O&M requirements for a large solar scheme:

The case study of the Solar Powered Water System in Camp 12, Rohingya refugee crisis, Cox's Bazar, Bangladesh

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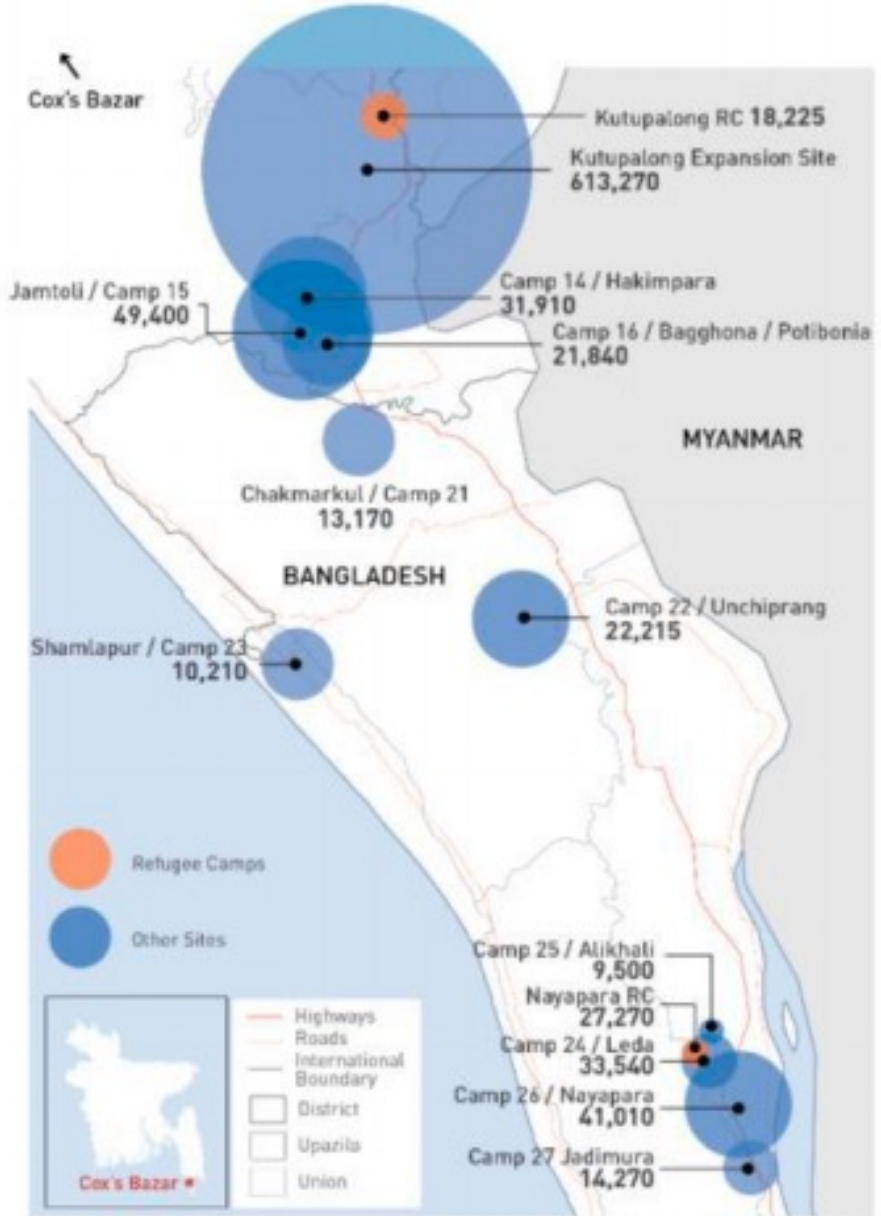
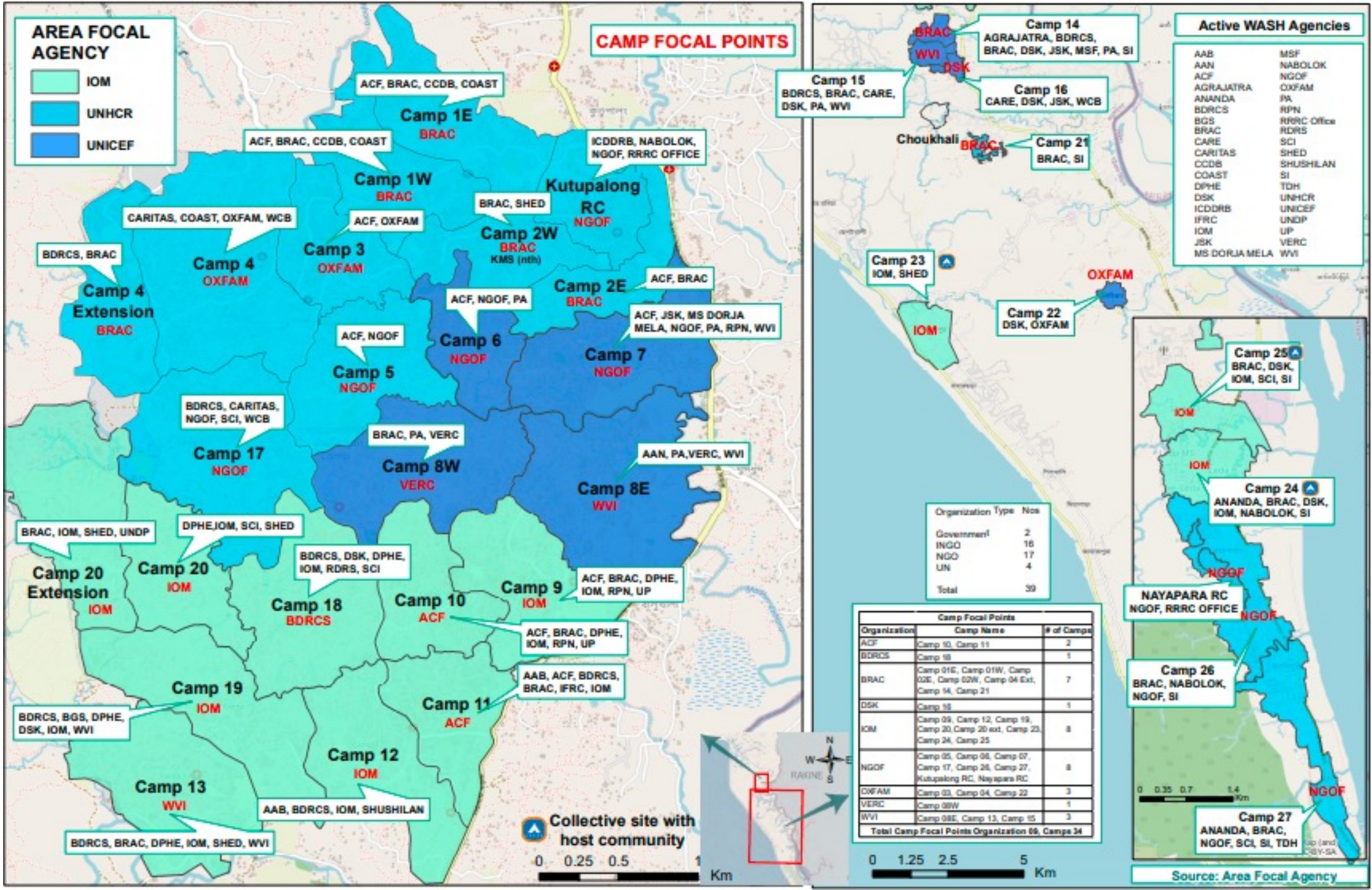
Refugee sites in the Cox's Bazar District



