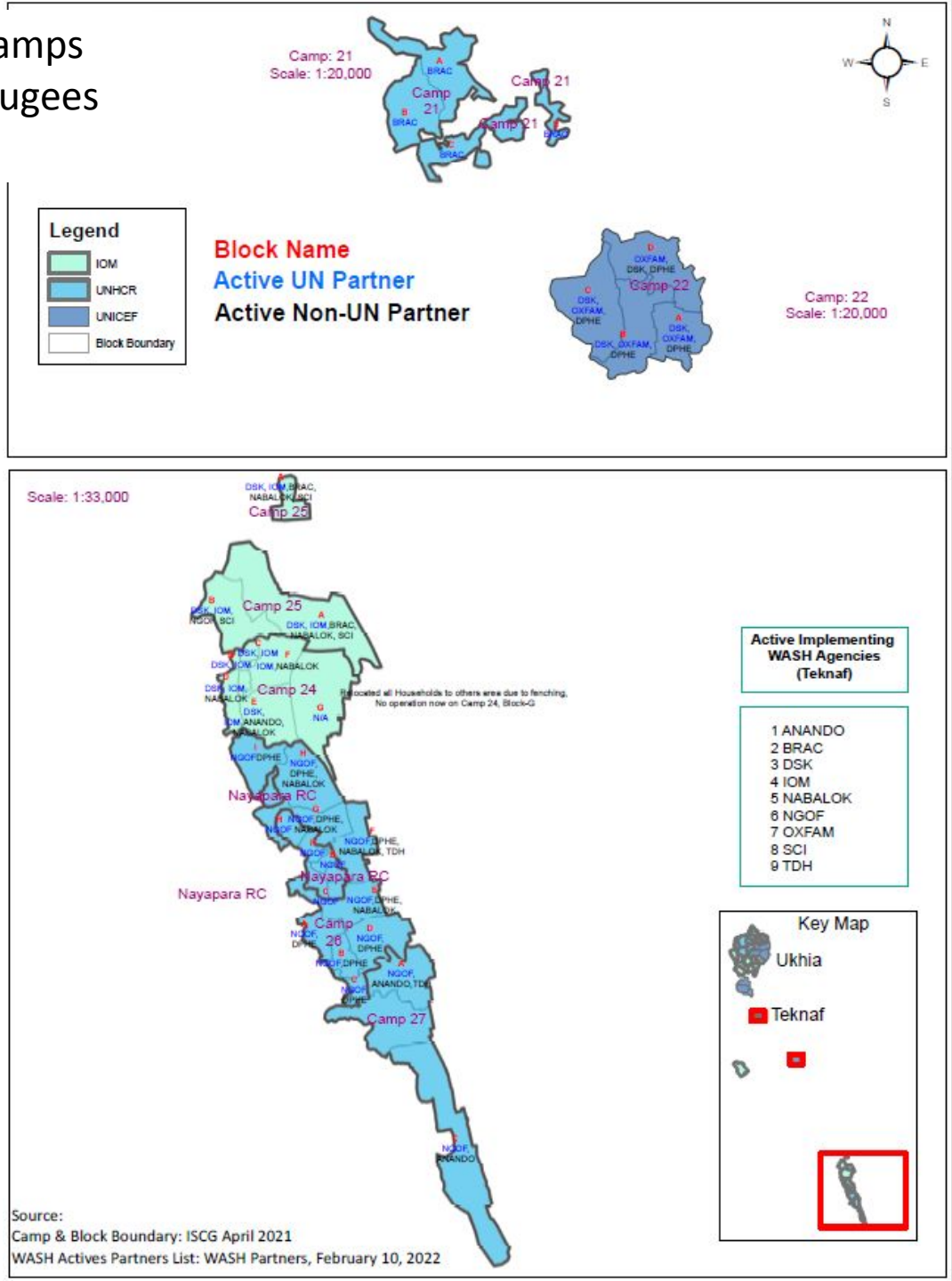
- **902,066 Rohingya Refugees** in mega-camp (6 times more dense than New York City) – most of them since August 2017
- 443,516 Bangladeshi affected as Host's community
- Budget 2023: 78 millions USD in HRP (around 55 millions raised in 2022) for WASH
- Tropical climate (monsoon season – May to September)
- Flood prone area
- Hilly terrain
- 32 active WASH Partners



WASH Response in camps
902,066 Rohingya Refugees
33 camps

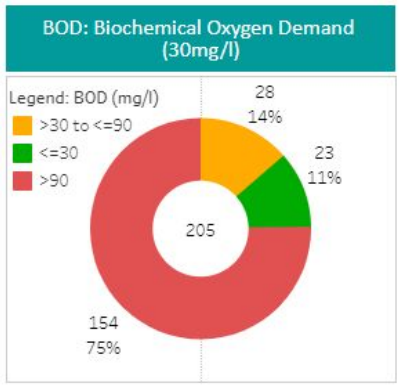
+ 443,516
Bangladeshi
In Host's
Communities

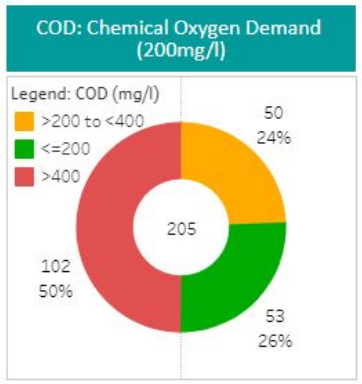


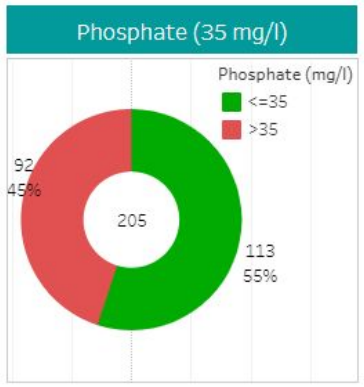


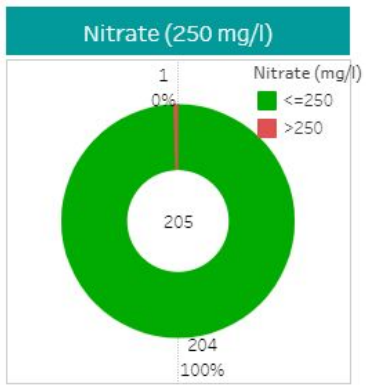
Few FSM data / context

- **99%** of households reporting using latrines in the camps
- **203** Fecal Sludge Treatment Plants in camps
- **45.976 latrines** in the camps
- **21** person per functional latrine in camps (2022)
- **1.1 l/h/d of** Sludge transferred (average production of sludge of **995m3 /day)**
- Capacity of treatment = 879 m3 (88%)

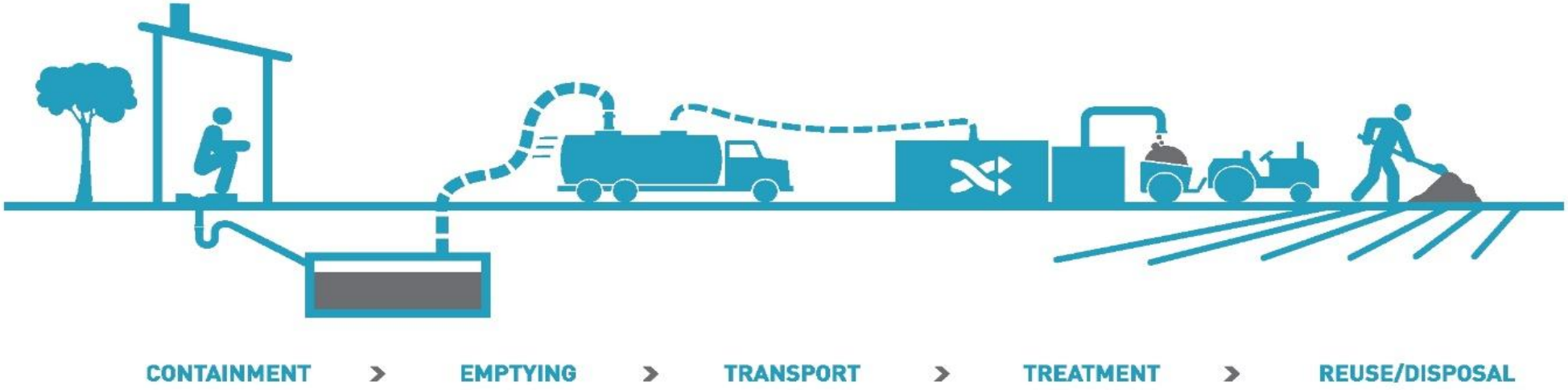








Sanitation value chain in Rohingya Camps + FSM Strategy



Mohammad Ashfaqur Rahman (Sojib)
WASH Officer – Sanitation
morahman@unicef.org

Containment

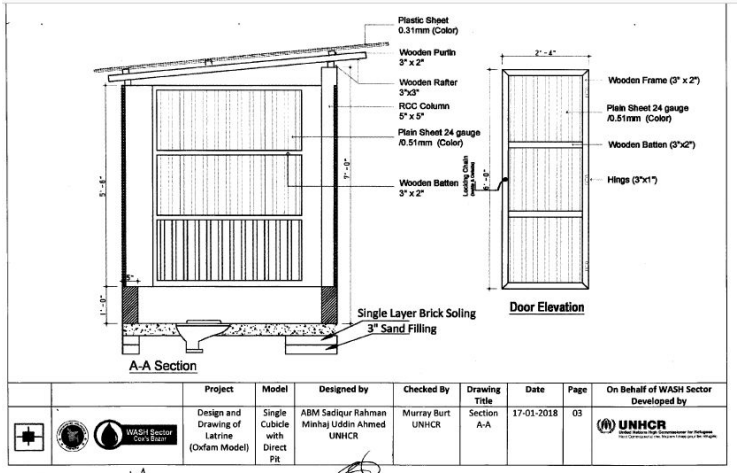
- Harmonized WASH sector design
- **21** person per functional latrine in camps (2022)
- Identified pocket gap (some blocks with 30/40 beneficiaries per latrine) -> density issues
- WASH partners to focus on O&M / upgrades
- Women friendly features / disability inclusion

Major Containment Type:

a) Single pit latrine

b) Twin pit latrine

c) Septic tank latrine

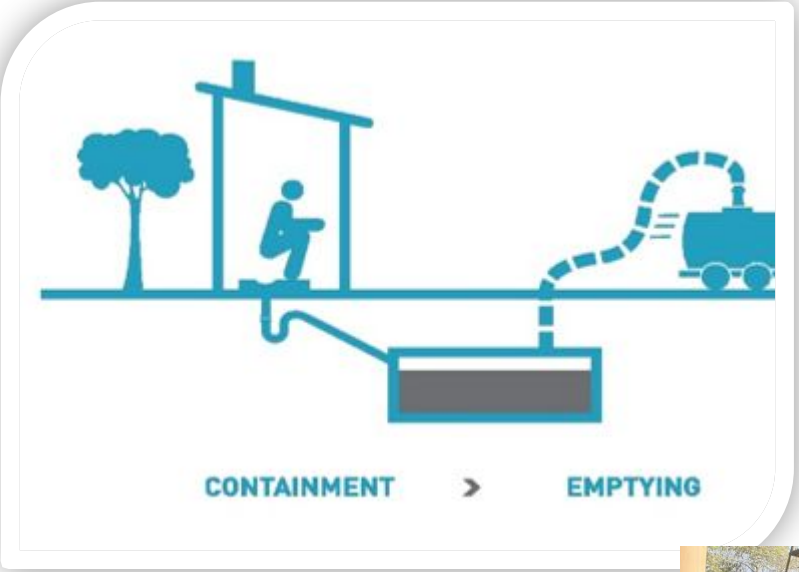


(a)

(b)

(c)

Emptying / Collection

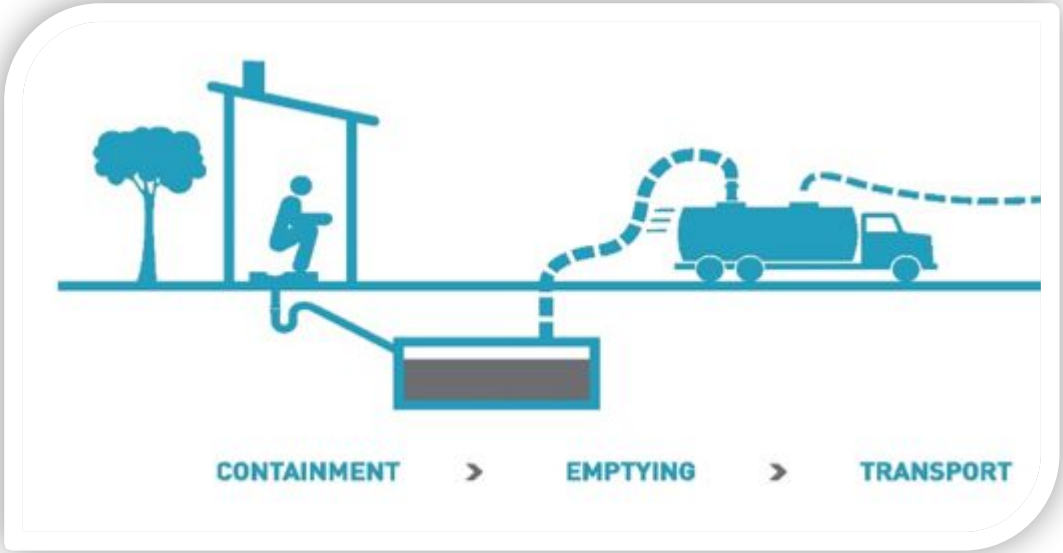


- Avoid Manuel desludging (bucket)
- Use desludging pump
- Desludging rate every 2 months on average (based on volume / population / type of latrine/geography/soil condition etc.)
- Safety/health rules
- Challenge: accumulative solid sludge in pits + solid waste creating blockage

