EVALUATION REPORT

Evaluation of the Sanitation Technology Demonstration in Emergency Settings in Lebanon Programme (STDP)

© Difaf SAL, field visit

LEBANON COUNTRY OFFICE
March 2023

unicef | for every child

Evaluation of the Sanitation Technology Demonstration in Emergency Settings in Lebanon Programme (STDP)
Final Report

United Nations Children's Fund
Three United Nations Plaza
New York, New York 10017

December 2022

This report is available for download at:
https://www.unicef.org/evaluation/reports#/?&Region=MENAR&Country=Lebanon

For further information, please contact:

Evaluation Office
United Nations Children's Fund
Three United Nations Plaza
New York, New York 10017
evalhelp@unicef.org

CONTENTS

ACKNOWLEDGEMENTS

This evaluation has been conducted by Difaf SAL, with all reasonable skill, care and diligence within the terms of the contract with the client, incorporating our General Terms and Conditions of Business and taking account of the resources devoted to it by agreement with the client. The information contained in this report is, to the best of our knowledge, correct at the time of printing. The interpretations and recommendations are based on our experience, using professional skill and reasonable judgment, and upon the information that was available at time of conducting and producing this work. This report is confidential to the client and we accept no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known.

This evaluation was led by Hussam Hawwa. The evaluation team included Haneen Khalifeh, Ahmad Osman, and Ilina Slavova, as well as Hussein Rayshouni and Ramy Sawaya on the technical level. All final reviews were conducted by Hussam Hawwa with thanks to Ziad Antonios for his peer review and Abbas Baalbaki for field support. Leslie Morris-Iveson (independent consultant) provided advisory support on the final report.

Difaf would like to sincerely thank UNICEF team, namely Kevin Bonel, Tamara Nassereddine, Justice Kamwesigye and Paul Edwards for their invaluable feedback well as the WASH Representative Committee. Many thanks as well to the WASH community in Lebanon which includes government representatives Suzy Hoayek (Ministry of Energy & Water), Manal Mousallem, and Mohammad Abyad (Ministry of Environment) as well as all respondents and collaborators namely project Implementing Partners, Refugees as well as host community representatives during field assessment works for their valuable contributions and time.

ACRONYMS & ABBREVIATIONS

ABR	Anaerobic Baffled Reactor
ACF	Action Against Hunger
ACW	Aerated Constructed Wetland
AFD	Agence Française de Développement
AnF	Anaerobic Filter
BAF	Biological Aerated Filter
BMGF	Bill & Melinda Gates Foundation
BORDA	Bremen Overseas Research & Development Association
BPB	Beirut Port Blast
CAPEX	Capital Expenditure
CDD	Consortium for DEWATS Dissemination
CDR	Council for Development & Reconstruction
CPD	Continuing Professional Development
CSO	Community Support Organization
CW	Constructed Wetland
DAC	Development Assistance Committee
DEWATS	Decentralized Wastewater Treatment Technologies
DFM	Design for Manufacturing
EC	European Commission
EDL	Electricitee Du Liban
EIA	Environmental Impact Assessment
ELV	Environmental Limit Values
EM	Evaluation Matrix
EPA	Environmental Protection Agency
EQ	Evaluation Question (Main)
ET	Evaluation Team
EU	European Union
FAO	Food & Agriculture Organization
FGD	Focus Group Discussions
FHH	Female Headed Households
GoL	Government of Lebanon
GPS	Global Positioning System
MDC	Multi-dimensional Crisis
MHH	Male Headed Households
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoI	Ministry of Industry
MoPH	Ministry of Public Health
MoSA	Ministry of Social Affairs
NBS	Nature-Based Systems
NGO	Non-governmental Organization
NSSS	Non-Sewered Sanitation System
NWSS	National Water Sector Strategy
O&M	Operation & Maintenance
OECD	Organization for Economic Co-operation & Development
OPEX	Operational Expenditure
PPP	Public Private Partnership
PUPA	Public Partnerships
SAP	Sanitation Action Plan
SI	Solidaritee International
SME	Small and Medium Enterprise
SOP	Standard Operating Procedures
SOER	State of the Environment Report
SSF	Slow Sand Filter
STDP	Sanitation Technology Demonstration Project
SWOT	Strength, Weakness, Opportunity, Threats
TF	Trickling Filter
ToC	Theory of Change
ToR	Term of Reference
ULRB	Upper Litani River Basin
UNDP	United Nations Development Program
UNEG	United Nations Evaluation Group
UNHCR	United Nations Higher Commission for Refugees

GVC	Gruppo Di Volontariato Civile
HH	Household
HRT	Hydraulic Retention Time
IEE	Initial Environmental Examination
INGO	International Non-Governmental Organization
IP	Implementing Partners
IR	Inception Report
IS	Informal Settlement
ISO	International Organization for Standardization
IoT	Internet of Things
IWMO	International Water Management Institution
KII	Key Informant Interviews
KPI	Key Performance Indicator
Lab	Laboratory
LARI	Lebanese Agricultural Research Institute
LIBNOR	Lebanese Standards Institution
LL	Lebanese Lira
LOST	Lebanese Organization for Studies and Training
LRA	Litani River Authority
LRB	Litani River Basin
LRBMS	Litani River Basin Management Support Program
M&E	Monitoring & Evaluation
UNICEF	United Nations Children's Fund
UPM	Umwelt-Projekt-Management GmbH
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WAP	WASH Assessment Platform
WB	World Bank
WE	Water Establishment
WHO	World Health Organization
WVI	World Vision International
WWTP	Wastewater Treatment Plant
VASyR	Vulnerability Assessment of Syrian Refugees
Vs	Versus

List of Scientific Units, Symbols, & Abbreviations

A	Annum
BOD_5	Five-day Biological Oxygen Demand
°C	Degrees Celsius
Cap	Capita
CFU	Colony Forming Units
CH_4	Methane gas
COD	Chemical Oxygen Demand
CO_2	Carbon Dioxide gas
D	Day
DO	Dissolved Oxygen
FC	Fecal Coliforms
g	Gram
H_2	Hydrogen gas
H_2O	Water
H_2S	Hydrogène sulphide
HDPE	High Density Polyethylene
Kg	Kilogram
Km	Kilometer
kW	Kilowatt
kWh	Kilowatt-hour
m	Meter
m^2	Meter Square
m^3	Cubic Meter
mg	Milligram
ml	Millilitre
mm	Millimetre
mV	Millivolts
N	Nitrogen
N_2	Nitrogen gas
NTU	Nephelometric Turbidity Unit
NH_3	Ammonia
NO_2	Nitrite
NO_3	Nitrate
O_2	Oxygen
ORP	Oxidation-Reduction Potential

P	Phosphorus
PE	Polyethylene or Population Equivalent
pH	Potential of Hydrogen
ppm	Parts Per Million
PVC	Polyvinyl Chloride
P_2O_5	Phosphorus Pentoxide
T	Tonne
TC	Total Coliforms
TDS	Total Dissolved Solids
Temp.	Temperature
TN	Total Nitrogen
TP	Total Phosphorus
TS	Total Solids
TSS	Total Suspended Solids
UV	Ultraviolet

EXECUTIVE SUMMARY

There are more than one million Syrian refugees registered in Lebanon, and more than half are children. With almost a third of refugees residing in informal settlements (ISs), sanitation remains a critical priority. The political decision by the Government of Lebanon (GoL) not to officially recognize these settlements has meant that all structures that serve Syrian refugees need to be temporary, and structures in IS cannot be connected to the formal water, electrical, or sewer systems.

The crowded conditions of many informal settlements and other shelters occupied by displaced Syrians are associated with serious health risks for women and children. Adequate sanitation is vital to prevent the spread of disease from wastewater. Where wastewater treatment does not exist, desludgers must operate at a very high cost. In 2017, UNICEF spent US $4.4 million on desludging activities in IS. Wastewater treatment plant (WWTPs) options are typically deployed as a means to remove contaminants from wastewater to improve public health and to avoid (or reduce) the need for desludging. Decentralized wastewater treatment systems (DEWATS)[1] have shown promising results in developing countries, performing effectively with minimal costs.