- 34 camps in Cox's Bazar district hosting around 855,000 refugees
- Significant influxes have occurred in 1978, 1992, 2012, and in 2016 from Rakhine State, in Myanmar
- The largest influx took place in August 2017 when over 700,000 Rohingya refugees fled across the border into Bangladesh
- Since 2017, over 685,000 refugees are located within the Kutupalong Expansion Site referred to as the Mega Camp
- 170,000 refugees located in camps further south down the Cox's Bazar Peninsula.

Operational presence map



Introduction – Solar Powered Water (SPW) scheme in C12

The System was commissioned in July 2019

This project is a collaboration between IOM, the Japan International Cooperation Agency (JICA) and the Bangladesh Department of Public Health Engineering (DPHE) funded by PRM and the government of Japan.

Camp	Population	Population Coverage:
12	22,976	86% of the camp population
19	6,385	29% of the camp population
Total	**29,361**	

Introduction – Key design considerations

1. Target water supply: 587 m3/day (9 hours of pumping on average per day) and 20 liters/person/day.

2. provide a community tap stand within 100m of all beneficiary households, despite the hilly terrain (sphere standards: < 500m)

3. Provide enough taps to reach 100 people / tap (sphere standards: 250 ppl/tap).

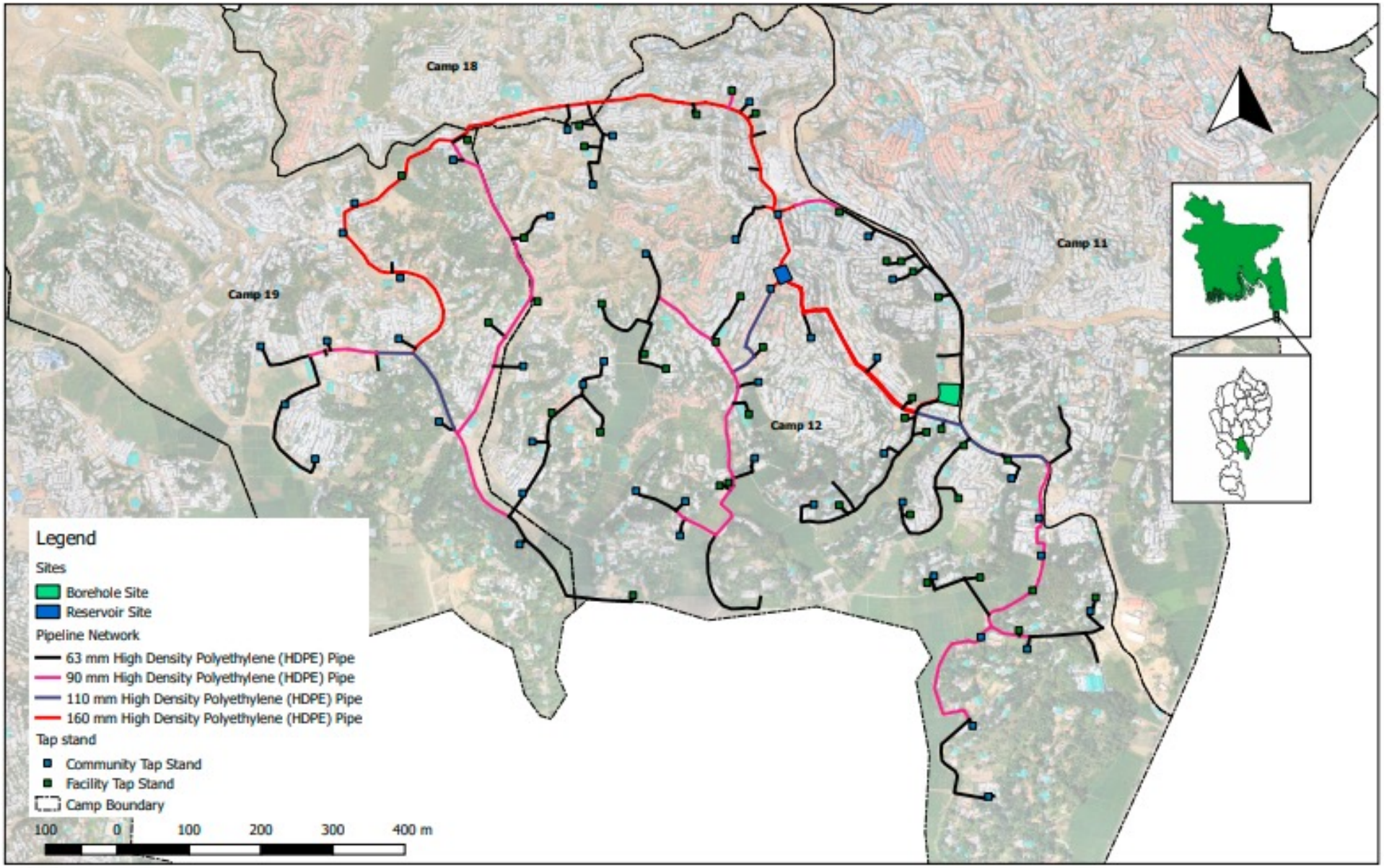
4. To supply water to 53 communal facilities