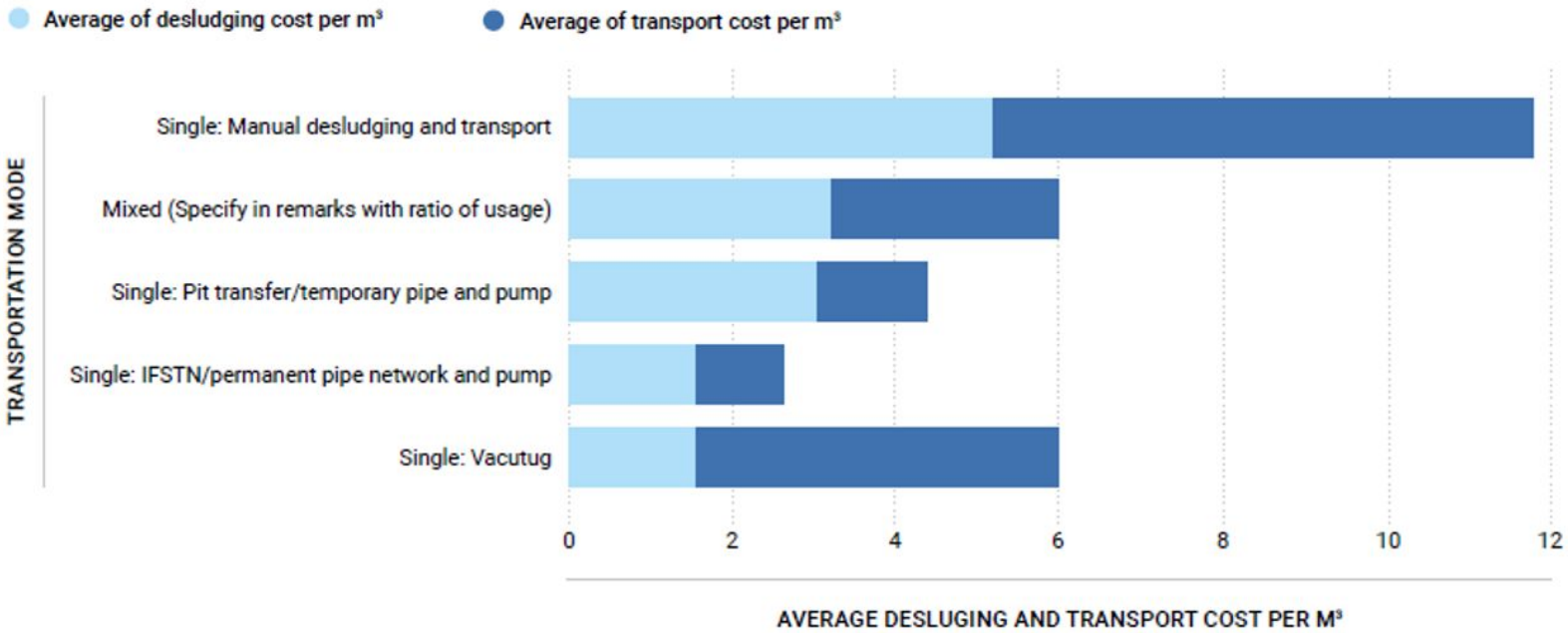
Way of desludging

- Desludging through pump
- Desludging through vacutug
- Few manual desludging in area with access issues

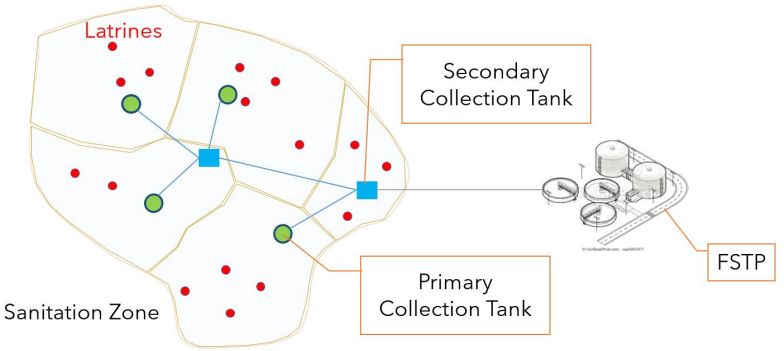
Transportation



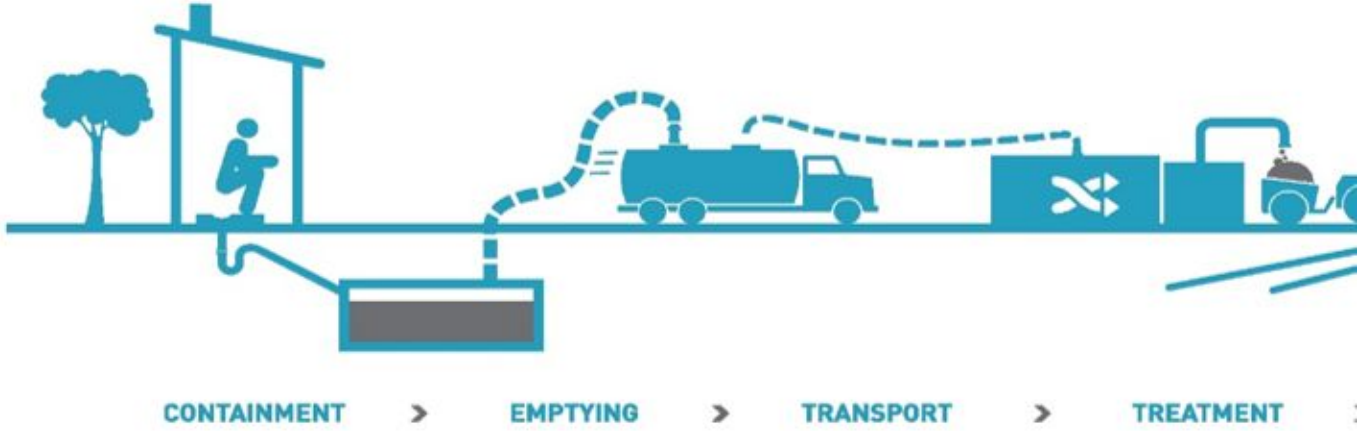
- 29,718 m3 of FS in transit per month (+26% in wet season)
- **Intermediate Faecal Sludge Transfer Network (IFSTN)** as the most cost-effective



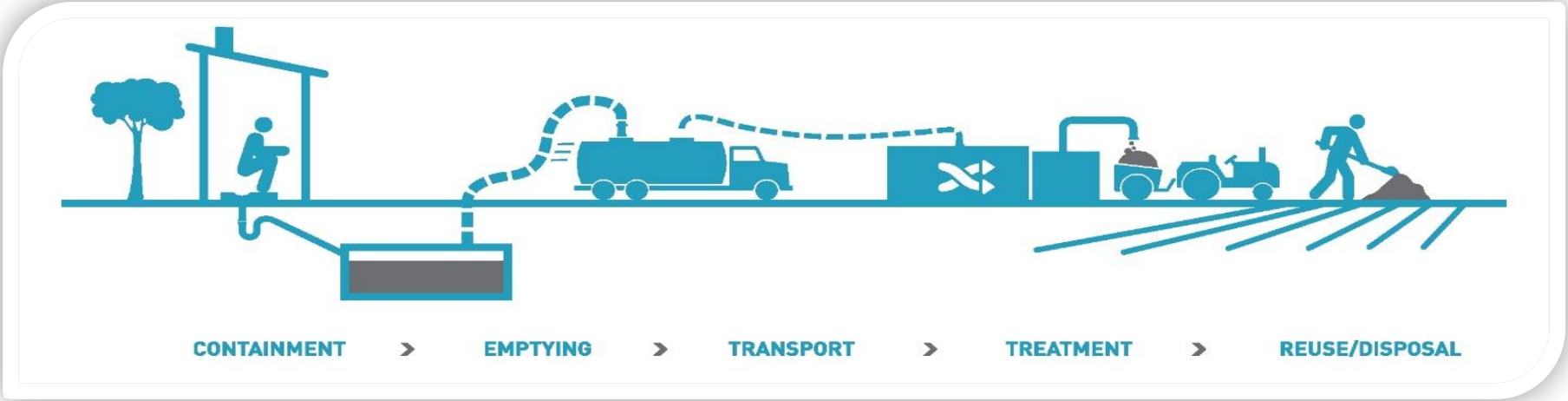
Way of transporting:



Treatment Plant



Reuse / Disposal



- Co-composting?
- Bio-gas?
- Omni Processor?
- Liquid back to water streams and infiltrated underground.

Different Feacal Sludge Treatment Technologies in Cox's Bazar

Jafar Ikbal
WASH sector Engineer
jafar.ikbal@brac.net

Anaerobic Baffled Reactor (ABR):

- 6 to 15 m3 per day
- 23% FSTPs are ABR
- Treatment Component:
  - Drying bed
  - Anaerobic baffled reactor
  - Polishing pond

Advantage:

- Moderately less area required (Avg. 49 m2/m3)
- Low O & M cost
- Effluent quality good than other treatment process

Disadvantage:

- Moderately higher capex (Avg. 5,758 USD per m3)
- Scalability Low
- Low pathogen removal capacity

Decentralized waste water treatment system (DEWATS)

- 3 to 6 m3 per day
- 9%+ FSTPs are DEWATS
- Treatment Component:
  - Settler tank
  - Up flow filter
  - Infiltration trench

Advantage:

- Less area required (Avg. 29 m2/m3)
- Low CAPEX & OPEX
- Effluent quality good than other treatment process
- Scalability high

Disadvantage:

- Nitrogen and nitrate removal capacity low

Mega FSTP 1 & 2

- 120 to 180 m3 per day
- Treatment Component:
  - Planted drying beds
  - Anaerobic lagoon
  - Trickling filter
  - Constructed wetland (vertical and horizontal)
  - Anaerobic Filter Reactor
  - Polishing pond
  - Up Flow Filter

Advantage:

- Low OPEX & whole life cost
- Effluent quality consistently good than other treatment process

Disadvantage:

- High CAPEX
- Large footprint area required

Up Flow Filter (UFF)

- 3 m3 per day
- 22% FSTPs are UFF
- Treatment Component:
  - Settler tank
  - Filter
  - Planted Contructed Wetland

Advantage:

- Less area required (Avg. 28 m2/m3)
- Low OPEX
- Scalability high

Disadvantage:

- High CAPEX
- Whole life cost moderately high

Waste Stabilization Pond (WSP)

- 2.5 to 5 m3 per day
- 6%+ FSTPs are WSP
- Treatment Component:
  - Drying beds
  - Anaerobic pond
  - Facultative pond
  - Maturation pond
  - Plantation bed & Soak Well

Advantage:

- Less area required (Avg. 13 m2/m3)
- Moderately low OPEX
- Effluent quality moderately good

Disadvantage:

- Moderately high CAPEX
- Scalability low

Lime Stabilization Pond (LSP)

- 5 to 10 m3 per day
- 14% FSTPs are LSP
- Treatment Component:
  - Drying Bed
  - Lime lagoons/ stabilisation ponds
  - Polishing Pond

Advantage:

- Moderately less area required (Avg. 47 m2/m3)
- Low CAPEX

Disadvantage:

- Effluent quality poor than other treatment process
- Whole life cost high
- Health and safety risk to the operators

Decentralized approach: case study of IOM DEWATS, Rohingya refugee crisis, Cox's Bazar, Bangladesh