In this setting, the Sanitation Technology Demonstration in Emergency Settings Programme (STDP) aimed to develop decentralized, cost-effective, innovative, and sustainable small-scale wastewater treatment solutions; to test them and produce evidence for their potential replication in IS and host communities, and develop lessons to promote globally in other humanitarian crises.

This evaluation

This evaluation of the STDP was commissioned by UNICEF in Lebanon (LCO) in its last phase of implementation as part of the agreement between UNICEF and its donor, the Bill & Melinda Gates Foundation (BMGF). The evaluation serves to enhance accountability and learning, and to provide a clear evolutionary assessment which would help in better defining the potential for developing and implementing DEWATS solutions in Lebanon involving small and medium sized enterprises (SME's) support.

The **purpose** of the evaluation is to provide lessons about the challenges and success factors of implementing innovative WASH solutions through an independent assessment of the project design, implementation, and performance by identifying success/failure factors, critical barriers and enablers to adapting, testing and mainstreaming requirements.

The evaluation looks at the relevance, efficiency, effectiveness, sustainability (barrier to scale) of the SDTP programme, with an added criteria of gender. The evaluation questions are:

Criteria	Evaluation Questions
Relevance	**EQ1.**How relevant is the project to the urgent needs of the refugees and host communities in Lebanon?
Efficiency	**EQ2.**To what extent has the intervention been cost effective?

[1] DEWATS is a technical approach, characterised by a passive design that uses physical and biological treatment mechanisms such as sedimentation, flotation, aerobic and anaerobic treatment.

	EQ8 To what extent did the partnerships with IPs, institutions and the private sector facilitate the achievement of the project outcomes?
Effectiveness	**EQ3.** To what extent was the intervention successful in implementing effective, financially feasible and innovative technological solutions to treat wastewater in emergency context? **EQ4.** To what extent was the project able to build institutional knowledge and strengthen the capacity of stakeholders to improve global humanitarian responses in similar emergency context? What are the lessons learned in the process? **EQ5.** Did project activities show signs of creating unintended positive or negative outcomes? If yes, which activities contribute to this?
Sustainability & Barrier to Scale	**EQ6.** To what extent are the implemented solutions likely to remain operational following the closure of the project? What are the conditions to maintain their sustainability?
Gender	**EQ7.** To what extent has this initiative's design and implementation taken gender into consideration?

The evaluation took place between April and December 2022, during the final stage of the SDTP programme, and was undertaken by a team of consultants from Difaf saf consulting, based in Lebanon.

Methodology

The evaluation is a technical and socio-economic summative evaluation of the technologies and models produced under the STDP, and was conducted by comparing community-level results and outcomes to conditions before the programme. A participatory approach that involved all relevant stakeholders in the evaluation process was applied.

The evaluation team used a mixed methods approach, which involved quantitative methods for the technical assessment (a sampling process determined 13 sites to visit, out of which 3 sites were visited for qualitative data collection; lab tests were conducted for 16 systems on 13 sites), and qualitative methods. The data was collected through a literature review, key informant interviews, small group interview, focus group discussions, and direct observations. A sample[2] was stratified by key demographic criteria (age, sex, refugee status) to ensure a fully representative range of viewpoints. The data was also used to develop two distinct case studies, one in an informal settlement in the Bekaa and one in a host community in Akkar.

Wastewater samples were collected by the technical evaluation team during the field visits to the designated sites. Sampling methodologies developed by the EPA and modified by UPM were used for collection; and two sampling campaigns were performed. The water samples collected as part of the first testing campaign were processed in certified laboratories and with the probe

[2] The technical general assessment included 16 systems sampled from 13 sites. For the lab analysis, 3 samples were tested from each system. the first sample was taken from the inlet, the second from an intermediate treatment stage, and the third from the effluent after treatment. Samples were tested for organic, inorganic, bacteriological, and physical parameters. Lab measurements were performed in replicates

equipment for validation of results. The samples collected in the second campaign were analyzed by a certified laboratory different to the ones used in round one.

Findings and Analysis

The following findings were synthesised from the data collected:

Relevance

- The STDP programme is highly relevant, meeting critical needs of refugees and host communities in Lebanon.
- STDP relevance is further demonstrated in wastewater being determined as a priority in national emergency plans. The STDP has maintained its relevance throughout the unfolding multi-dimensional crisis, by initiating a slow and long process of establishing services and building trust. It provides a relevant example of a humanitarian-development nexus approach.
- On a technical level, the evaluation team finds that the DEWATS intervention was relevant in terms of the policies for temporary settlements. The STDP approach is also found to be nationally relevant, aligned with national level policies for host communities.

Efficiency

- The investments into WWT are justified and a high emphasis on cost-effectiveness has been placed in design and implementation of the STDP. Emerging reports suggest that desludging services are reduced.[3] Although the return on investment has not yet been achieved, value for money is found to be good should the lessons be available for the wider humanitarian sector.
- A participatory approach to working with partners was shown throughout implementation, enhancing efficiency. UNICEF's strength at managing partnerships with IPs and relevant authorities has led to positive project outcomes.
- Communities/beneficiaries were less involved, particularly in initial stages which is reasonable given the programme concept. However, a lack of early engagement in communities may have led to some setbacks, specifically with theft and problems with landlords.
- The STDP has been designed as a PPP, and a variety of private entities were engaged. There are some good outcomes in terms of setting the foundation for SMEs to take on services or manufacturing, encouraged by the launch of the open-source designs.

Effectiveness

- The technical assessment of the 13 sites has shown that the selected technologies demonstrate good performance as per international design standard and guidelines[4], with an average of 90% treatment efficacy of organics in Batch 3.[5] The systems are doing exceptionally well in terms of removal of organic pollutants. Further, the systems can be considered robust with 79% of the systems actively treating wastewater (to various degrees).[6]

[3] Data on frequency was not available at the time of evaluation. Sufficient data is needed over a longer period.
[4] e.g. BORDA15
[5] This pertains to the organic contaminants of water – the main target for treatment
[6] Defined by having some form of active treatment, not necessarily high-functioning or high level of contaminant removal. Systems that are in basic operation. Vandalism is huge impact on functioning of systems, and was not factored in.

Keeping functionality stable and reaching tertiary level treatment remained challenging, however continuous refinement was still in progress at time of evaluation.

- The experimental approach to the programme – which includes the selection, design and contextualization is found to be very good (a strength of the programme). This aspect has been enhanced by an adaptive/iterative approach where learning is input through successive batches. Despite this, better integration of criteria in Batch 3 could have been applied given the complex problems on the ground that were encountered.
- Institutional knowledge and capacity of local stakeholders were built, and lessons are being captured that are relevant for global humanitarian response.
- The SDTP has seen the emergence of major unintended negative (issues with landlords and theft) and some hints of positive (potential reuse of wastewater for irrigation) consequences.

Sustainability

- Given the worsening multi-dimensional crisis in Lebanon, sustainability is subject to factors outside the scope of the STDP and cannot be expected with typical activities and outcomes. The risk of vandalism is negatively impacting on sustainability.
- There is evidence that partnerships now operate beyond UNICEF's involvement, although some partnerships may not continue supporting the SDTP. The programme is not yet recovering costs, and donor funds will likely be needed, partially because an O&M system is not fully realized.
- Open systematic communications have led to improved institutional knowledge, which will extend beyond completion of SDTP.

Gender

- The project design made no clear reference to gender considerations and did not establish gender related indicators, although some women's participation in the programme was noted. This can partly be explained by the low interactive element of DEWATS.
- Despite a poor gender inclusion, minor benefits to women and children resulting from the programme were noted.

Conclusions

The evaluation team has concluded that the STDP has made commendable achievements in establishing and refining an innovative technological solution to treat wastewater generated by and discharged from informal settlements (IS) in Lebanon. The STDP has successfully developed a WWT option that is appropriate for the complex emergency. It has been successful in establishing proof of concept.

The evaluation team finds that there is an evident potential to decrease desludging frequency in ISs, based on data from IPs and analysis of bacteria growth. Improved sanitary conditions in sites where sanitary problems existed prior to the intervention are noted. In the absence of a policy regulating the ISs however, the systems will continue to require routine check-ups and maintenance by the IPs.

The project has successfully piloted a technology in one host community in Akkar, where the users' buy-in and the interest by the municipality to replicate such systems have been notable. The project could not respond to similar needs in host communities living next to ISs in the Bekaa, which, similar to the ISs, use septic tanks and pay for desludging.