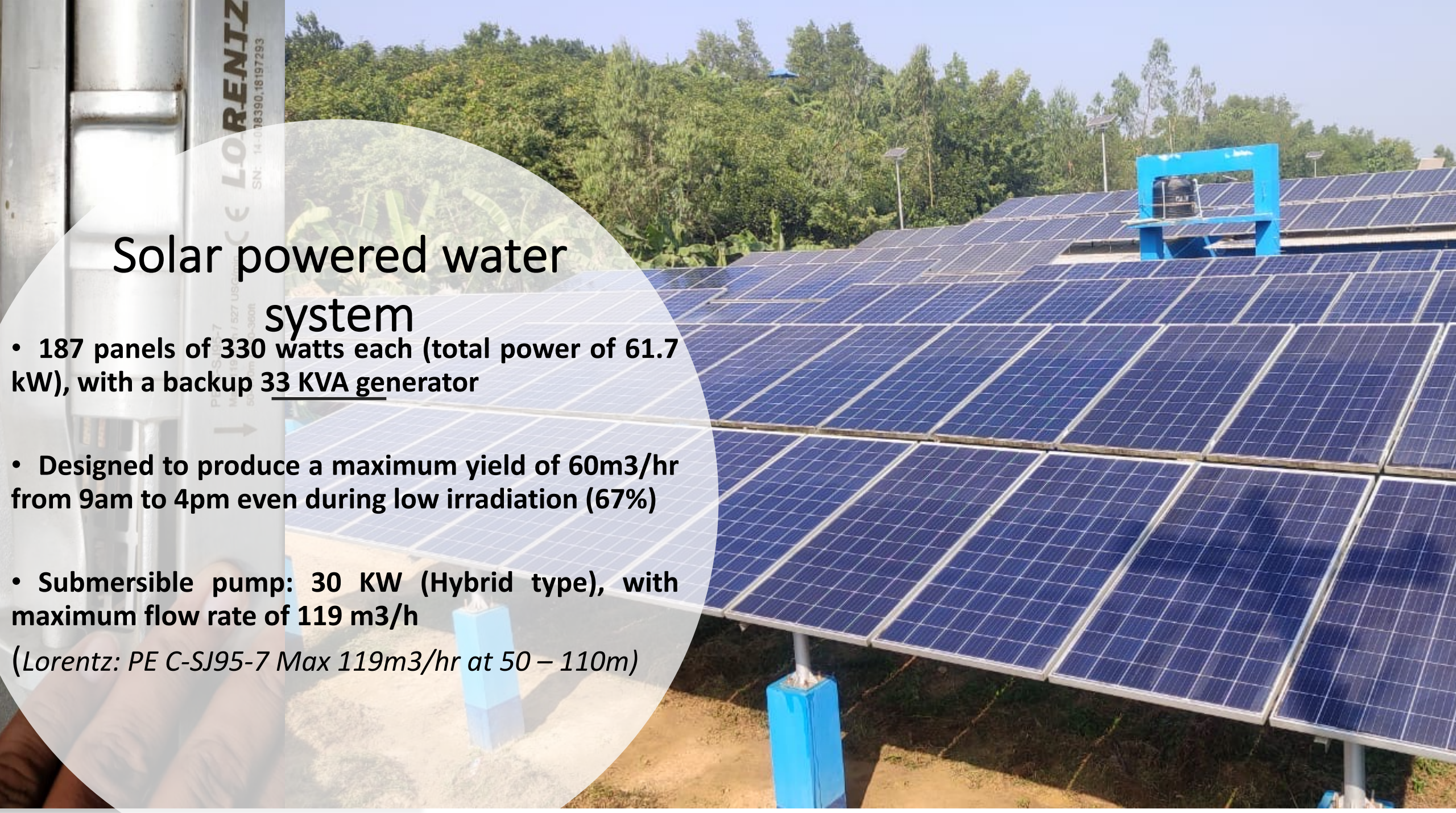
5. Storage capacity: 570 m3 (6 tanks of 95 m3 each – Oxfam T95 type)

Fire response in Camp 9: Water trucking support from C12 Solar system

Water network specifications

- 9.9 km of HDPE pipe installed.
- Total area: 0.88 km2
- 358 taps installed for the community and facilities
- Ratio: 106 ppl/tap





Solar powered water system

- **187 panels of 330 watts each (total power of 61.7 kW), with a backup 33 KVA generator**

- **Designed to produce a maximum yield of 60m3/hr from 9am to 4pm even during low irradiation (67%)**

- **Submersible pump: 30 KW (Hybrid type), with maximum flow rate of 119 m3/h**

(*Lorentz: PE C-SJ95-7 Max 119m3/hr at 50 – 110m)*

Solar pumping system

- Daily Average: 135 KWh
  - Maximum in Feb : 163 KWh
  - Minimum in Jul: 100 KWh