Alessandro Petrone
IOM Head of WASH in Cox's Bazar, Bangladesh
apetrone@iom.int

Baudoin Luce
IOM WASH Officer, Global WASH Team
lbaudoin@iom.int

washsupport@iom.int

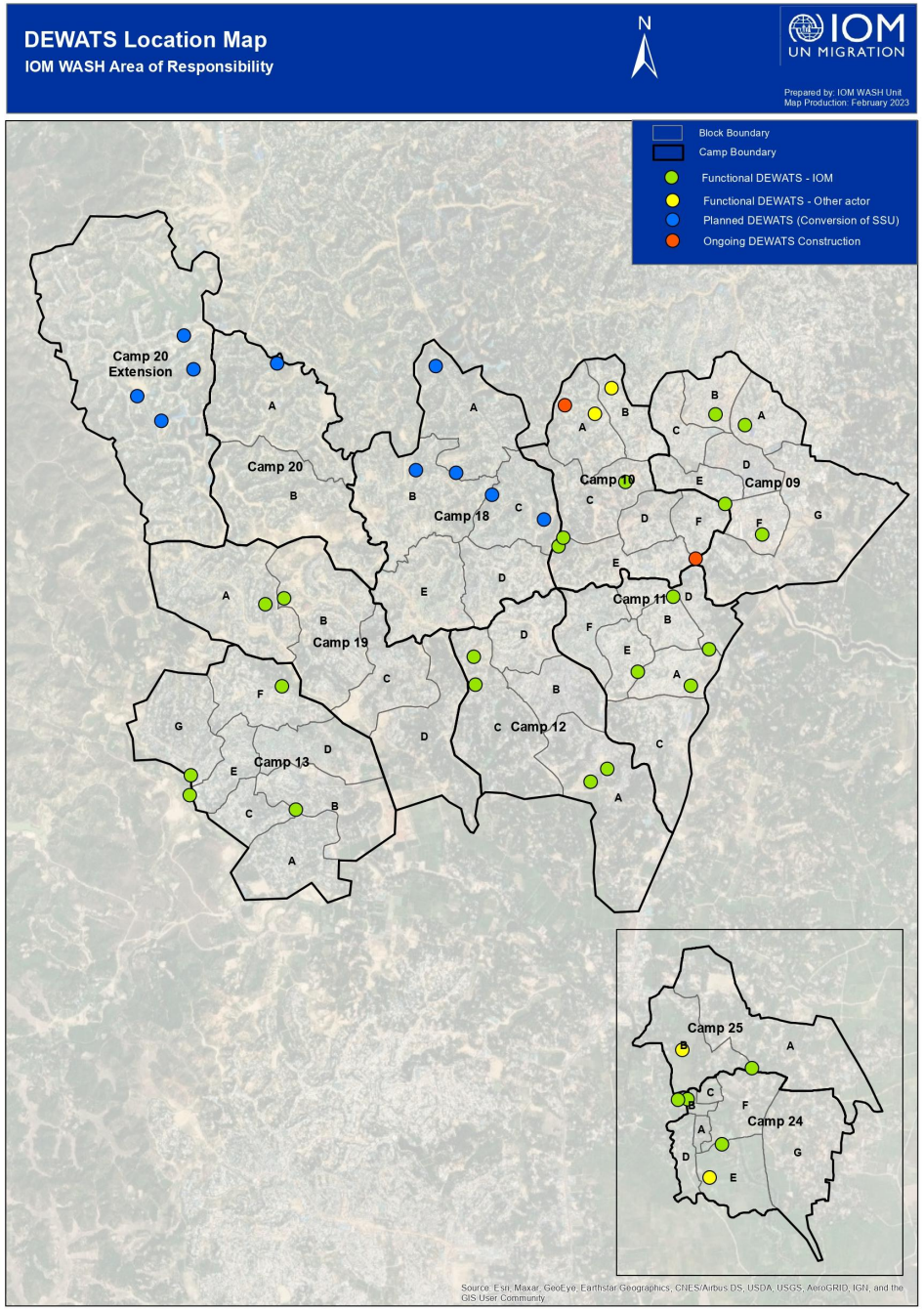
IOM DEWATS

“ For longer term decentralized FSM technology, the DEWATS score well against a number of the key indicators and are therefore considered the most effective ‘all round’ FSM technology” quoted from the Technology comparison study report conducted by ARUP, Oxfam and UNHCR.

25 completed

2 ongoing

10 in plan



Treatment mechanism (1)

ATS specifications:

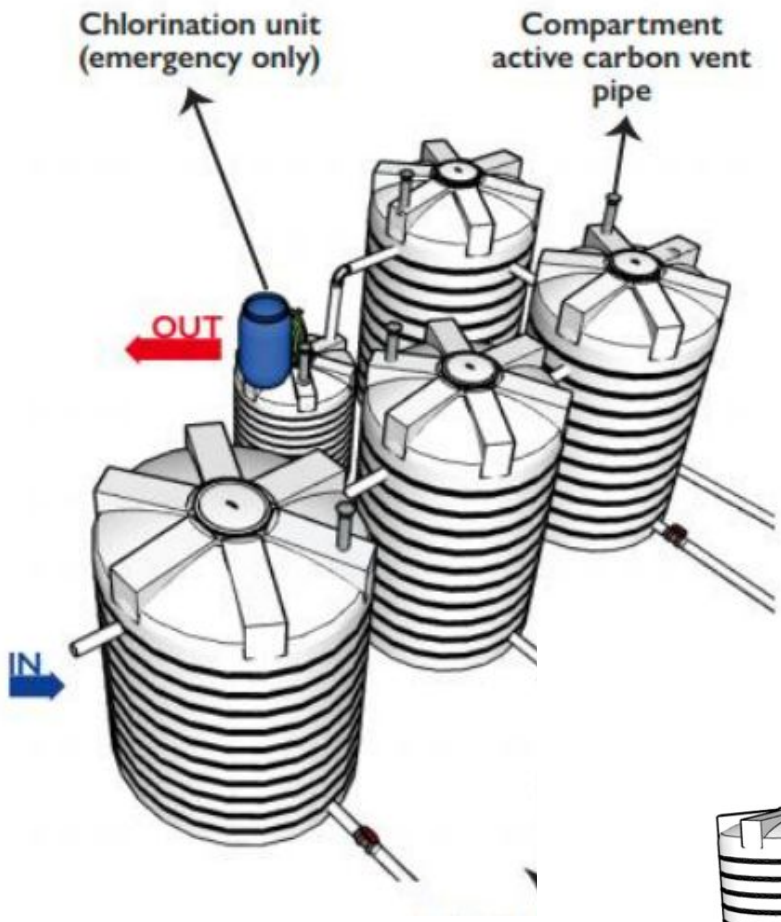
A total of 5 plastic tanks is needed

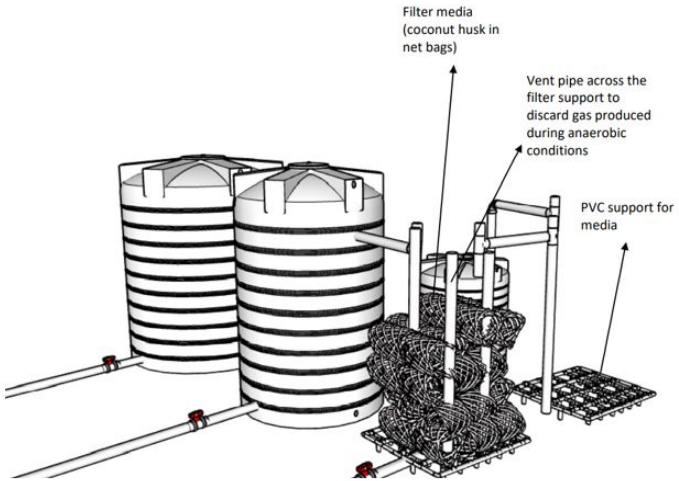
The first and second tanks (10,000 L and 7,500 L respectively) act as septic tanks by bio-digesting the sewage and retaining the majority of suspended solids

The third and fourth tanks (7,500 L each) act as Upflow Anaerobic Filters and are filled by a filter media (fragment of coconut husk which have a proven life expectancy when immerged in wastewater)

The last tank (2000 L) is used for final clarification or disinfection, in case of emergency

Each tank is fitted with a vent pipe filled with active carbon for odor elimination



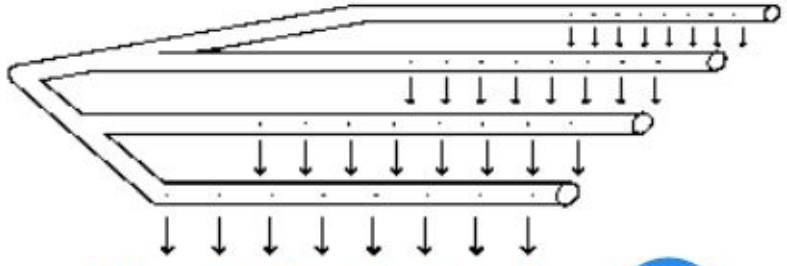


Treatment mechanism (2)

Infiltration trenches:
Soil infiltration tests were conducted, finding a rate of 60 l/m^2/d for semi-saturated sandy soil (within expected range for treated wastewater)

The infiltration surface of the Soak Field is given by the quotient of the effluent discharge and the infiltration rate: 3100 (l/d)/60 l/m2/d) = 51.7 m2

The length of the Soak field is given by dividing the infiltration surface by 2 x depth of the trenches (1.6m): 51.7 (m2)/1.6 (m) = 32 m



Effluent infiltration into the soil through a soak field (infiltration trenches)

5

IOM UN MIGRATION

Performance analysis

3,100
Liters of sludge treated per day

5170
People with access to safe FSM.

Environmentally friendly. No added chemical and power supply.

Designed to minimize O&M requirements

Materials locally available

System totally sealed / no smell or exposure

96% reduction of fecal coliform after treatment

99.6% reduction of helminths after treatment

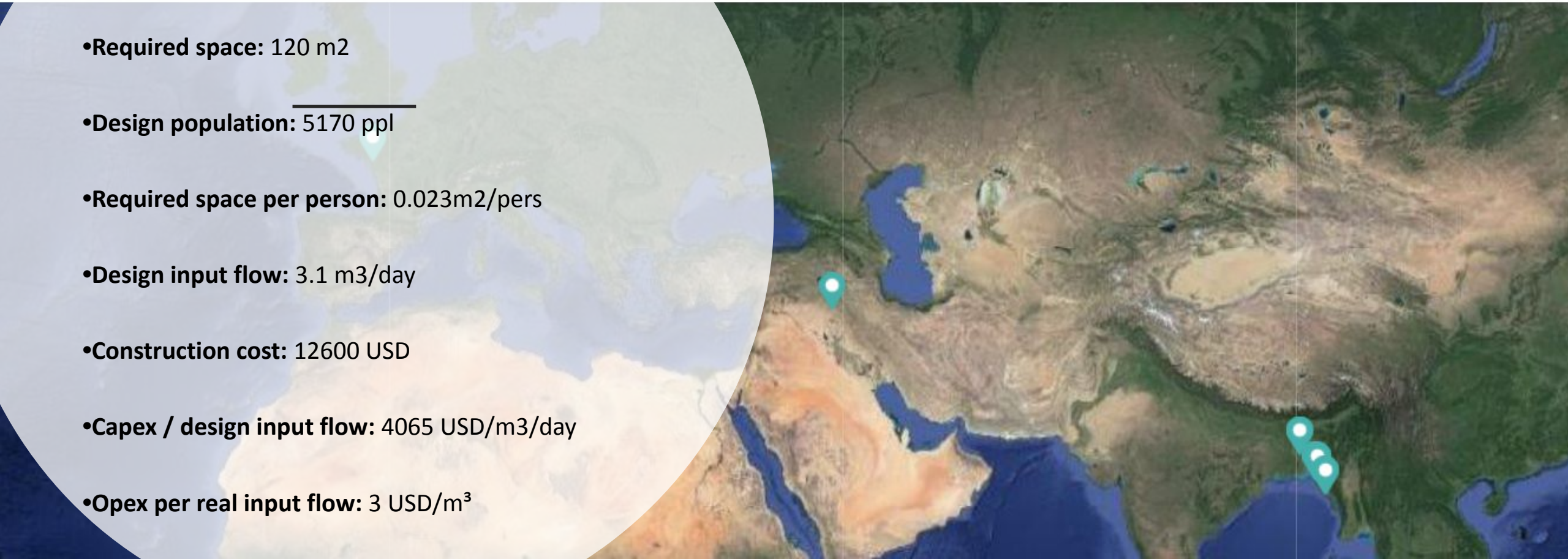
Summary of parameters tested by ICDDR,B: average of 12 rounds results in 3 DEWATS in C9 and C23 (2) - 2 samples (inlet & outlet)			
E. Coli reduction	E. Coli (cfu/100ml)	TS reduction	TSS reduction
96%	**16880**	**70%**	**96%**
COD reduction	BOD reduction	TN reduction	TP reduction
83%	**87%**	**60%**	**77%**
Ammonium reduction	Helminths reduction	Salmonella (P/A)	Vibrio cholera (P/A)
38%	**99.6%**	**75%**	**80%**