The evaluation team finds that of the three outcomes of the STDP, two have been met and one outcome has been partially met. The two outcomes met include:

- Innovative sanitation technology that improved wastewater treatment and fecal sludge management was utilized in informal settlements targeted by the project and in one host community;
- The sanitary conditions for the targeted Syrian refugees and Lebanese host communities have improved as a result of the technology, in areas where sanitation problems existed.

The third immediate outcome: “findings from the use of the technology are shared with relevant national and humanitarian stakeholders” was partially met at the time of the evaluation, and can be fully met by the project’s end with continued monitoring and reporting on the performance of the systems and sharing the results to inform the WASH sector.

Recommendations

Overall, the recommendations consider outcome-level improvements focused on four key areas, summarized below**:**

Key area 1: Replication

A culture of DEWATS has been activated and based on Batch 3 technologies, DEWATS can progress at full speed. Capacities being built are in progress, awareness is now strong. To enhance sustainability and further-roll out, SOPs and operations should be strengthened.

UNICEF should closely monitor the implementation of all systems and enforce a developed sampling and analysis campaign leading to systematic and efficient testing and reporting. SOPs to be strengthened include developing a decision-support matrix taking continuously into consideration such circumstances. It should develop a marketing/communication strategy can further establish its elements, with particular focus on low-energy / low opex features vs high treatment efficiency and protection of the environment.

At the national level, learning should be shared from the process with other sector actors and stakeholders, such as agriculture, shelter and energy; and at the global level, write up the good practice points on how UNICEF and partners was able to contextualize the DEWATS (key enabling factors), to communicate through the Global WASH Cluster.

Key area 2: Complex operating environment

The operating environment is highly volatile. Considering current economic crisis (and the increasing risk of humanitarian crisis with the complete faltering of centralized WWTPs) There is a need to further refine the DEWATS innovation. This is necessary to avoid the turning of an assumption into a risk (such as an extreme rise in the exchange of the USD).

The evaluation team recommends to further refining Business Development and continue collaboration with the private sector both on production and on adaptation to fit available material. Plans should be made with IPs for the continued maintenance and operation during and after the project closure

Key area 3: Host community improvements

Aspects of working in host communities present continuous challenges to effectiveness and in scale-up. In ISs, the landlord's approval and good will is required for the installation of DEWATS, as well as the acceptance of the technologies by the refugees and their informal leader (*Shawish*) further actions are needed to establish ownership and community level benefits & acceptance.

Operational recommendations include reducing or avoiding using attractive material and to consider incorporating landlords into side benefits (service agreement); whilst seeking support from legal experts about finding mechanisms that would off-setting self-interest that would compromise systems functionality. It is important to ensure that the IS community fully understands the needs of the project to ensure its protection, and to avoid misuse and theft

Key area 4: DEWATS technology

The DEWATS installed have achieved proof of concept, however, further improvements are needed. Some technical recommendations include, for the tertiary treatment component, to prioritize implementation with a smaller number of IPs, and pair this with closer follow-up and more regular testing and validation of test resultswould compromise systems functionality

It is recommended to develop an exit strategy for IPs managing the systems, including handing-over requirements, several SOPs should be standardized, including for communications and problem handling guidelines; inoculations and start up procedures; technical auditing of the systems for a full picture of the exact performance of each installation; and to develop a detailed O&M Manual. Additional procedures are needed for reporting, data cleaning, analysis; for performance monitoring; and for third-party lab monitoring.

1. INTRODUCTION

After a decade of responding to the Syrian crisis, Lebanon is still hosting the largest number of refugees per capita in the world. There are more than one million Syrian refugees registered in Lebanon, and more than half are children.[7] As of 2021, with 22% of these refugees were residing in informal settlements (ISs)[8], sanitation remains a critical priority. Adequate sanitation is vital to promote health and prevent the spread of disease from wastewater in humanitarian settings. Wastewater treatment plants (WWTPs) options are typically deployed as a means to remove contaminants from wastewater. Decentralized wastewater treatment systems (DEWATS)[9] have shown promising results, performing effectively with minimal costs. Untreated wastewater is not only a general challenge in refugee settings, it is an often overlooked element of fast growing small and medium sized cities, low income/informal settlements and rural areas where wastewater infrastructure is often non-existent, outdated or inadequate.

The Sanitation Technology Demonstration in Emergency Settings (STDP) is a 5 year programme (2019-2023) designed and led by UNICEF in Lebanon, and implemented by 7 partners in the Bekaa Valley and Akkar regions. The STDP was awarded US $2.5 million in 2018 by the Bill & Melinda Gates Foundation (BMGF), as a project aimed to develop decentralized, cost-effective, innovative, and sustainable small-scale treatment solutions. There was a strong lesson learned component, as the solutions are tested, and evidence produced for potential replication in informal refugee settlements as well as within Lebanese host communities; and potentially to be replicated globally in other humanitarian crises with similar environmental conditions.

UNICEF in Lebanon (LCO) has commissioned an evaluation of the STDP in its last phase of implementation as part of the agreement between UNICEF and BMGF. The evaluation serves to enhance accountability and learning, and to provide a clear evolutionary assessment which would help in better defining further potential for developing such programs and implementing DEWATS solutions in Lebanon involving SME's support and mobilizing local economies.

Context – Informal settlements and wastewater

The crowded conditions of many informal settlements and other shelters occupied by displaced Syrians are associated with serious health risks for women and children. The political decision by the Government of Lebanon (GoL) not to officially recognize these settlements has consequences: all structures that serve Syrian refugees need to be temporary, no structures should give the impression of permanence, and structures in IS cannot be connected to the formal water, electrical, or sewer systems. This presents a major challenge for delivering adequate water, sanitation and hygiene (WASH) services, particularly as connecting IS to local drinking water and wastewater network cannot be officially permitted.

The situation regarding wastewater services has become particularly dire in Lebanon's rural areas. The wastewater sector suffers from chronic under-investment, and recent studies estimate that only 8% of the population is actually served by wastewater treatment, while only 60% of the population is connected to a sewage collection network.[10] Poor on-site pit latrines or septic tanks are common, emptying directly into open fields or watercourses. The practices result in increased risks for outbreak of communicable diseases, as evidenced by the observed numerous cases of skin

[7] STDP grant narrative proposal
[8] According to OCHA report "Increasing Humanitarian Needs in Lebanon", April 2021.
[9] DEWATS is a technical approach, characterised by a passive design that uses physical and biological treatment mechanisms such as sedimentation, flotation, aerobic and anaerobic treatment.
[10] Data from EBRD Wastewater Treatment Plant (pre-feasibility study)

diseases and diarrhoea cases among children under five years of age. Tensions at the community level have flared as WASH resources are stretched and local authorities are struggling to cope with the additional service demands imposed by the growing refugee populations. Additionally, ecosystems are negatively impacted in terms of pollution.

Not only do health and environment problems persist in IS, but typical interventions to address the problems are unsustainable and the costs are very high – covering a service in lieu of providing other critical humanitarian services. In 2017, UNICEF spent US $4.4 million on desludging activities in IS. Nearly one in three IS in UNICEF's catchment area, which service more than half of the Syrian refugee population residing in IS, requiring at least monthly desludging activities. UNICEF's contracts with unregulated vendors in order to meet the level of need for desludging and wastewater transport services. The current method is unsustainable, and costs will continue to grow to US $6-7 million annually, which UNICEF will need to expend annually in lieu of providing other critical humanitarian services. As a result of the massive construction of sanitation systems done by UNICEF, wastewater does not present an immediate problem within in the IS, but desludging is a major financial burden and the wastewater (WW) ends up untreated in the environment and in areas near the IS. As part of its broader efforts to improve WASH services, UNICEF has identified an urgent need to provide and/or improve wastewater treatment services, to improve the physical environment of communities, as well as hygiene and sanitation, to prevent the outbreak of health epidemics, and to reduce inter-community tensions and violence.