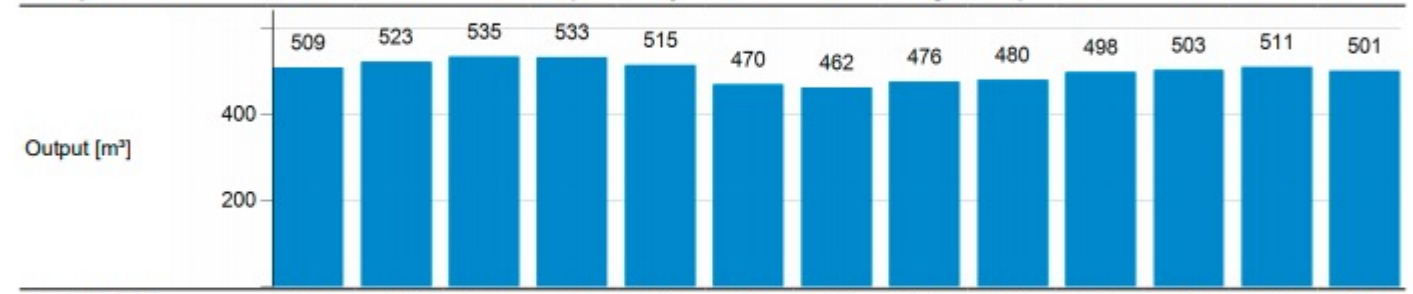
- Total energy produced = 550 days * 135 = 74 250 KWh

- Daily output in average: 502m3/day

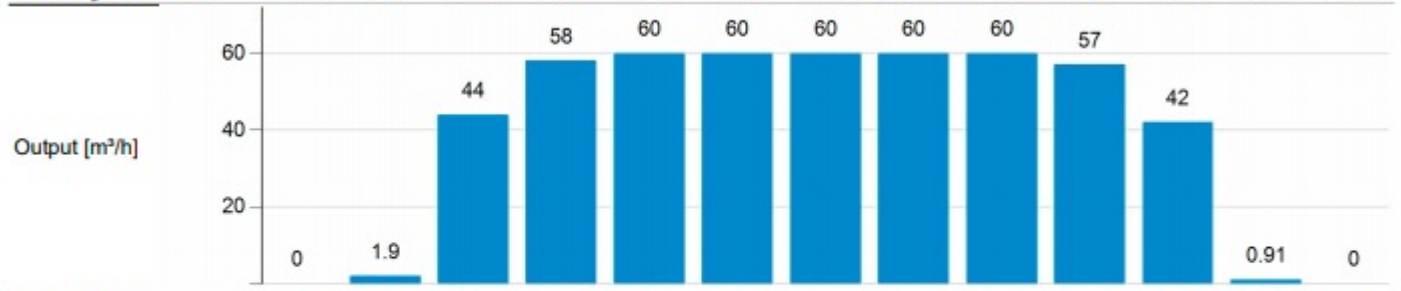
- Maximum yield of 60m3/hr from 9am to 4pm

SunSwitch setting in PumpScanner min. 200 W/m²

Daily output in average month 501 m³



Daily values	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av.
Energy [kWh]	158	162	162	150	131	103	100	110	112	130	144	156	135
Irradiation [kWh/m²]	5.7	5.9	6.0	5.6	4.8	3.8	3.6	4.0	4.1	4.8	5.2	5.6	4.9
Rainfall [mm]	0.27	0.63	1.5	4.0	8.1	18	22	17	10	6.1	1.6	0.33	7.5
Ambient temp. [°C]	20	23	25	26	27	28	27	27	27	26	24	21	25



Hourly values	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
Energy [kWh]	0.38	3.8	8.5	13	16	18	18	17	15	12	8.2	3.7	0.37
Irradiation [kWh/m²]	0.013	0.13	0.29	0.46	0.58	0.66	0.68	0.66	0.58	0.46	0.29	0.13	0.013
Ambient temp. [°C]	20	20	21	23	25	27	29	30	30	30	30	29	29

O&M: handover and preventive maintenance with contractor.

- *Proper handover of system:*
  - ✓ *System performance tested*
  - ✓ *Training of staff*
  - ✓ *User's Manual*

- *Define clear terms in the agreement with contractor including:*
  - ✓ *Maintenance schedule for Solar PV system*
  - ✓ *2 years warranty for system and 5 years extension for pump, motor and controller.*
  - ✓ *To plan spare parts for key elements: Solar panels; submersible pump, etc.*

O&M: the team

- *Designed to minimize operation and maintenance requirements*
- *Team of 10 Rohingya volunteers living in the camps.*
- *One IOM engineer to supervise the team and monitor the system*

O&M: regular activities

- To carry out regular jar test and to prepare the chlorine solution for the in-line disinfection system.