IOM UN MIGRATION

Case studies

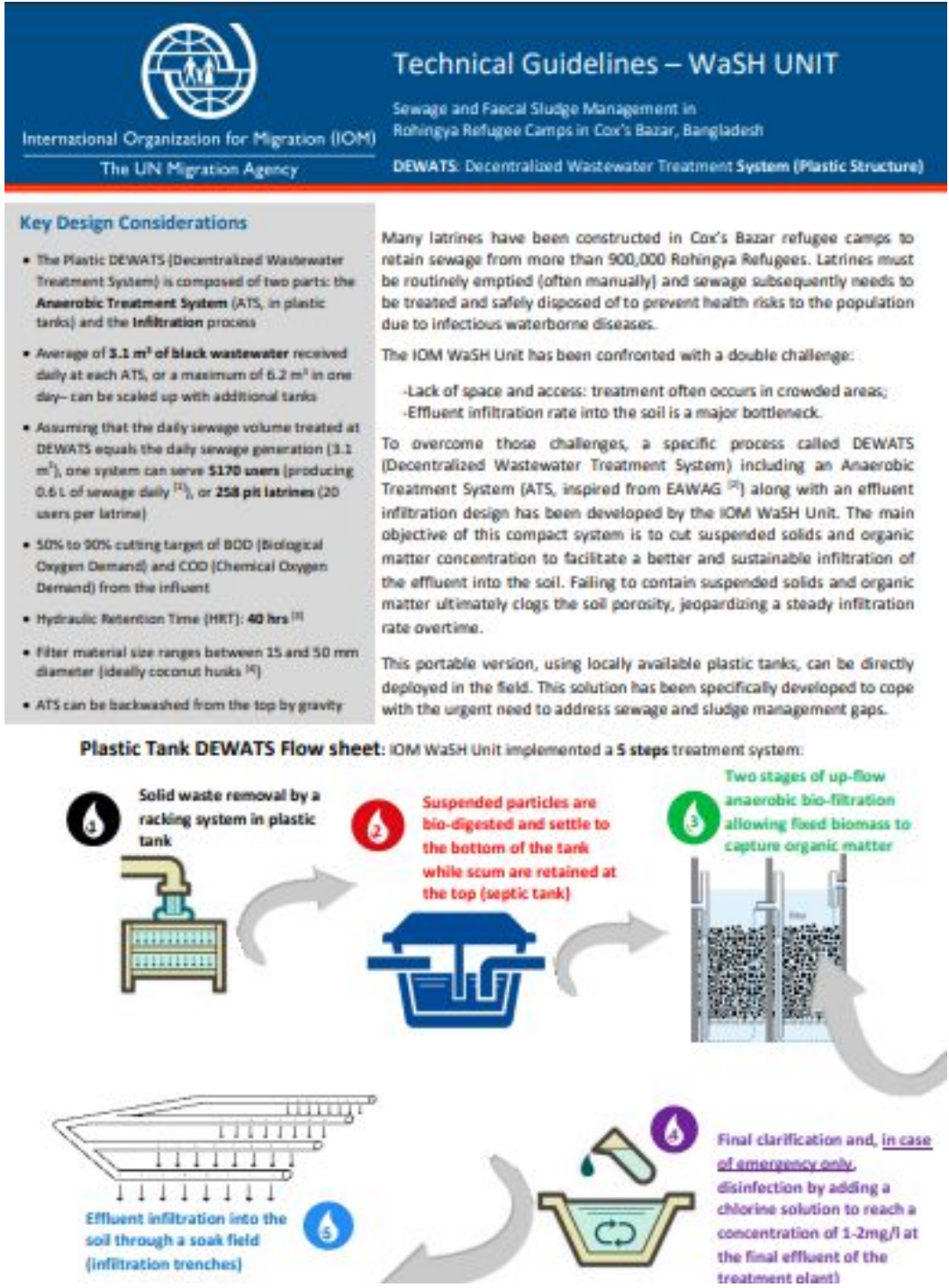
PUBLISH A CA

- **Required space:** 120 m2
- **Design population:** 5170 ppl
- **Required space per person:** 0.023m2/pers
- **Design input flow:** 3.1 m3/day
- **Construction cost:** 12600 USD
- **Capex / design input flow:** 4065 USD/m3/day
- **Opex per real input flow:** 3 USD/m³



Resources for DEWATS installation and O&M

- IOM DEWATS Fact Sheet.pdf
- IOM_DEWATS_Performance analysis.pdf
- IOM_SOP_DEWATS Installation.pdf
- IOM_SOP_DEWATS_O&M.pdf



International Organization for Migration (IOM)
The UN Migration Agency

Technical Guidelines – WaSH UNIT

Sewage and Faecal Sludge Management in Rohingya Refugee Camps in Cox's Bazar, Bangladesh

DEWATS: Decentralized Wastewater Treatment **System (Plastic Structure)**

Key Design Considerations

- The Plastic DEWATS (Decentralized Wastewater Treatment System) is composed of two parts: the **Anaerobic Treatment System** (ATS, in plastic tanks) and the **Infiltration** process
- Average of **3.1 m³ of black wastewater** received daily at each ATS, or a maximum of 6.2 m³ in one day– can be scaled up with additional tanks
- Assuming that the daily sewage volume treated at DEWATS equals the daily sewage generation (3.1 m³), one system can serve **5170 users** (producing 0.6 L of sewage daily [1]), or **258 pit latrines** (20 users per latrine)
- 50% to 90% cutting target of BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) from the influent
- Hydraulic Retention Time (HRT): **40 hrs** [3]
- Filter material size ranges between 15 and 50 mm diameter (ideally coconut husks [4])
- ATS can be backwashed from the top by gravity

Many latrines have been constructed in Cox's Bazar refugee camps to retain sewage from more than 900,000 Rohingya Refugees. Latrines must be routinely emptied (often manually) and sewage subsequently needs to be treated and safely disposed of to prevent health risks to the population due to infectious waterborne diseases.

The IOM WaSH Unit has been confronted with a double challenge:

-Lack of space and access: treatment often occurs in crowded areas;
-Effluent infiltration rate into the soil is a major bottleneck.

To overcome those challenges, a specific process called DEWATS (Decentralized Wastewater Treatment System) including an Anaerobic Treatment System (ATS, inspired from EAWAG [2]) along with an effluent infiltration design has been developed by the IOM WaSH Unit. The main objective of this compact system is to cut suspended solids and organic matter concentration to facilitate a better and sustainable infiltration of the effluent into the soil. Failing to contain suspended solids and organic matter ultimately clogs the soil porosity, jeopardizing a steady infiltration rate overtime.

This portable version, using locally available plastic tanks, can be directly deployed in the field. This solution has been specifically developed to cope with the urgent need to address sewage and sludge management gaps.

Plastic Tank DEWATS Flow sheet: IOM WaSH Unit implemented a **5 steps** treatment system:

Faecal Sludge Management Challenge:

Promoting thermophilic anaerobic digestion in faecal sludge in Rohingya's refugee camps

AITAA Thailand

icddr,b

IOM UN MIGRATION

HIF Humanitarian innovation fund | elrha

FSM challenge: problem identification

- Already innovative as DEWATS was replicated in Nigeria by the IOM WASH team

- Adopted by other WASH partners in Cox's Bazar

=> The infiltration process remains an essential component where the soil properties are a key factor

The innovation process

Problem identification

Partnership discussion, call literature review

Innovative solution identified with partners

Agreement with partners

We are here !

Pilot project – evidence gathering

Market dialogue – cost analysis; scalability and replicability of solution

Publication , dissemination, knowledge sharing and advocacy

***Adoption** by other partners in different contexts*

IOM UN MIGRATION

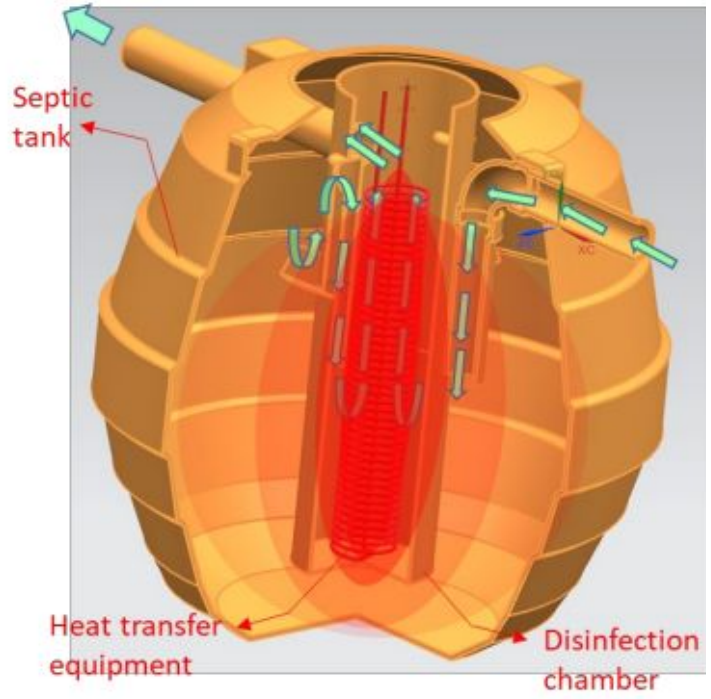
Existing evidence on thermophilic anaerobic digestion

Literature review:

- Thermophilic anaerobic digestion (AD) removes higher concentrations of pathogens compared to mesophilic anaerobic digestion (AD) (Labatut et all, 2013).
- Temperature: inactivation factor for E. coli (Forster-Carneiro et al, 2010).
- Thermophilic conditions effective in breaking down pathogens as helminth eggs at 55°C (Pandey et Soupir, 2011; Fidjeland et al. 2015).
- Vibrio cholerae is inactivated when exposed to temperatures above 45°C (Solarte, 1997).

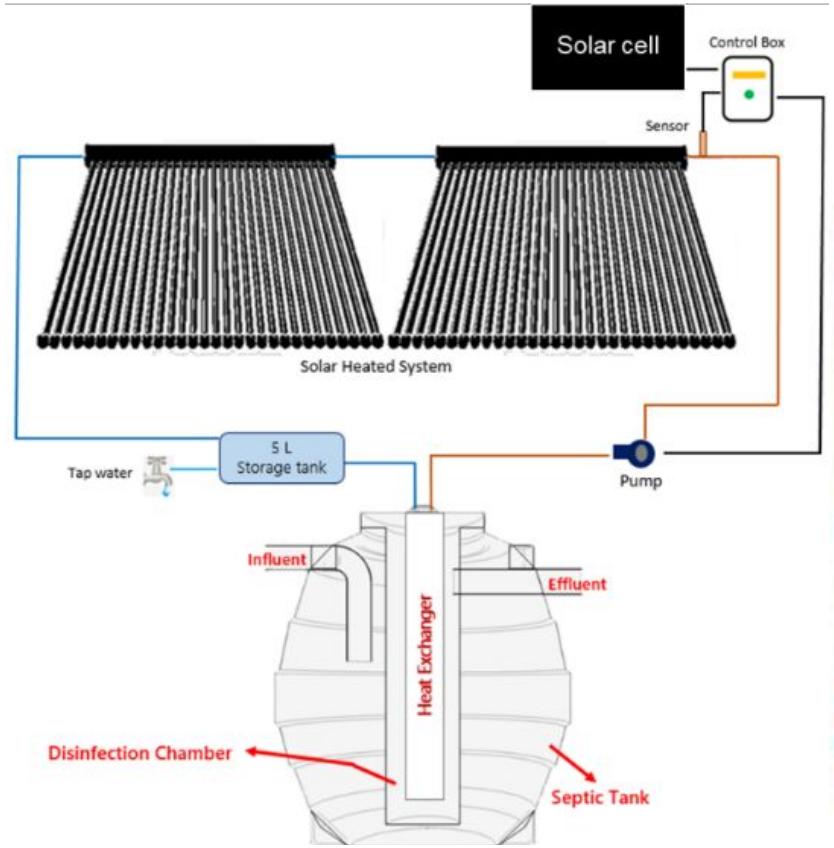
Solar septic tank empirical data (operating at 40–53 °C):

- 2–4 log reduction of total coliform (TC) and 3–5 log reduction of E. coli - compared to just 0 –1 log reduction of E. coli and total coliform in the conventional septic tank.



Innovative Solution - Adaptation of Solar septic tank

- Solar heating system including solar modules, solar modules mounting structures; cabling and fittings; inverter; and heat transfer equipment.
- Disinfection chamber and heating unit with temperature sensors.



Humanitarian innovation fund | elrha

IOM UN MIGRATION

AITAA Thailand

Project Learning Objectives

- The IOM DEWATS is upgraded with adapted solar power heating technology in collaboration with regional academic partner

- The thermophilic anaerobic digestion adapted to IOM Dewats creates reduction of specific pathogen and contribute to cholera prevention.