Subject of Evaluation

Funded by the Bill & Melinda Gates Foundation (BMGF), the Sanitation Technology Demonstration in Emergency Settings Programme (STDP) is a 5-year project designed and led by UNICEF in Lebanon (2019-2023). The project now is drawing into its completion and has been given an extension.[11] As described Grant Proposal Narrative it is implemented by seven partners in the Bekaa Valley and Akkar regions. In 2018, the project was awarded $ 2.5 million funded by BMGF and was implemented by UNICEF Lebanon along with local and International Non-Governmental Organizations (INGOs) as implementing partners (IPs), involved small and medium enterprises (SMEs), and engaged international experiences in direct support of informal settlement refugees, and host communities towards improved sanitation, local economies, and environmental conditions.

Purpose and Objectives:

The project aimed to develop decentralized, cost-effective, innovative, and sustainable small-scale wastewater treatment solutions, test them, and produce evidence for their potential replication in informal refugee settlements as well as within Lebanese host communities, and potentially develop them globally in other humanitarian crises with similar environmental conditions. The project adopted an innovative approach – both in terms of technology and implementation.

The **purpose** of the STDP is to: *"Identify and implement innovative sanitation technological solutions to treat wastewater generated by Syrian refugees and discharged from Informal Settlements (IS) in Lebanon, which can serve as a lesson learned to improve global humanitarian responses in similar contexts."*

The **additional objectives** of the STDP are to build a solid Public Private Partnerships (PPP) benefitting Lebanese citizens and refugees with DEWATS spreading in the market. As mentioned, notable environmental and economical improvements are projected to take place locally, nationally,

[11] The grant was initially for 3 years but was granted a 2 year extension largely due to COVID-19 related delays.

and globally in case the project proved to be successful on both the technical (technological treatment) level, as well as the project (design, adaptability, relevance) level.

Development Hypothesis:

UNICEF also hypothesized that implementing a more innovative and sustainable solution through a PPP can reduce costs by 75% by reducing the frequency of desludging from weekly/monthly to annually. UNICEF estimates the desludging frequency to be reduced at least to a yearly desludging frequency after the installation of the proposed solution. The reduction of the frequency of desludging will save at least $2.6 million per year. By reducing desludging frequency, UNICEF would also be able to reduce dependence on unlicensed vendors as well.

On this basis, the STDP would be considered a success if it could demonstrate improvement of sanitary conditions and environmental conditions (via discharge of treated wastewater). These improvements should consider the context of the IS in its design and its targeting, working towards reducing women's vulnerabilities and answering their needs. An additional success would be the national scaling of the technology to IS and host communities with the appropriate conditions, and replication in Syria and other humanitarian contexts in which UNICEF is responding.

Project Scope:

UNICEF had forecast a target population of 200,000 Lebanese citizens or approximately 40,000 households. Sites reported as being under threat of eviction (from WAP) were not considered in this approach. From the WASH Assessment Platform (WAP) data, UNICEF estimated that 1,061 sites hosting more than 98,500 Syrian refugees will be targeted by the Project to ensure reduction of desludging frequency and to improve sanitary conditions mitigating health and environmental risks. In terms of geographical scope, STDP covered 42 Informal Settlement (IS) sites distributed between the Bekaa Valley (Mid/Eastern Lebanon) and the Akkar governorate (Northern Lebanon).

Timeline:

The project's initial duration was 36 months, which includes (i) a six-month inception period in which UNICEF assessed available wastewater technologies and selected an intervention, and (ii) a 28-month implementation period during which UNICEF implemented the intervention in selected ISs. Due to delays in hiring, frequent consultant changes and the COVID-19 pandemic, the project was extended for another 24 months, ending in December 2022. In terms of chronological scope, STDP has been in activity since 2017, thus for a total period of five years. A full timeline of the project was created based on the documents provided by UNICEF including the main challenges faced, results framework of the project, and the reporting periods followed:

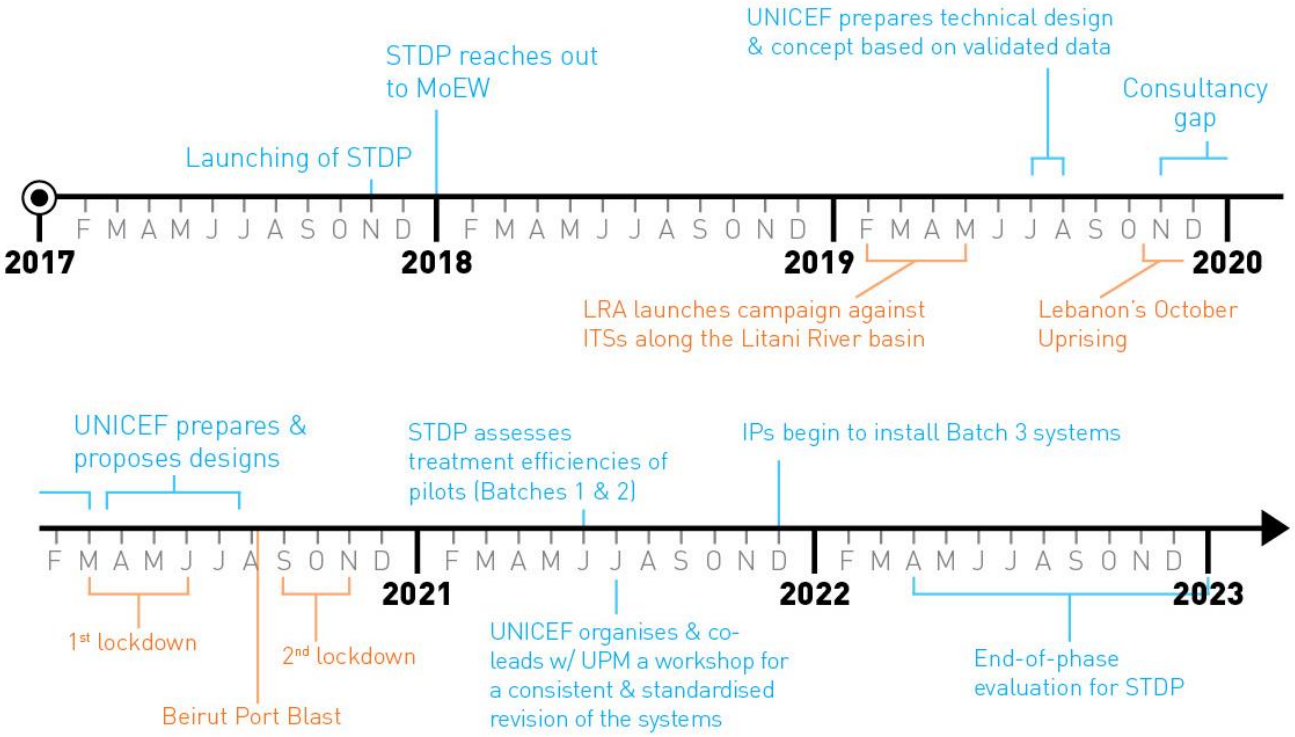


Figure 1: STDP Timeline & Multi-Dimensional Crisis Events

Technology development:

To develop the DEWATS, an iterative "Batch" development system was advanced. In Batches 1 and 2, the objective was to test a variety of designs. The partners selected sites based on desludging costs, environmental concerns and acceptance of the landlords, then the designs were developed based on the site characteristics using eight combinations of technologies and tested on site. In Batch 3, the objective was to validate marketable designs. The starting point of the process were the designs developed in a workshop co-facilitated by UPM, in which participants assessed the performance of batches 1 and 2 technologies. The designs were therefore available for validation and sites were selected for the testing of these specific designs.

All the systems had a settler followed by an anaerobic baffled reactor (ABR). In the different sites, anaerobic filters (AnF), biological aerated filters (BAF), or trickling filters (TF) have been installed for secondary treatments. Finally, the effluent was then polished during the last (Batch 3) trials using tertiary treatment technologies designed to ensure a minimum footprint. The tested tertiary technologies were slow sand filters, aerated (micro) or conventional wetlands and ultraviolet radiation (UV).

Partners, stakeholders and beneficiaries:

The STDP targets Lebanese Citizens and, Syrian Refugees as well as the WASH sector as a whole. UNICEF and the water sector utilized data from the WASH assessment platform (WAP), which provides real-time information on selecting regions in which to implement innovative sanitation technologies, and support the selection of the most appropriate IS. Several stakeholders have collaborated to the Project which is being implemented in close coordination with the Ministry of Energy and Water (MoEW), and to some extent the Ministry of Environment (MoE), perhaps more through the former counterpart.