- To test the free residual chlorine (FRC) on daily basis at tap stands level - (0.3mg/l < FRC < 0.5mg/l)

O&M: regular activities

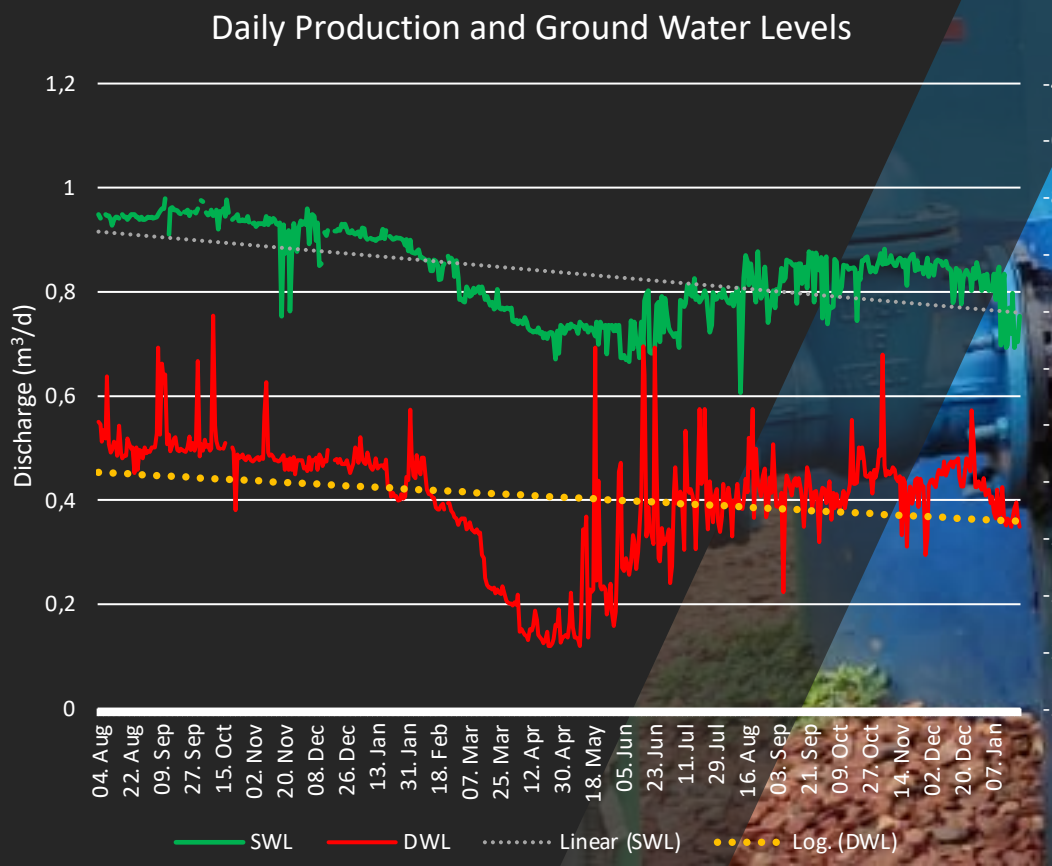
- Regular repair & maintenance work done by technician & volunteer group. Repair of taps, pipeline, tanks, etc.

- Clean 1 reservoir/ week (each tank cleaned every 6 weeks)

Solar panel O&M:

cleaning: 2 times per week.