- Adaptability and scalability of innovative solution is ensured in order to make the solution replicable in different densely populated humanitarian context.

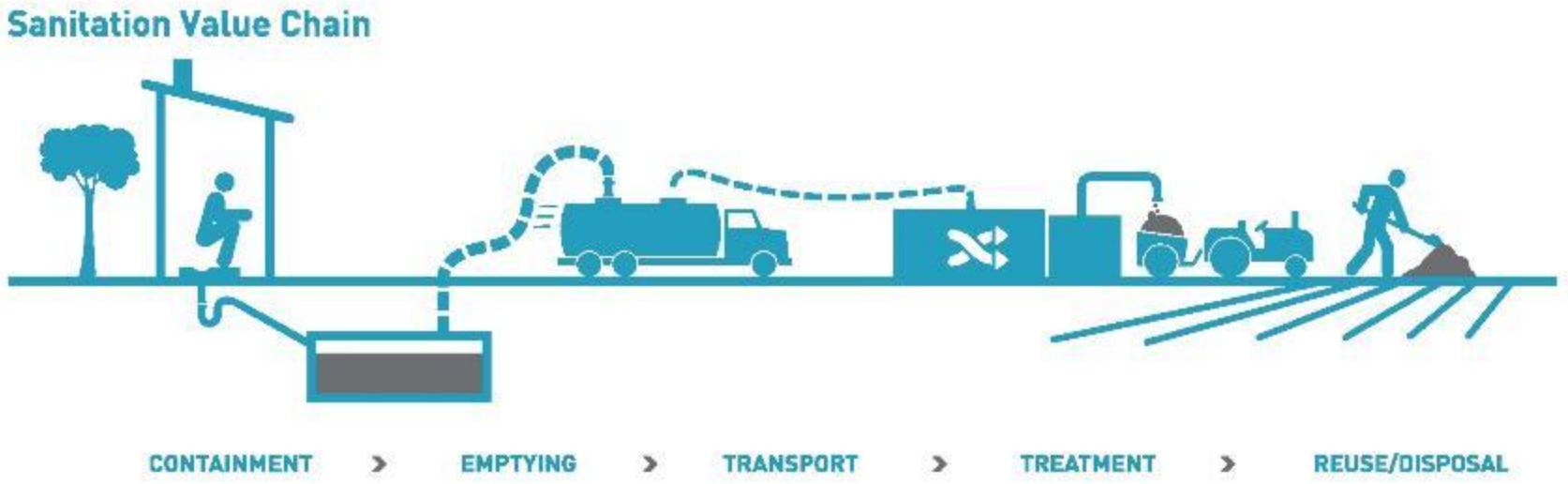
AITAA Thailand

Mega FSTPs/ centralized approach

Grover Mamani Casilla
WASH Officer
mamanica@unhcr.org

FSM GOAL AND OBJECTIVE

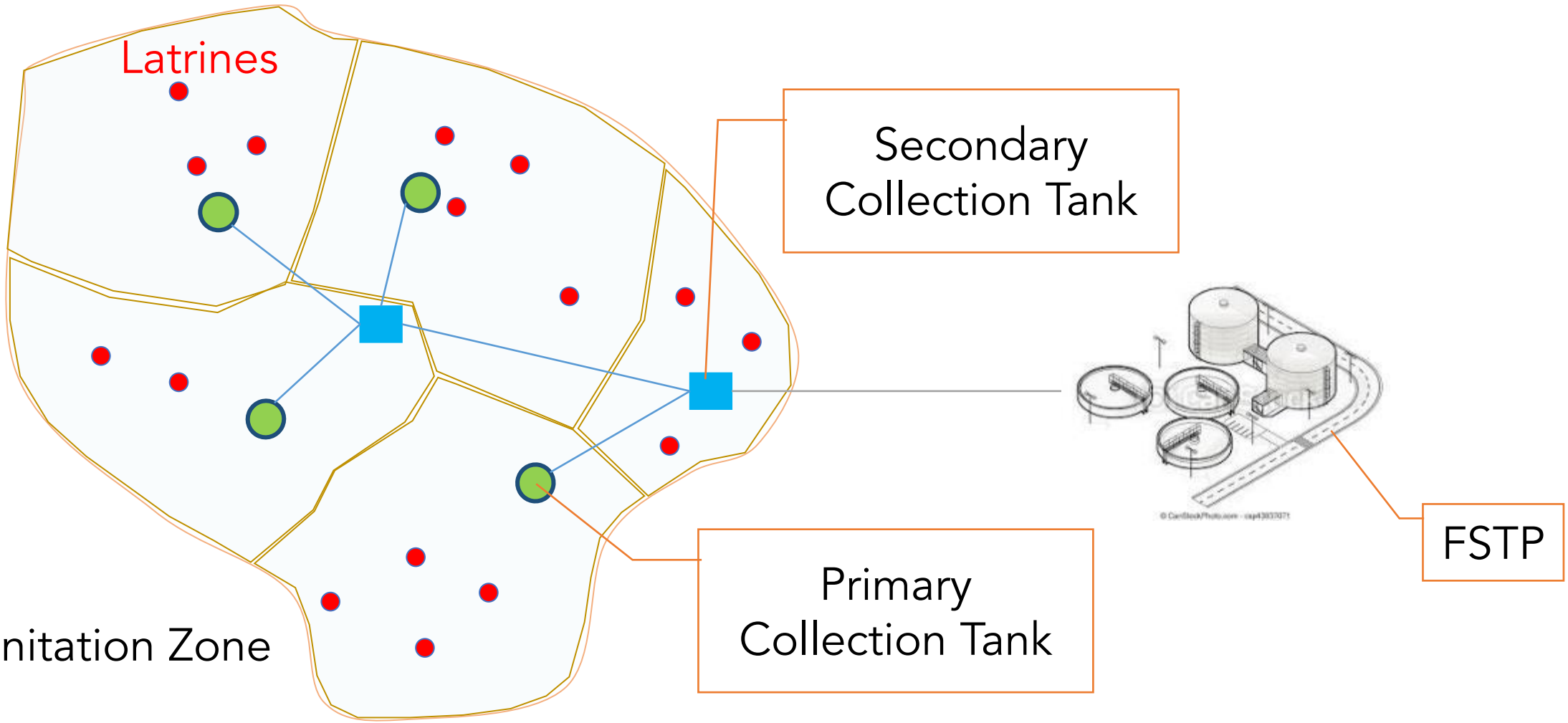
To provide sustainable, cost-efficient and safe systems to contain, empty, transport, treat and dispose/re-use faecal sludge in the Rohingya refugee camps