Several stakeholders have collaborated on the Project which is being implemented in close coordination with the Ministry of Environment (MoE), Ministry of Energy and Water (MoEW), and between 2019 and 2021, UNICEF worked with Implementing Partners (IPs):

- World Vision International (WVI)
- Action Contre Faim (ACF)
- Solidarités International (SI)
- Lebanese Organization for Studies & Training (LOST)
- Sawa for Development and Aid (Sawa)

Four of the IPs implemented and managed systems under Batch 1 and five of them did the same under Batch 2. In 2022, new partners were selected by UNICEF and added to the previous ones, in line with its commitment to localization: Save the Children (SCI) (partnered with Nabad) and LebRelief. Some of the systems started in Batches 1, 2 and 3 were handed over from the original partners to the new partners, and it is currently planned to hand over other systems to local counterparts, which some are already getting seriously engaged.

The PPP aimed to target Lebanese Small and Medium Enterprises (SMEs) to ensure a national benefit and more significant value of the investment in the development of the sanitation solution. The involvement of Lebanese SMEs was considered simple and straightforward, as factories producing PVC and HDPE tanks are present in the country. UNICEF aimed, using its internal supply procedures, to select and directly contract one or several SMEs to produce the NSSS in Lebanon.

2. THE EVALUATION

This evaluation looks at the relevance, efficiency, effectiveness, sustainability (barrier to scale) of the SDTP programme, with an added criteria of gender. It is a technical and socio-economic summative evaluation of the technologies and models produced was conducted by comparing their results, outcomes, and their effects on the community to sanitation and environmental conditions before their installation. A participatory approach that involved all relevant stakeholders in the evaluation process was applied. The evaluation methodology followed a mixed methods approach, which included quantitative methods for the technical assessment, and qualitative methods. A sampling strategy was used to ensure a fully representative cohort.

The evaluation took place between April and December 2022, at the final stage of the SDTP programme, and was undertaken by a team of consultants from Difaf saf consulting, based in Lebanon.

Purpose and Objectives

The **purpose** of the evaluation serves to provide lessons about the challenges and success factors of implementing innovative WASH solutions through an independent assessment of the project design, implementation, and performance by identifying success/failure factors, critical barriers and enablers to adapting, testing and mainstreaming requirements.

As specified in the Terms of Reference (ToR), the **objective** of this external evaluation is for accountability and learning purposes. Learning was extracted for each phase of the Project through:

- Identification and planning of the tech innovation.
- Implementation of the innovation (implementation approach).
- Innovation process, including design, testing and filtering of technologies.
- Dissemination of findings to inform the WASH sector in Lebanon, national authorities and the humanitarian actors working in similar contexts.

The evaluation's **specific objectives** are as follows:

- To assess the innovation systems and the innovation process for quality and rigor and evaluate the ability of the innovations to achieve the desired outcomes and results set by UNICEF.
- To critically assess the relevance, effectiveness, sustainability, and emerging impact of the project.
- To assess the intervention's overall design, implementation approach, management arrangements, partnerships, adaptability and conflict sensitivity (intended and unintended outcomes).
- To provide lessons learnt, challenges and success factors of designing and implementing innovative and sustainable sanitation solutions in a refugee context, as well as the potential replicability of such systems.

Criteria

The evaluation questions are set out as follows:

Criteria	Evaluation Questions
Relevance	**EQ1.**How relevant is the project to the urgent needs of the refugees and host communities in Lebanon?
Efficiency	**EQ2.**To what extent has the intervention been cost effective? EQ8 To what extent did the partnerships with IPs, institutions and the private sector facilitate the achievement of the project outcomes?
Effectiveness	**EQ3.** To what extent was the intervention successful in implementing effective, financially feasible and innovative technological solutions to treat wastewater in emergency context? **EQ4.** To what extent was the project able to build institutional knowledge and strengthen the capacity of stakeholders to improve global humanitarian responses in similar emergency context? What are the lessons learned in the process? **EQ5.** Did project activities show signs of creating unintended positive or negative outcomes? If yes, which activities contribute to this?
Sustainability & Barrier to Scale	**EQ6.** To what extent are the implemented solutions likely to remain operational following the closure of the project? What are the conditions to maintain their sustainability?
Gender	**EQ7.** To what extent has this initiative's design and implementation taken gender into consideration?

The evaluation matrix can be found in Annex 3.

Evaluation Scope

Thematic Scope. The evaluation deals with project efficiency, effectiveness, scale-up potential, solution export potential, community acceptance, and public authority acceptance. These criteria were assessed on three levels which are: big-picture Project Level, a zoom-in on the Technical Level, and the Innovation Level. Viewing the project through these three lenses allows the formulation of a comprehensive understanding of the project as a mechanism composed of many moving gears, where the individual gears and the mechanism as a whole are all looked at.

Geographical Scope. The project focused on ISs under the jurisdiction of UNICEF. These ISs are spread over the governorates of Akkar and Bekaa, as well as Baalbek to a lesser extent.

Chronological Scope. The evaluation covers the timeframe from 2017 to 2022. Qualitative data collection took place between 7 June and 6 July 2022, whilst quantitative data collection took place between 7 June and 17 August. Samples and Templates of the tools used can be found in ANNEX 12

As part of the agreement between UNICEF and BMGF, this external evaluation was conducted at the last phase of the project implementation, six months before the project completion and, after all systems have been installed. It thus provided a clear evolutionary assessment which would help in better defining further potential for developing such programs and implementing DEWATS solutions in Lebanon involving SME's support and mobilizing local economies, giving sustainability proper acknowledgement from both humanitarian and developmental angles.

Methodology

A participatory approach that involved all relevant stakeholders in the evaluation process was applied. The evaluation team used a mixed methods approach, which involved quantitative methods for the technical assessment (field and lab tests for 16 systems on 13 sites), and qualitative methods; literature review, KIIs, SGIs, FGDs, and direct observations. A sample was stratified by key demographic criteria (age, sex, refugee status) to ensure a fully representative range of viewpoints, and to promote data saturation for the FGD and SGDs.

The data was used to develop two distinct case studies, one in an informal settlement (IS) in the Bekaa and one in a host community in Akkar. This evaluation compares STDP against the current approach (i.e. in the absence of the STDP), namely the use of latrines with on-site containment (septic tanks, holding tanks, covered and uncovered pits, cesspits) or with direct discharge to water bodies, and rarely connections to sewer networks or stormwater channels. The predominant use of onsite containment required regular desludging, rather than total absence of sanitation.

A more detailed description of the methodology is as follows:

Primary Data Collection

Primary data was collected through field visits performed by the technical evaluation team; systems were examined firsthand, and samples were taken for lab analysis. In addition, KIIs were held during the field visits during which data was obtained immediately from the relevant interviewees. Collection of data was achieved by:

Key Informant Interviews (KIIs). The evaluation team conducted 40 KIIs at different levels of project implementation. The list of the staff and potential stakeholders to be interviewed was decided in consultation with UNICEF prior to the data collection process. The KIIs provided insights into (i) the outcomes of the project activities (ii) major challenges (iii) success factors in implementing the project (iv) the operational environment and (v) any contextual issues which may have affected the implementation of the project, its effectiveness, and results. Furthermore, the KIIs with suppliers, industrials, and manufacturers involved in the project were conducted through a rapid market assessment performed in order to try to gauge the economic feasibility dimension.