Static and dynamic Water level measurement on daily basis



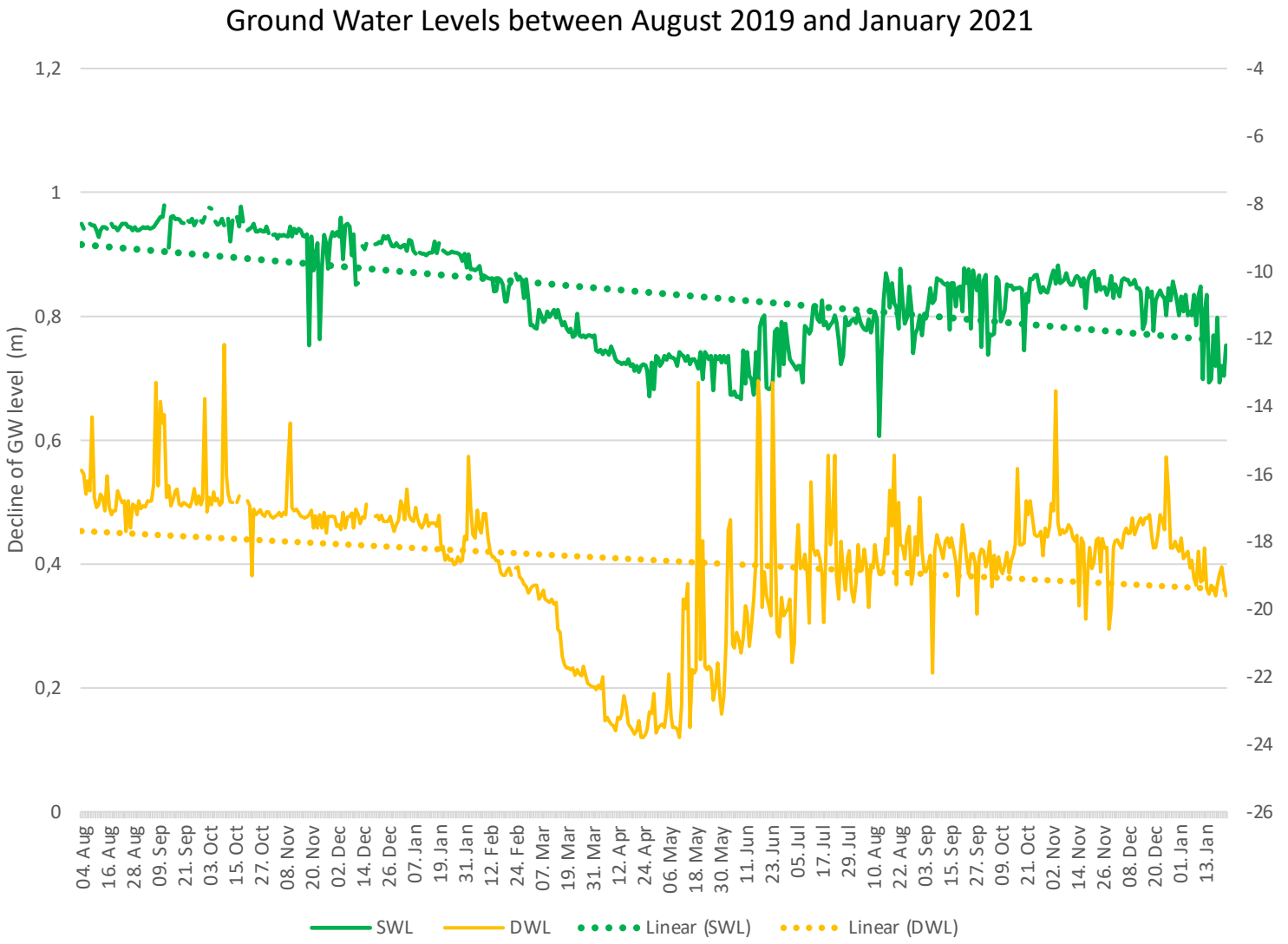
Water level Monitoring:

- Static water level (in green) and dynamic water level (in yellow) measured between August 2019 and January 2021.

- In August 2019; SWL: 8.7m; In August 2020; SWL: 11.4m; **Decline SWL = 2.7 m**

- Coherent with groundwater model developed by IOM , GWR and Dhaka University.