Source: https://flic.kr/p/A37Tg3

UNHCR
The UN Refugee Agency

Intermediate Faecal Sludge Transfer Network IFSTN

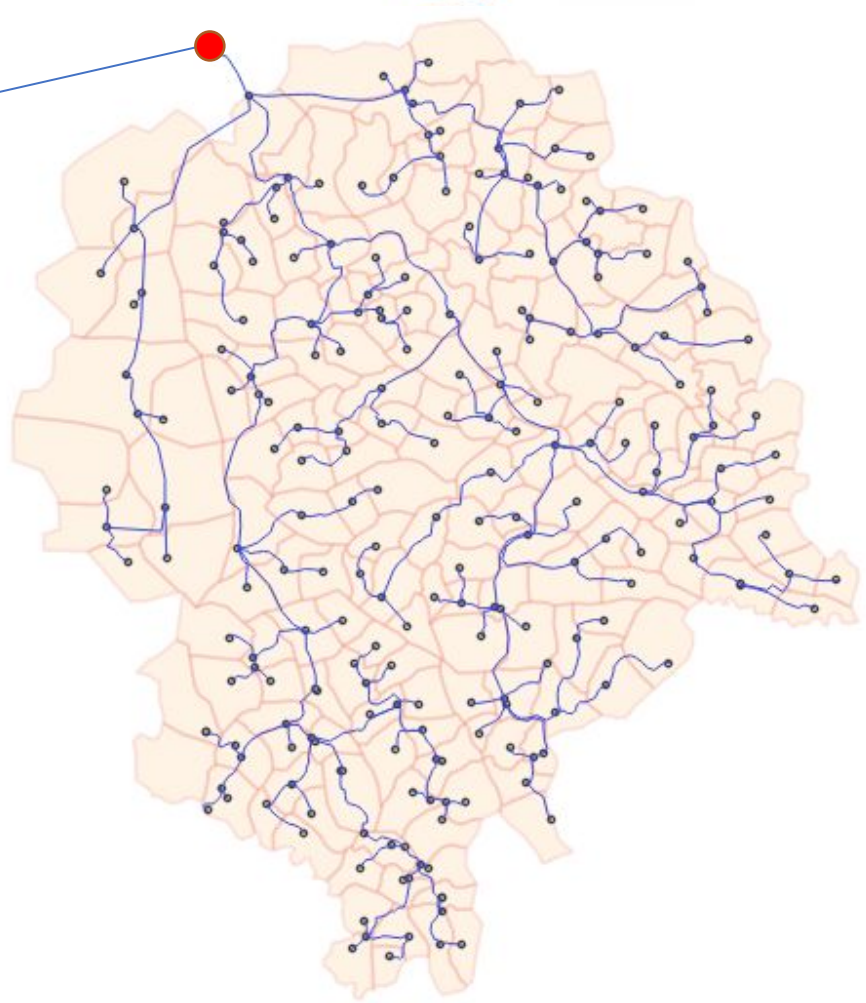


UNHCR
The UN Refugee Agency

TRANSFER NETWORK 1

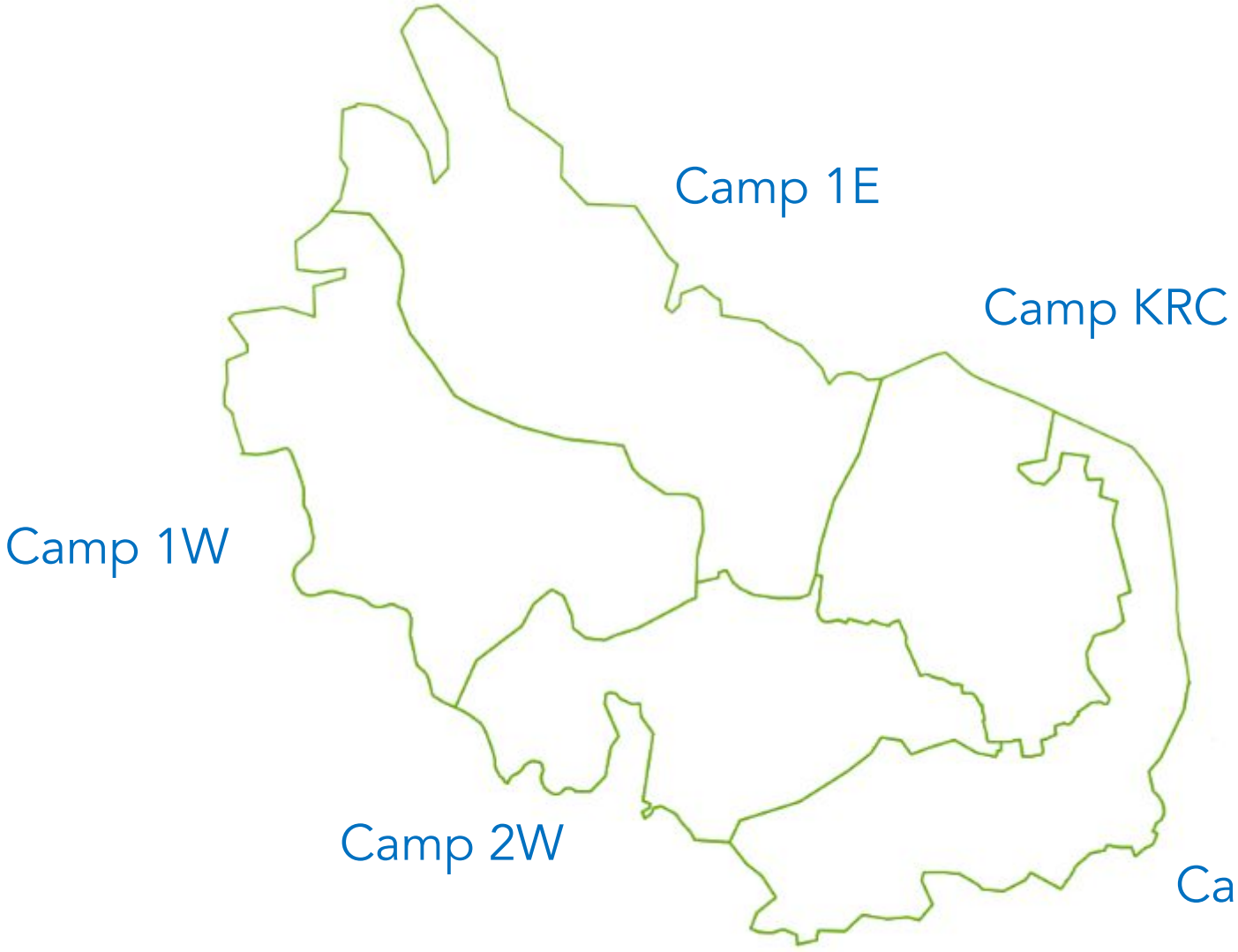
FSTP Camp 4X

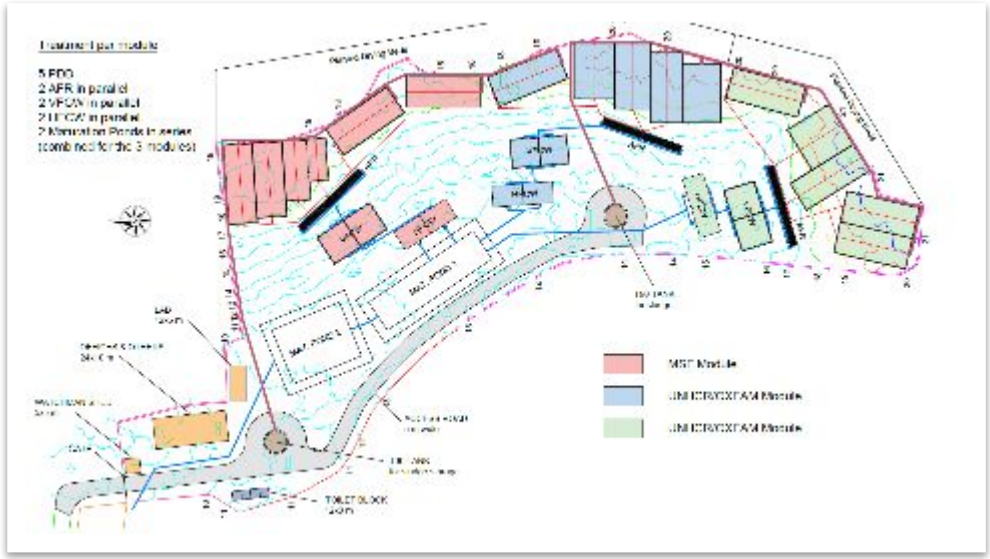
Camp 4



UNHCR
The UN Refugee Agency

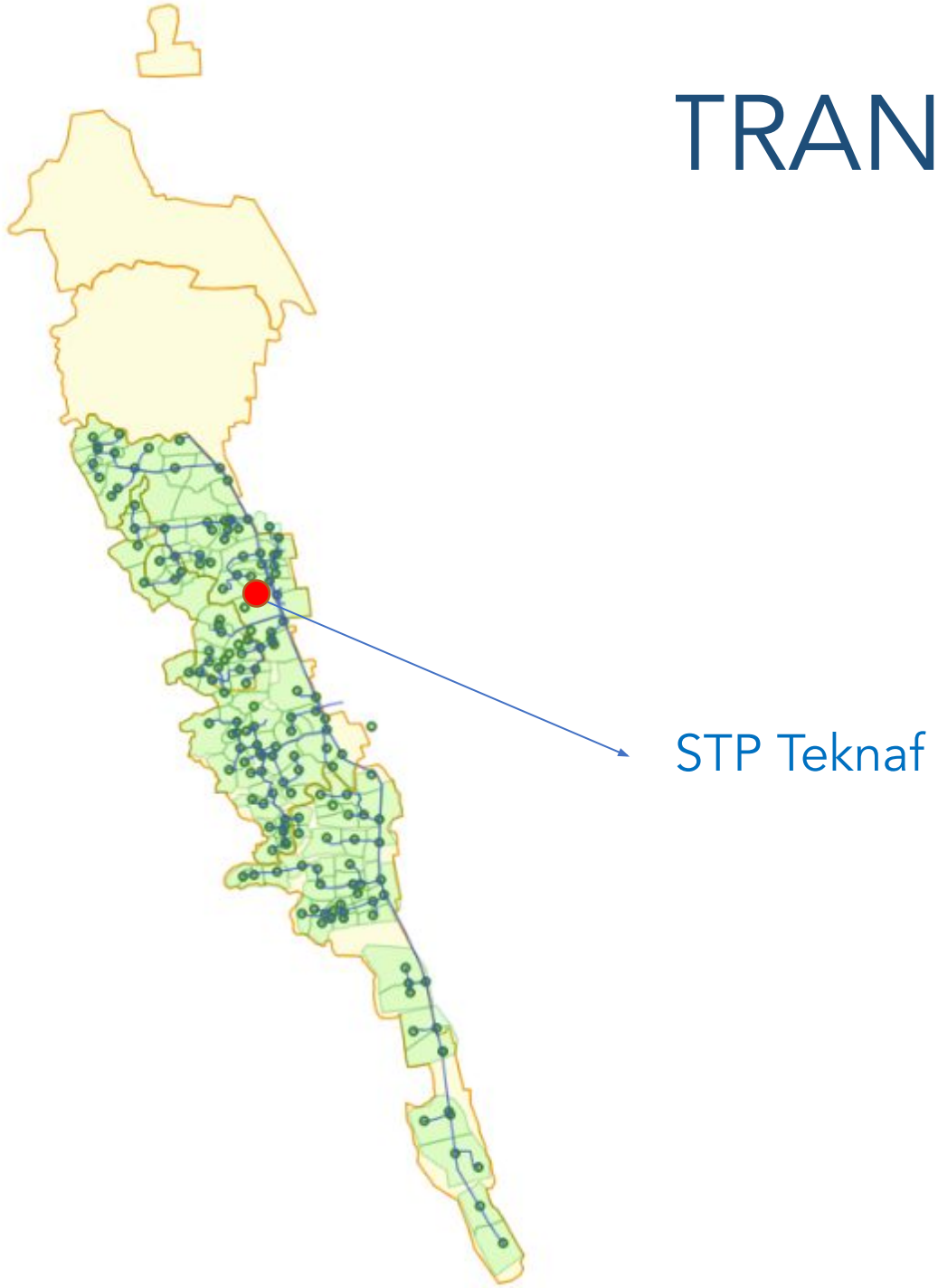
NETWORK 2





FSTP Kutupalong

TRANSFER NETWORK 3



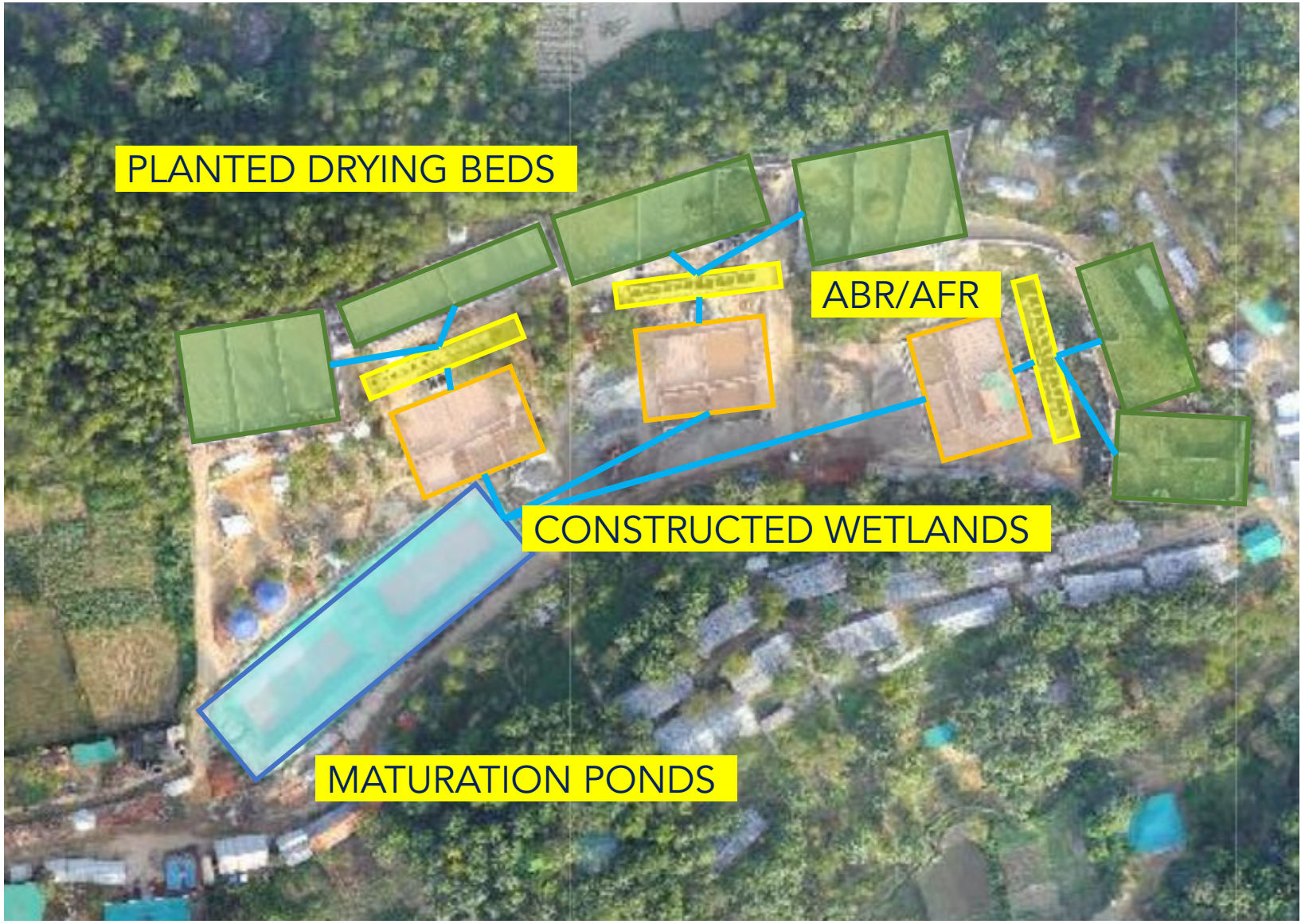
UNHCR
The UN Refugee Agency

FSTP-1
CAMP 4X

- Operational since 2019
- Capacity:120 m3/day
  120,000 refugees
- Operation Cost: USD 15,000
- By products:
  - Stabilized Sludge
  - Biogas
  - Treated water
  - Grass

UNHCR
The UN Refugee Agency

FAECAL SLUDGE TREATMENT PLANT 2



- Operational since 2022
- Capacity: 180 m3/day
- By products:
  - Stabilized Sludge
  - Treated water
  - Grass
- Provides de service to Host Community and Refugees

UNHCR
The UN Refugee Agency

FROM TRADITIONAL TO NON-CONVENTIONAL FSM SOLUTION

- DEMONSTRATION: Appropriate, cost-efficient, safe solutions were piloted, upscaled and validated by third-party assessment
- ADVOCACY: Non-conventional solutions required advocacy work with government, local and international agencies and WASH Sector
- INFLUENCE: The results of centralized solutions in Cox's Bazar context are an example of simple and nature-based solutions for FSM, that can be replicated in similar context.