Level	Data Source	Total Number	Methods
All Levels	Project Baseline & Report	All requested & provided	Desk top Study Process tracking
	Specific DEWATS Literature	All researched or inhouse	Literature Review
	Three Sites (one Host)	2 Case Studies (1 IS vs 1 HC)	Mixed
Project & Innovation	UNICEF representatives	7 (3F / 4M)	KII
	IPs Project manager/ Focal point	16 (3F / 13M)	KIIs & SGIs
	GoL Ministries (MoE, MoEW, and MoA)	3 (3F / 0M)	KIIs
	Municipalities, NGOs, landlords, shawishes and desludging vendors	9 (1F / 8M)	KIIs
	SMEs, suppliers, manufacturers	7 (1F / 6M)	KIIs
	Syrian refugees from ISs and Lebanese beneficiaries	5 Syrian refugee women 5 Syrian refugee men 1 Lebanese woman 1 Lebanese man	3 FGDs in 2 sites Phone KIIs with beneficiaries
Technical Assessment: 26 DEWATS Systems 12 IS Sites 1 Host Community Site	Lab Validations In-house Lab 3rd Party Lab	3 Samples	Lab Analyses
	1st Sampling Campaign In-house Lab 3rd Party Lab	Batch 1: 2 systems Batch 2: 2 systems Batch 3: 12 systems	KIIs with IPs Direct Observation Lab Analyses On-site Measurements
	2nd Sampling Campaign In-house Lab 3rd Party Lab	Batch 3: 10 systems	Direct Observation Lab Analyses On-site Measurements

Wastewater Sample Collection and Lab Analysis. The evaluation team underwent a general scoping mission to the 28 sites as an initial step, followed by a discussion with UNICEF to identify the most relevant sites for evaluation. As per the project's Financial Proposal, twelve evaluation sites were selected according to the technology selection, the site selection done by UNICEF, the innovation aspect, and the performance check.

Interest in evaluating treatment DEWATS performance played an important role in site selection. Innovative criteria have also been given attention to; aerobic systems that utilize creative aeration techniques (be it leading to low footprint requirements etc.), innovations in odor control, wastewater transportation, system integration and more had an impact on system selection. Systems that are working efficiently and others that are failing were taken into consideration to assess or validate success and failure factors, with a bit more focus on the matured model used for Batch 3 DEWATS. The below criteria were finally developed as minimal set of inclusions, and upon which the evaluation team relied on to justify final systems and site selection:

Evaluation Team Site Selection Criteria
B1 , B2 Models
Failing / Dysfunctional B3 Systems of Approved Treatment Chain Options
Functional (non-disconnected) B3 Systems Covering All Treatment Chain Options
Lebanese Host Community & Syrian IS
All Implementing Partners
All potential end-use/ Discharge destination
Critical Social / Relational Aspects (Reported Tensions)
All Various Set-ups & Technical Specifications
Covering Full Range of CAPEX vs. OPEX

Based on the criteria above, the evaluation team selected thirteen sites, out of which three sites were also visited for qualitative data collection. The selection of sites for technical evaluation started with an initial filtering step where a ground check of the status of systems was performed to establish which systems were reported to be in reasonably good operational status (noting that some systems were not functioning due to recent vandalism or operational issues). Through this process and in consultations with UNICEF, the team identified a sample of systems that can be evaluated technically.

Wastewater samples were collected by the technical evaluation team during the field visits to the designated sites. Sampling methodologies developed by the EPA and modified by UPM were used for collection. Samples were taken half-way from the reactor depth to avoid the collection of scum that is floating on the surface. An adequate volume of sample was transferred from the reactor to a bucket, properly mixed, then transferred to 0.5 L sampling bottles. The process was done swiftly to avoid oxygenation of anaerobic samples. The bottles were stored in coolers with ice, then transferred to the laboratory for analysis.

Two sampling campaigns were performed. The water samples collected as part of the first testing campaign were processed in certified laboratories and with the probe equipment for validation of results. The samples collected in the second campaign were analyzed by a certified laboratory different to the ones used in round one. Results were used in the objective analysis of current standing of treatment efficiencies, and cross-compared with UNICEF results being populated in tandem. The results of these analysis can be found in Findings (as first level summary) and conclusions (second level analysis). Limitations were outlined and results were objectively and scientifically assessed for validity and cross-checking. The following parameters were tested for in the laboratory:

- Chemical Oxygen Demand, COD
- Biological Oxygen Demand, BOD5
- Total Phosphorus, TP
- Total Nitrogen, TN
- Fecal Coliforms, FC
- Total Suspended Solids, TSS

Furthermore, the team performed on-site measurements for physiochemical parameters using a multi-parameter probe. The measured parameters were:

- Dissolved oxygen
- Temperature
- pH
- Conductivity

- Oxidation-Reduction Potential
- GPS coordinates

The final selection of exact systems / site was communicated to UNICEF after conduction of the first set of interviews with project holders and implementers, one week before commencement of evaluation field visits and can be found in Annex.

Case Studies. To support the evaluation with illustrative examples that would show IS and HC systems, three sites were selected from Batch 3 for qualitative data collection – the only site within a host community (Menjez, Akkar), a site considered successful by UNICEF and IPs within an IS (Bar Elias) and another site in a refugee community in Akkar (Ouadi el Jamous), where the system design was similar to that in Menjez. From these sites, two case studies were produced in order to further cross-check and illustrate and conclusions, findings, recommendations. A summary can be found at the end of the report, while the complete Case Studies can be found in Annex.

Secondary Data Collection

Secondary data was collected through desk review, key informant interviews (KIIs), focus group discussions (FGDs) and reports of second-hand observations. The various methods of collecting this data are presented below:

Desk Review of Project Documents. Desk review of the project and documents was conducted at the inception phase to gain a comprehensive understanding of the project implementation since 2017.

Literature Review. A review and some targeted research was conducted on classical references for DEWATS, as well as new innovative systems that are being explored in humanitarian and development settings. Although it would not be possible to benchmark the Lebanese experience against European or international standards, some supporting arguments or insights can be useful in the discussion and analysis here, specifically for experiences in nearby countries (such as Jordan, Iraq, Palestine, etc.). Articles and guidelines on similar Innovation in humanitarian and development WASH sectors have also been reviewed.

Methods of Analysis & Findings Validation

The evaluation criteria formed the basis and starting point for developing the main research questions for this evaluation outlined below.

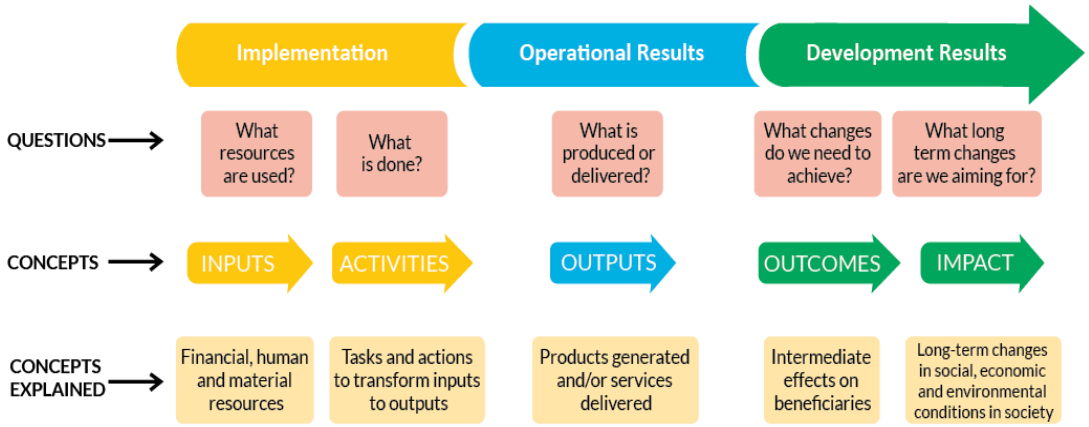


Figure 1 Conceptual Framework of Evaluation

Triangulation of Data

The evaluation focusses on innovation at three levels: the solution selection, the process and the implementation; alongside the outcomes of the innovation (the project as a whole). At each of the three levels of the evaluation, the evaluators assessed main innovative achievements, technical success factors and project successes and barriers with the IS ambitious purposes benchmarked.