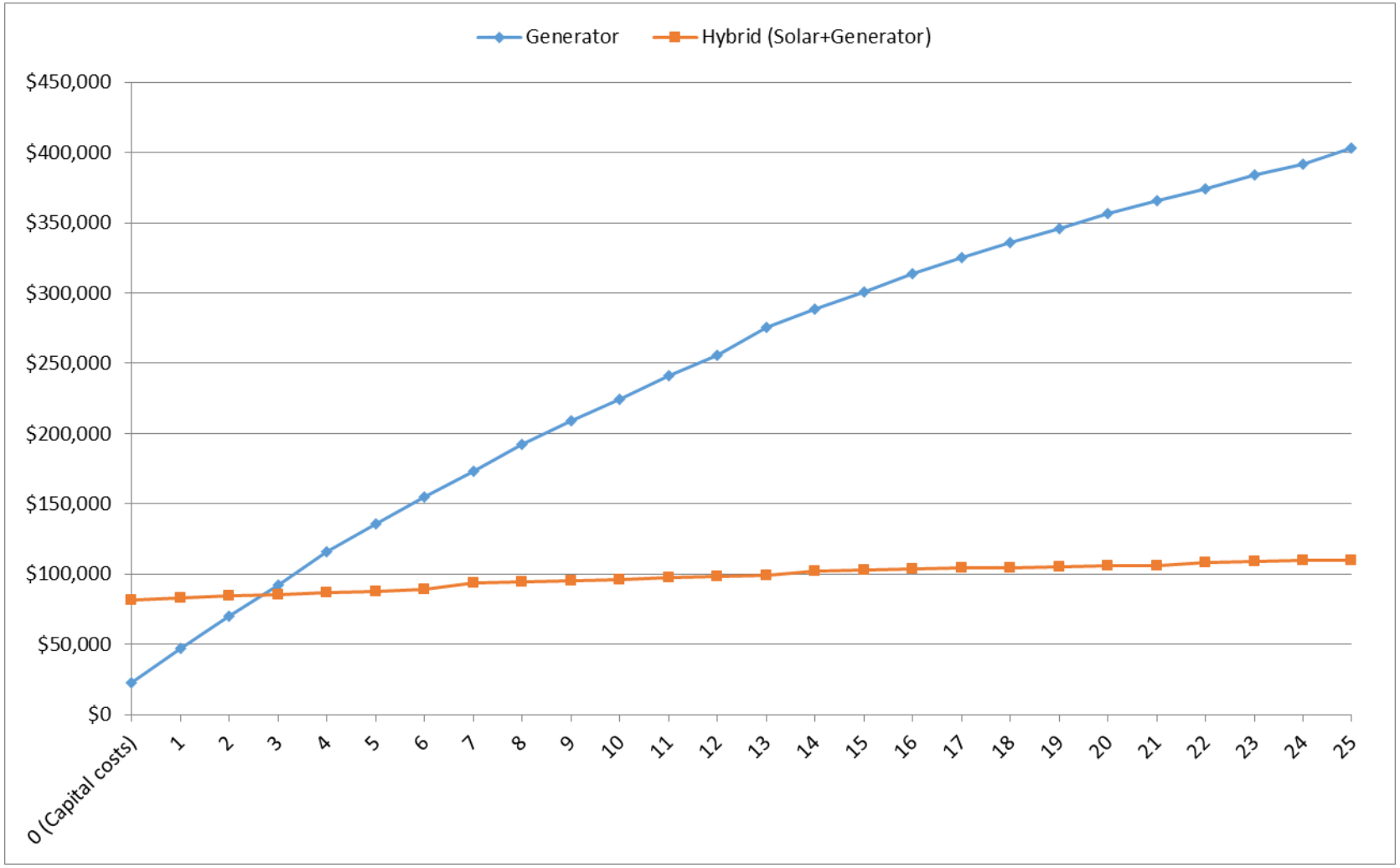
- There is no issue linked to this local decline in the camp as the pump is located at 45m.



Life Cycle cost analysis (1)

Cumulative Cost

Year	Generator	Hybrid (Solar+Generator)
0 (Capital costs)	$22,615	$81,785
1	$46,857	$83,098
2	$69,944	$84,348
3	$91,933	$85,538
4	$115,812	$86,672
5	$135,756	$87,752
6	$154,751	$88,780
7	$172,840	$93,732
8	$192,486	$94,665
9	$208,894	$95,553
10	$224,521	$96,399
11	$241,492	$97,205
12	$255,665	$97,972
13	$275,479	$98,703
14	$288,335	$102,222
15	$300,579	$102,885
16	$313,876	$103,516
17	$324,981	$104,117
18	$335,558	$104,690
19	$345,631	$105,235
20	$356,571	$105,755
21	$365,707	$106,249
22	$374,409	$108,631
23	$383,859	$109,080
24	$391,751	$109,507
25	$402,784	$109,914



Life cycle cost analysis (2)

The Return on Investment (ROI) of solar system	**32 months**
Costs saved with solar after 5 years:	$48,005
Costs saved with solar after 10 years:	$128,122
Costs saved with solar after 25 years:	**$292,870**
Water supplied in 25 yrs	4 589 875 m3
Whole life Cost of 1m3 of water with hybrid system	**0.26 USD/m3**
Whole life Cost of 1m3 of water with generator only	0.31 USD/m3

Conclusion:

The Solar Powered Water System ONLY has the capacity to provide an average of 502m3/day (99% of water distributed)

Return on investment after 32 months and total cost saving after 25yrs of 73%

Proper handover and warranties with the contractor is essential for preventive maintenance and minimize

The O&M is done directly by IOM volunteers trained from the affected population.