UNHCR
The UN Refugee Agency

KEY STAKEHOLDERS

ARUP

streamstech

BANGLADESH AGRICULTURAL UNIVERSITY

CWIS-FSM Support Cell

icddr,b

BILL & MELINDA GATES foundation

BORDA

MEDECINS SANS FRONTIERES

brac

NGO FORUM FOR PUBLIC HEALTH

ITN-BUET
Centre for Water Supply and Waste Management

URBAN waters

GENEVA TECHNICAL HUB

OXFAM

UNESCO | IHE DELFT

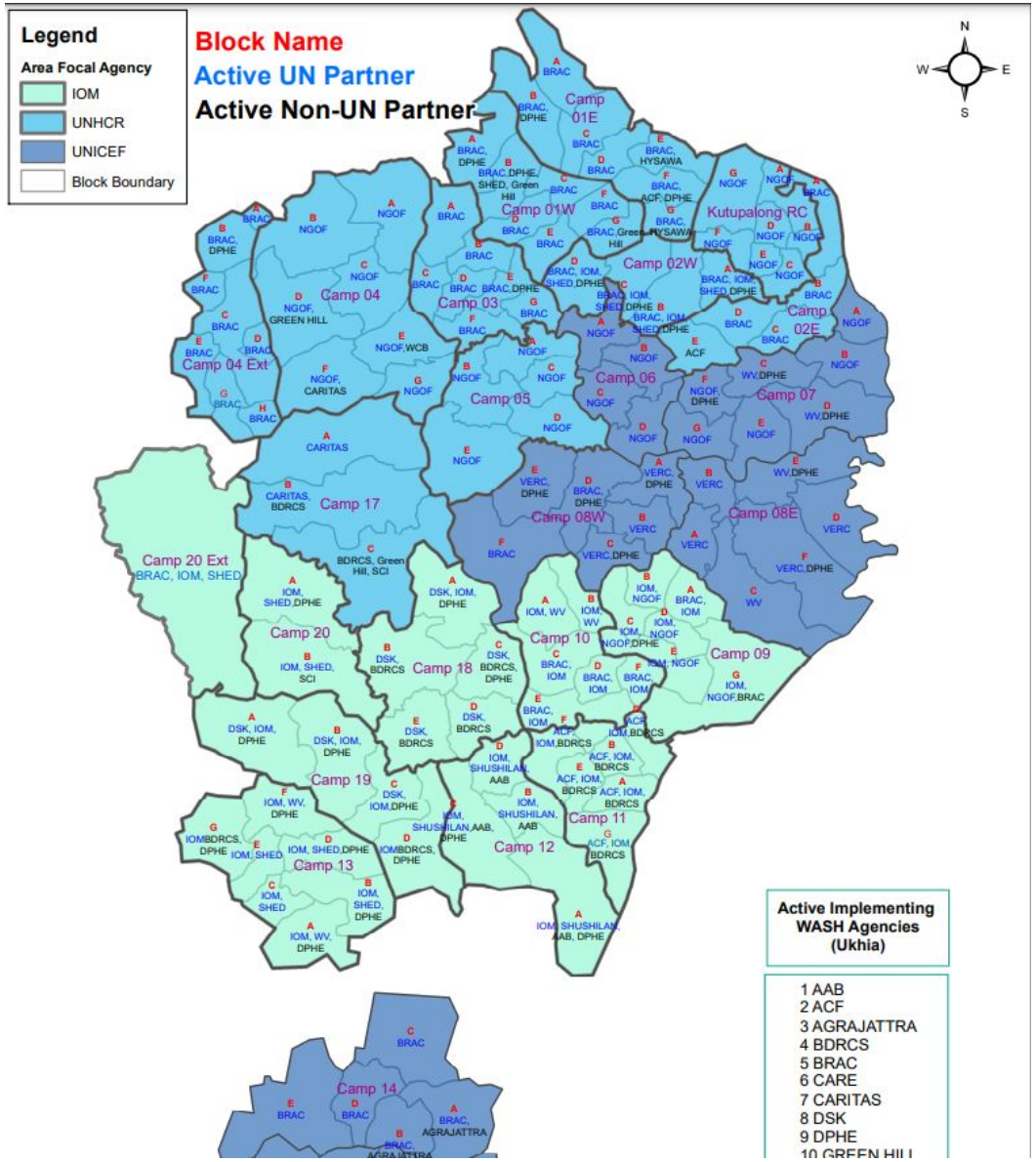
UNHCR The UN Refugee Agency

PIT INTELLIGENT TRACKER (PIT)

Safwatul Niloy
WASH Coordinator
SNiloy@oxfam.org.uk

Digitized Operation of IFSTN and Remote Monitoring

UNHCR Operational 14 camps
Population – around 360,000 Ind.
# of latrine containment – 13,500

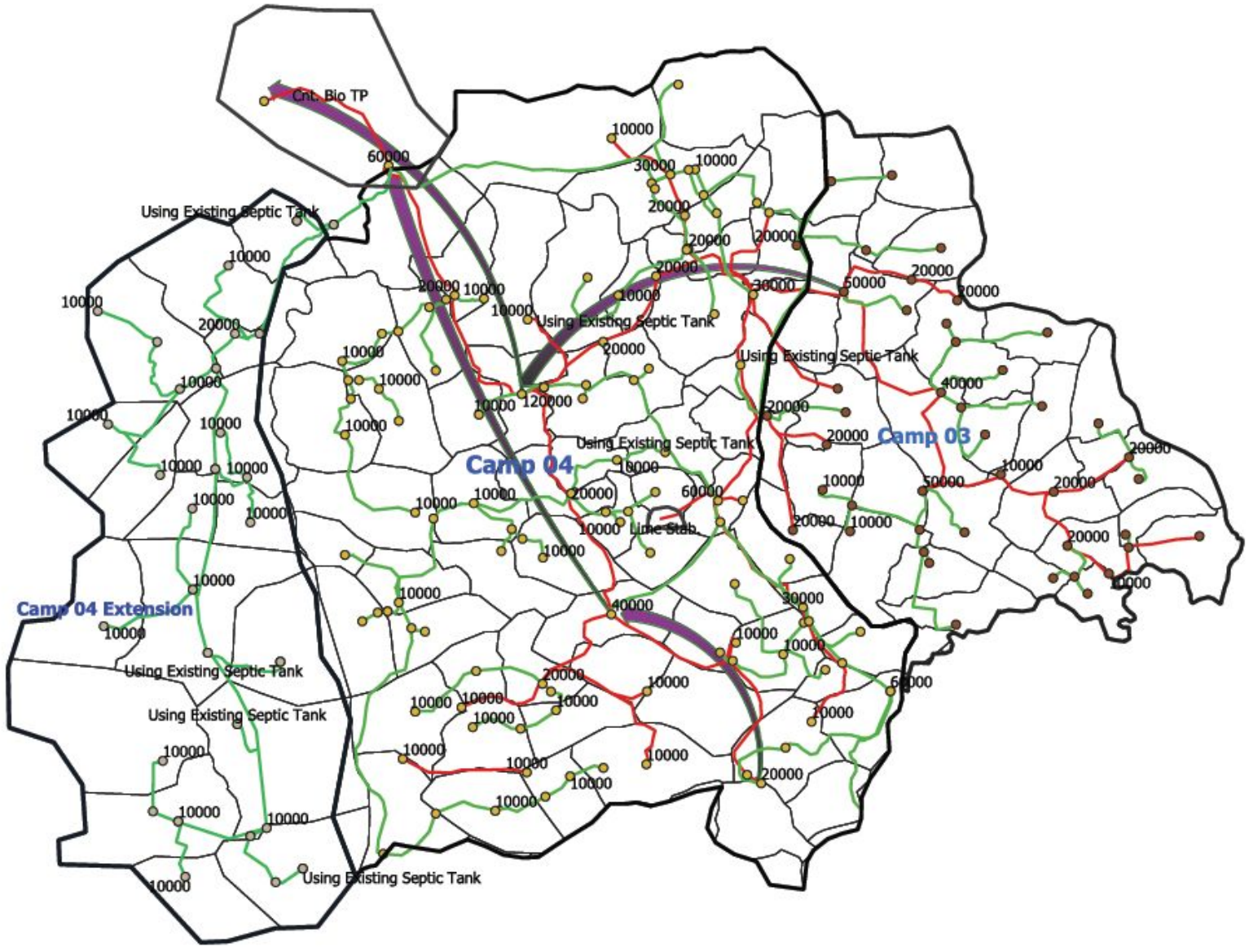


LatrineID	ConstructedBy
4563	Oxfam
4343	Oxfam
....	Oxfam
1407	Oxfam
4613	NGO_Forum
....	NGO_Forum
....	NGO_Forum
....	NGO_Forum
....	NGO_Forum
No	ACF
3645	Army
No	ACF
No	NGO_Forum

Current challenges on latrine data collection

- No latrine unique ID
- Complain based response for desludging.
- Less practice of digitized data collection / No analysis on latrine containment performance
- Systematic Operation of IFSTN

Intermediate Fecal Sludge Transfer Network - I (As Built Map)



UNHCR

OXFAM

Legend

Camp 4 extension(As Built)
- FSTP
- Camp 4 xAs Built Junctions
- Camp 4 ext
- Sewer Line As Built
- Camp 4-.
- Camp 3-

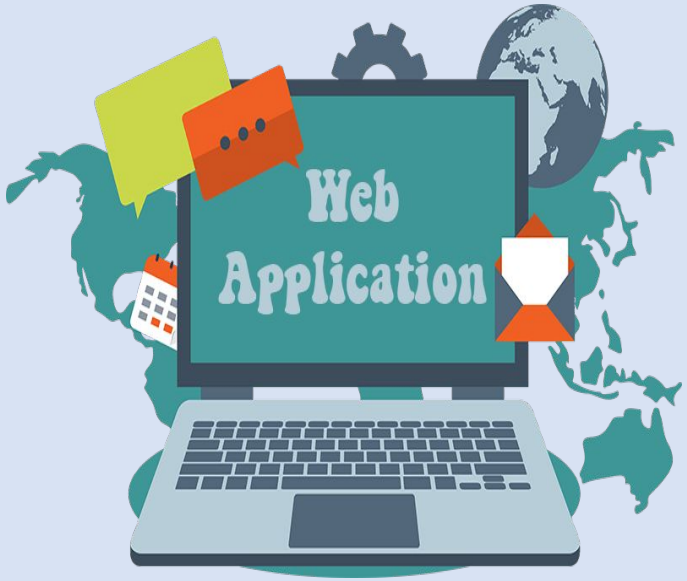
Camp 3 asbuilt
- Camp 3 as built Junction
- Sewer LIne As built Camp 3

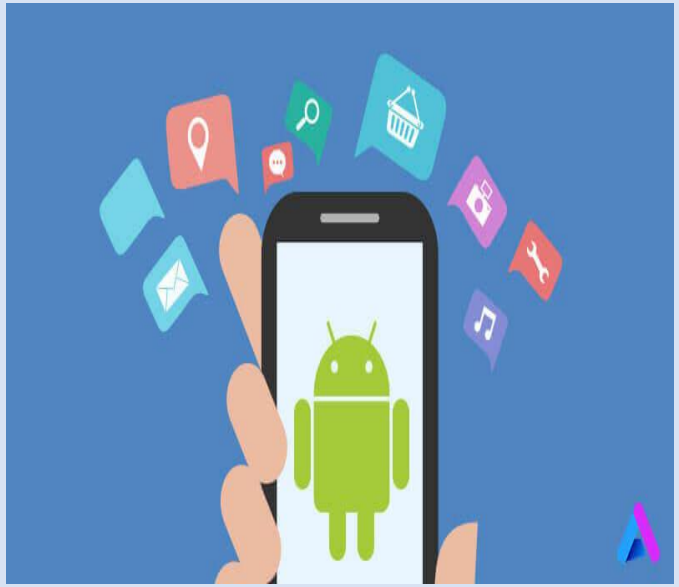
Camp 4 As Built
- GPS data base Camp 4
- New construction C 4
- Sewer Line Z C4 (OV)
- Bypass LInes Camp 4,Popular
- Camp 4 x SZ
- Camp 4 Sz
- Camp 3 Sz

Map Version - Initial
Creation Date- 31st December,2021

Notes - Maps to be updated based on the field anomalies if any.
Please follow the designed files / Maps for planned bypass line of the whole network including camp 5,17.

UNHCR /OXFAM Desludging Solutions





Android App

- Web Dashboard
- App Dashboard
- Desludging data
- Prediction Model

Developed by -KAZ SOFTWARE KAZ

Sanitation Value Chain in Camp

Data source of mobile application

Vacutug

IFSTN

Latrine containment

Desludging

Transportation

Treatment

Latrine Qr code with Unique ID

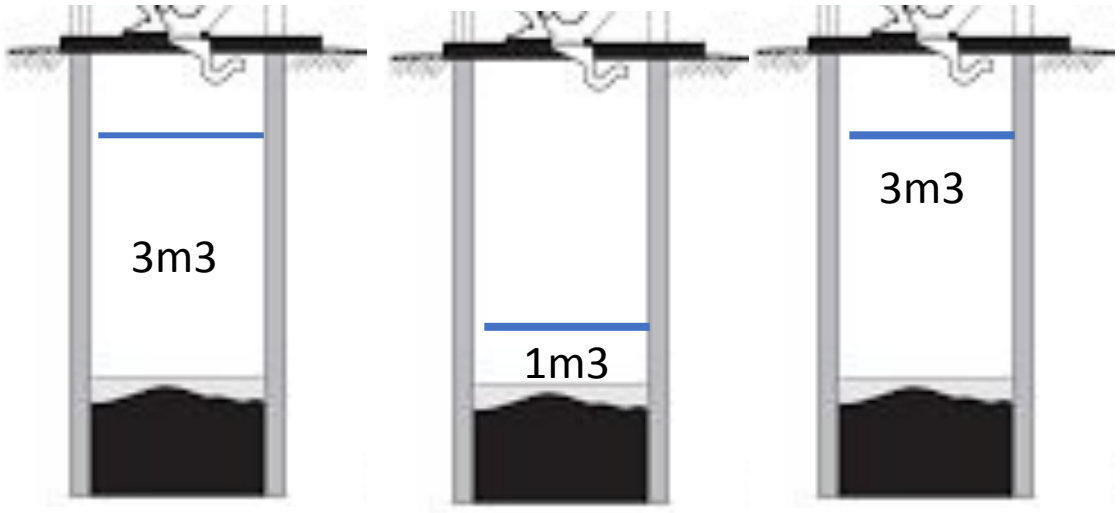
Printed Unique ID

App will read Qr code or can insert ID Manually

Predicting latrine next desludging date

Option -1

Latrine containment volume analysis



Baseline data

Data input (Dsz supervisor)