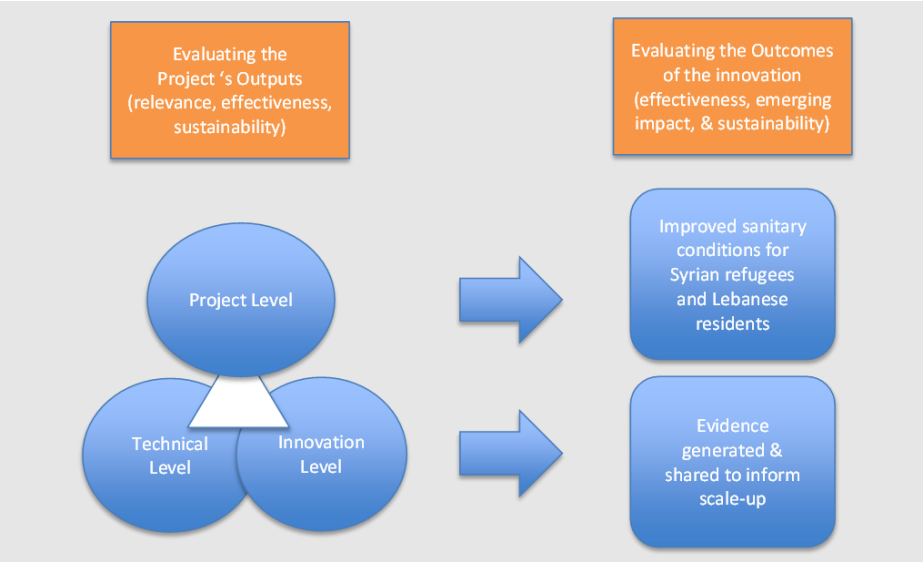


Figure 2 - Evaluation Methodology: Three Lens Levels

The Project Level. The study of the design phase of the project looked at how the project was initially conceived, the risks considered, the targets (realistic or too ambitious), the initial selection of technologies and design considerations, the selection and management of implementing partners, the engagement of the local communities and gender aspects, the reporting agreements, the monitoring of data etc.

The project implementation phase was evaluated by looking at (i) how the systems were implementing partners engagement quality assurance and reporting mechanisms (ii) what adaptations were considered (iii)how the evaluation process took place (iv) redesigns (v)choice of material for manufacturing (vi) overcoming challenges etc. Finally, the lessons learnt about the project development, outreach and knowledge dissemination were also evaluated for considering opportunities assimilated or missed, and the overall project contribution to knowledge build-up, the potential success for dissemination of technologies in local or similar markets and contexts.

The Technical Level (Treatment Technologies). The technology and models' evolution aspect of the systems installed were evaluated through a thorough study of the design, implementation and monitoring processes undertaken by the project, assessing specific technical enhancements for adapting and improving the technologies. The evaluation focused on the evidence used to inform decisions for the continuation and discontinuation of technologies across batches. The design, testing and filtering of the innovations and technicalities were assessed for suitability, treatment efficiency, and robustness. Operational complexities, and adaptability to both host and refugee contexts were also assessed, as well as potential or unaccounted aspects through a SWOT, which also takes into account market considerations. The evaluation thus focused on the safety, accessibility, equitable use and conflict sensitivity of the implemented innovative technologies in the 12 sites selected for the evaluation.

The Innovation Level. In addition to evaluating the technicalities, the team assessed the project outcomes regarding the current and cumulative effect of the innovation on sanitary conditions and access to safe WASH and on generating evidence that can inform the replication and scale up of the

technology for use in humanitarian and development context. The solutions-oriented aspect of the project DEWATS models were given enough attention from the evaluators in terms of innovation, in order to inform the potential upscaling in Lebanon and other humanitarian crisis geography based on the level of success and the replicability/scaling-up potential is key.

STDP Theory of Change

The project's primary outcome was "an innovative sanitation technology that improves wastewater treatment and faecal sludge management is used in informal settlements and host communities in Lebanon, improving sanitary conditions for Syrian refugees and Lebanese community residents, with findings shared for the overall humanitarian response with similar sanitation contexts." It is aligned with UNICEF's country strategy since it aims to contribute to "sustained use of safe water supply and sanitation services and adoption of hygiene practices, by children and their families" in vulnerable communities as per Lebanon Country Office Country Program Document LCO CDP Outcome 1. [12]

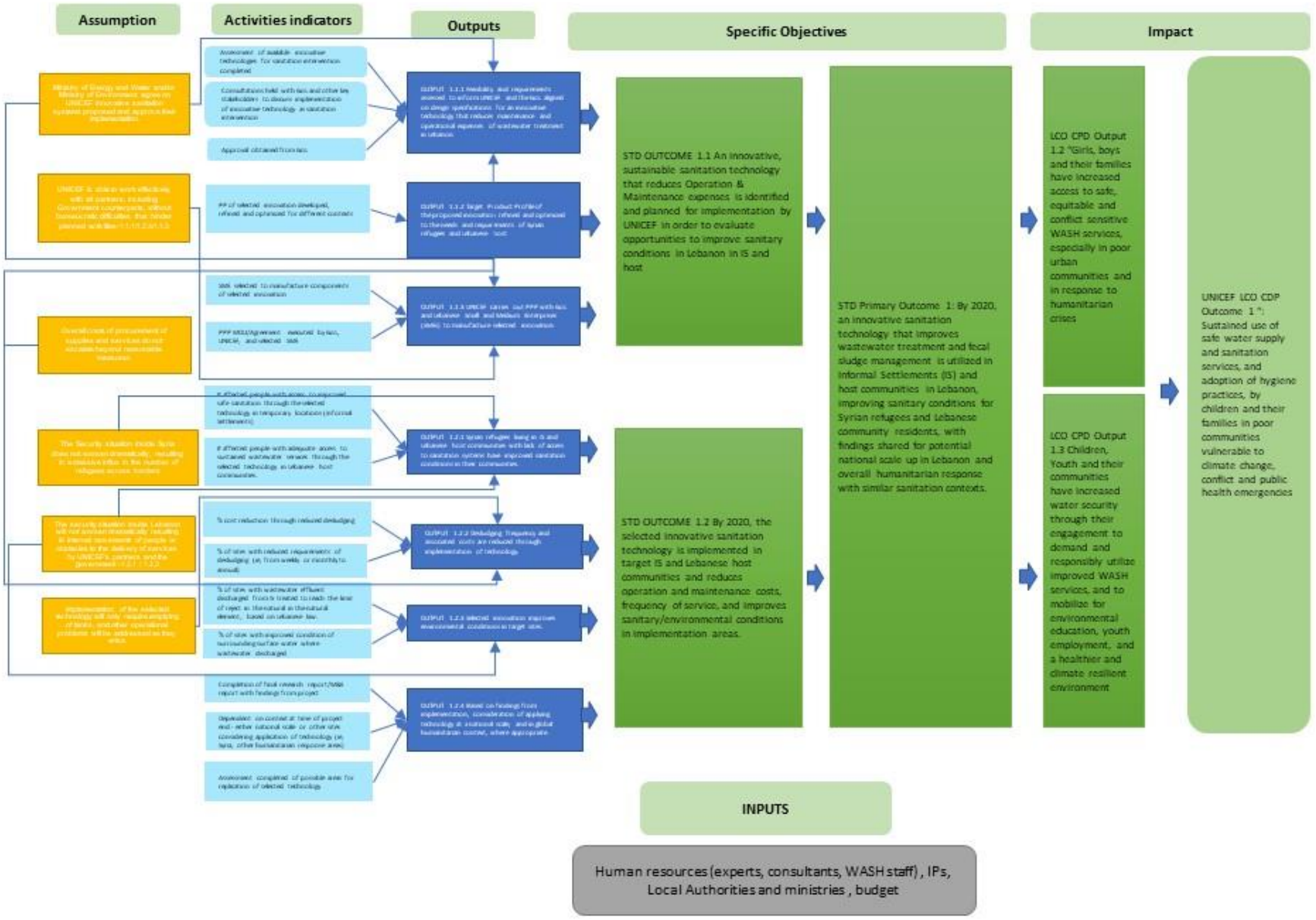
In a more precise detailing, UNICEF devised the outcomes into immediate vs intermediate as per below:
Immediate Outcomes

- An innovative sanitation technology that improves wastewater treatment and faecal sludge management is utilized in informal settlements (ISs) and host communities in Lebanon.
- The Sanitary conditions for Syrian refugees and Lebanese host communities are improved (as a result of the technology).
- Findings from the use of the technology are shared with relevant national and humanitarian stakeholders.
- Intermediate Outcomes
- Potential national scale-up of the technology.
- Potential scale-up of the technology in overall humanitarian response with similar sanitation contexts.