Filling rate (Predict Next Dsz date)

Option -2

Desludging frequency analysis

1. Latrine DsZ date recorded(1st Feb)
2. Next latrine DsZ (10th feb)
3. Model record 9 days as interval and predict next Dsz Date on 20th February.
4. Factor - Take in account rainy and dry season filling rate

- Initially low accuracy , with data flow each latrine will go towards correct prediction

Self corrective model

Current challenges for latrine data collection and desludging

LatrineID	ConstructedBy
4563	Oxfam
4343	Oxfam
....	Oxfam
1407	Oxfam
4613	NGO_Forum
....	NGO_Forum
....	NGO_Forum
....	NGO_Forum
....	NGO_Forum
No	ACF
3645	Army
No	ACF
No	NGO_Forum

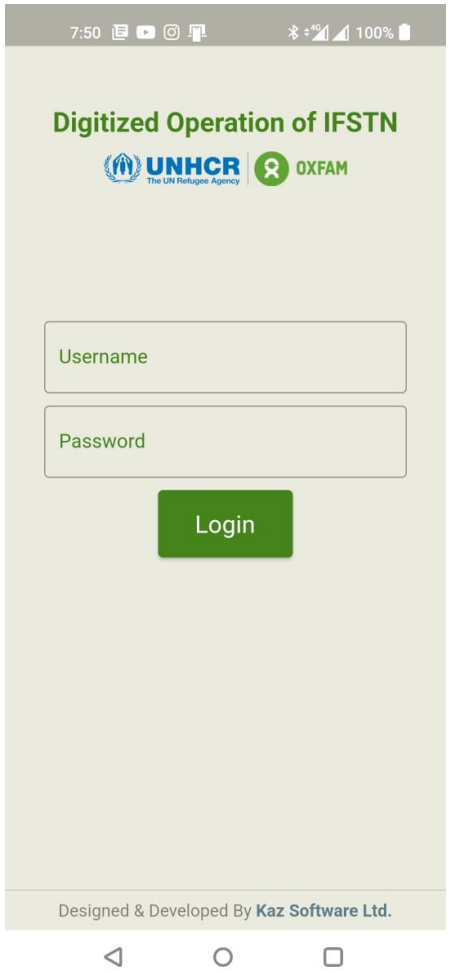
- No latrine unique ID
- Complain based response for desludging.
- Less practice of digitized data collection / No analysis on latrine containment performance
- Systematic Operation of IFSTN
- High operational cost

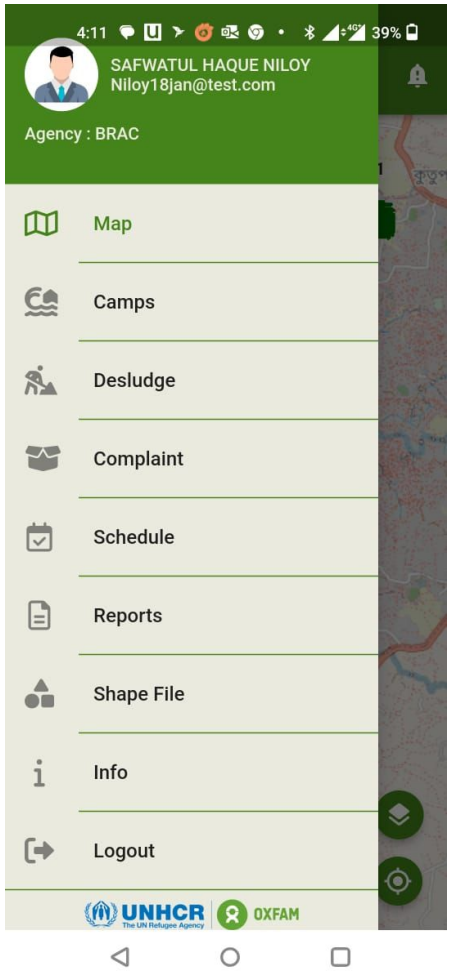
Latrine Qr code with Unique ID

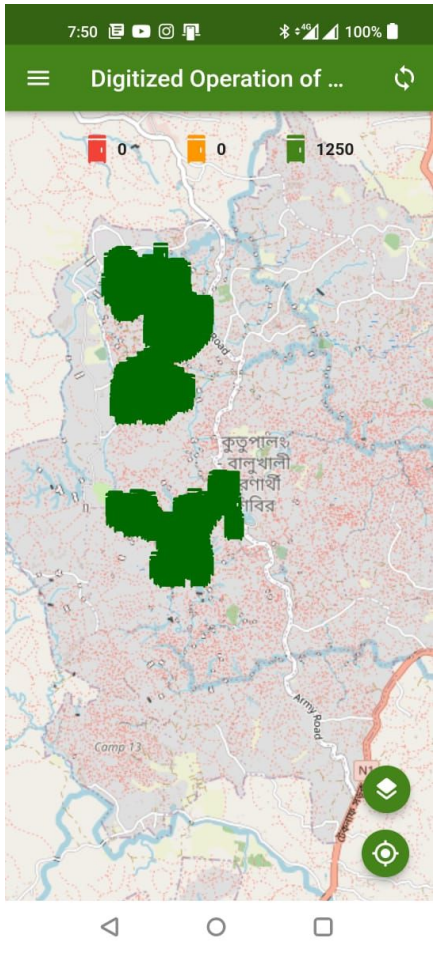
Printed Unique ID

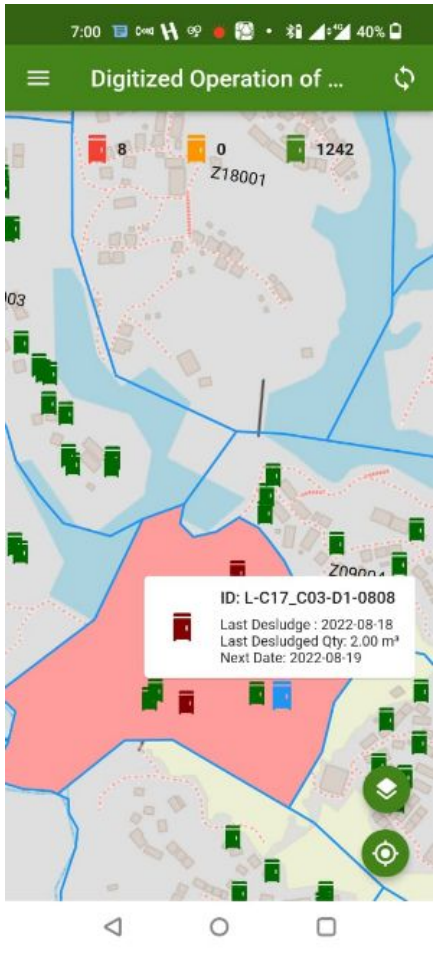
Android Version .

You can download the app from google store , Search for PIT APP

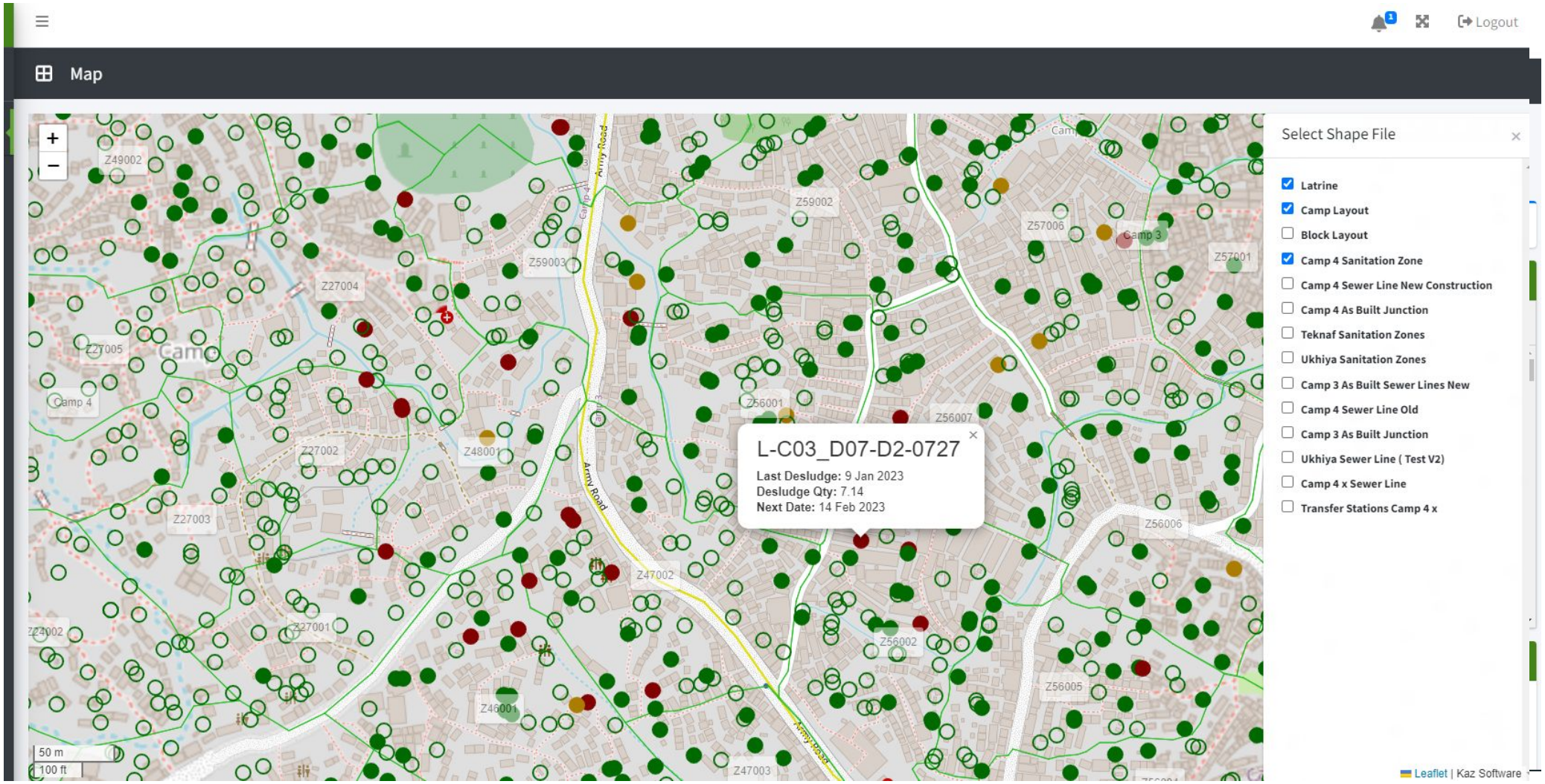








Web Version


Logout
Map
Select Shape File
Latrine
Camp Layout
Block Layout
Camp 4 Sanitation Zone
Camp 4 Sewer Line New Construction
Camp 4 As Built Junction
Teknaf Sanitation Zones
Ukhiya Sanitation Zones
Camp 3 As Built Sewer Lines New
Camp 4 Sewer Line Old
Camp 3 As Built Junction
Ukhiya Sewer Line (Test V2)
Camp 4 x Sewer Line
Transfer Stations Camp 4 x
L-C03_D07-D2-0727
Last Desludge: 9 Jan 2023
Desludge Qty: 7.14
Next Date: 14 Feb 2023
Camp 4
Camp 3
Army Road
Z49002
Z27004
Z27005
Z27002
Z27003
Z27001
Z59003
Z59002
Z57006
Z57001
Z56001
Z56007
Z56006
Z56002
Z56005
Z48001
Z47002
Z47003
Z46001
50 m
100 ft
Leaflet | Kaz Software

The FSTP monitoring dashboard

Shahidul Islam - Siam (FS Lab Manager) - dphefslcoxsbazar@gmail.com
Tanvir Ahmed (WASH sector IM) - taahmed@unicef.org

Challenges and Way Forward

- **Space availability**: Sanitation infrastructures have not been allocated enough space
- **Capitalization & experience sharing** Bangladesh/worldwide
- Finalize and operationalize **" FSM - WASH sector strategies"** (March 2023)
- **Advocacy:**
  - To Donors and partners on pocket gaps and challenges
  - To Government for approval & allocation of space
  - To ADB/WB on coordination and collaboration (omni-processor)
- **Cost-efficiency:**
  - Programmatic transition for more cost-efficient response (type of FSTP; FSTN; coverage…)
- **Improve performances:**
  - Decommissioning of old / poorly performing FSTP infrastructures
  - Develop technical guidance of re-use and/or disposal of the solid/liquid after treatment
  - Approach FSTP per catchment area and not necessary by camp (e.g: Teknaf area : 5 camps)
- **FS quality Monitoring:**
  - Monitor progress over time (and seasonal variation) + Adapt response to the findings

Thank you!

Any Questions?