As a Theory of Change (ToC) was not designed on the onset of the project, the Evaluation Team (ET) was tasked during the inception phase to construct one. The ET did this based on the Results' Framework (RF) shared by UNICEF. To construct the Theory of Change (ToC)[13], the Evaluation Team carried out a half-day workshop whereby they extracted the various project outputs and outcomes from the RF. The grid whose X-axis ranged from short term (far left) to long term (far right) was constructed, and whose Y-axis followed the sequence of the outputs and outcomes in the RF, placing the various outputs and outcomes where they deemed to be representative of a certain OP's or OC's level of immediacy. After the team members validated the respective positions of the various outputs and outcomes through discussion in plenary, then wrote down the assumptions and impacts that they saw befitted them. This process was ultimately verified through work discussions with UNICEF. Assumptions were outlined to ensure successes are presented properly in the findings section under relevance. The Team refined and completed it by adding the indicators' sections for assumptions and activities, with its broad outline being as follows:

[12] LCO CDP Outcome 1
13 Full project ToC under Annex.

STDP Reconstructed Theory of Change



Ethical Considerations

The evaluation process made sure to adhere to UNEG and UNICEF norms and standards, including:

- UNEG Norms and Standards for Evaluation (2016).
- Ethical Guidelines for UN Evaluations (2008).
- Code of Conduct for Evaluation in the UN system (2008).
- Integrating Human Rights and Gender Equality in Evaluation – Towards UNEG Guidance (2011).
- Ethical Research Involving Children, 2013 and UNICEF Procedure on Ethical Standards in Research, evaluation, data collection and analysis dated April 1st, 2021 (UNICEF Procedure).

The evaluation methodology was approved by UNICEF's Ethics Review Board on 10 June 2022. This was facilitated by three circumstances:

- The evaluation involved no minors.
- Mitigation measures were observed when interviewing members of vulnerable groups.
- The risks to the safety, privacy and wellbeing of the evaluation participants were limited (this point is elaborated upon below).

During the recruitment stage, the Evaluation Team made sure to conduct its own screening by way of ensuring that engaged employees were respectful of ethical norms and criteria. The Evaluation Team's experts, surveyors and facilitators were then made to sign an ethical chart (Impartiality, independence, quality, and transparency) as well as a pledge of ethical conduct in evidence generation to the UNICEF Procedure. As per UNICEF procedures, the Evaluation Team adhered to the five guiding principles that must inform ethical evidence generation.[14] The Evaluation Team declared no conflict of interest, and it committed to clearly identifying any potential ethical issues, or any vulnerable social groups targeted within before/during the assessment process.

Based on the suggested methodology, the Evaluation Team identified Syrian Refugees as a vulnerable group amongst the targeted population, especially Syrian women refugees who participated in one FGD with the Shawish. In the course of the FGD, the Evaluation Team made sure not to expose refugees in general and women refugees in particular to any risk or threat based on their participation in the FGD. This is to say that the selection/invitation was conducted in close coordination with WASH committees and the IS Shawish. Informed consent was also obtained from all participants according to a template previously agreed upon by UNICEF. Also, all members of the Evaluation Team signed on contractual confidentiality of all projects' information.

All primary data collection adhered to ethical research standards. A consent form was read prior to each interview, informing participants of the purpose of the evaluation and their engagement with the evaluation team, and of their rights. Verbal consent was collected for KIIs. For data collection conducted by telephone or similar technology, the interviewer obtained verbal consent from the participant and marked the consent form on behalf of the participant. The evaluation team informed participant that notes would be taken and secured participant approval before initiating any audio recording.

14 Namely: Respect, Beneficence, Justice, Integrity and Accountability.

Of particular note, qualitative data collection was undertaken with an expectation of confidentiality on the part of participants, such that individual responses will not be linked to an individual's identity, so as to encourage truthfulness in participation. Upon the conclusion of every KII, SGI, or FGD, an ID was provided to the interview/discussion in question by way of anonymizing the respondents – the IDs and names were linked on a separate, password-protected document.

Data collection was primarily conducted in Arabic, though English or French were also used in cases where the participant expressed a preference to speak in either of those languages. In this case, trilingual members of the evaluation team served as translators for the administration of the KII; notes or transcripts were then translated into English with the support of trained SI staff. Data codification and analysis were carried out in English.

The informed consent forms and protocols for the protection of participants' identity and for their safety, as well as for data protection and other relevant information are provided in Annex 4.
As far as intellectual property is concerned, the Evaluation Team abided by intellectual property legislation by clearly mentioning each source in the report whenever referencing it.

In the technical evaluation, the team followed international procedures (EPA) for sampling procedures, developing on steps. Lab results were validated by using multiple laboratories and carrying out a second sampling campaign to validate the results of the first. Additional validation of lab results was conducted with the Evaluation Team's multi parameter probe for on site measurements as well as in-house lab analyses. For Quality control, the Evaluation Team performed a validation to confirm the accuracy methods and obtain the approval of UNICEF to use its own lab results as needed. The procedure was documented and can be found in Annex 11.

Limitations

Over the course of the Evaluation, the Evaluation Team faced the following limitations due to the MDC circumstances, as well as the relatively short duration of the technical sampling campaign in the evaluation project and the seasonal restrictions:

- The timing of the technical evaluation was a challenge, where lab testing in Lebanon is not always available. Lab testing was challenging due to the worsening economic crisis. At times, scheduled lab services ran out of consumables, or closed earlier than expected for various reasons, and the Evaluation Team mitigated these closures and shortcomings by delivering to other labs if time permitted. If such delivery was not possible, the Evaluation Team took standard procedures to preserve samples in acid and refrigeration until the nearest opportunity was present. If next availability was delayed, samples were discarded, and tests were repeated. Several assumptions had to be made from UNICEF project design calculations such as flow numbers, and historical lab analyses data. Logistically it was impossible to verify these in due time, mostly relating to variable IS situations on the one hand, and records been taken prior to the Evaluation Team assuming its work. The Evaluation Team made all efforts to validate lab results when in doubt or when discrepancies arose, through own lab measurements or through duplicates and split samples sent to different labs. Extra efforts were made to make sure labs used similar methods in analysis.

- Most IPs were cooperative, some were less, however in fairness, most had left or been replaced due to high turnover in the context of economic crisis and delays in projects caused

by cases of force majeure. Information was complemented when it was possible to retrieve it from follow-up calls or UNICEF personnel. This made it challenging to be certain of some important systems details at the times. The Evaluation Team managed to be as accurate and detailed as possible, albeit some discrepancies. As such, flow measurements could not be confirmed, which have presented some assumptions in challenges.

- A market validation of items relating to successful technologies was attempted with limited sources and responsiveness. Due to the volatile situation of the Lebanese Lira, similar systems available on the market could not be identified for comparison of the prices, since prices of pieces were changing on a weekly basis. Therefore, the team collected data from manufacturers and UNICEF on current and anticipated production costs of DEWATS,and benchmarked it against the cost of conventional market systems of same capacities.

- Reliable data on the reduced frequency and cost of desludging was only partially available at the time of this evaluation, as Batch 3 systems were installed around the end of 2021, and desludging had not been conducted on all of the examined sites by the time of data collection. IPs reported that Batch 3 systems were undergoing desludging only in the case that a failure occurs in the system (e.g., clogging), other than that, the systems were not in need of desludging at all; The team obtained data on desludging frequency reduction from IPs which have already used the desludging services after the installation of the systems and validated the reduced frequency with IS residents and vendors. To overcome this challenge, the evaluation team used a mathematical model to calculate the anticipated reduction in the desludging frequency and estimated the cost based on average of costs shared by IPs.

- Some discrepancies in the analyses of key water quality indicators were observed in results provided by different sources. This was mitigated through a second testing campaign, aimed at validating earlier results, such as two reports shared by UNICEF assessing 6 systems,

- Samples were collected only in the summer season, when water tables are low (June and July), which limits the evaluators' ability to assess the DEWATS' suitability to seasonal variations. Therefore, results of the quality of the effluent should be considered as a snapshot of the systems' performance in a specific point in time and under specific circumstances, which may not be the prevalent conditions in ISs throughout the year.

- The evaluation methodology included an assessment of host communities' perceptions of the adoption of new wastewater treatment technologies in ISs. As suggested by some IPs, the intervention aimed to positively influence host communities' perceptions of the ISs as pollutants and thus decrease risks of refugees' evictions. However, in the ISs selected for qualitative data collection, the respective IPs have not sufficiently engaged the host community (such as households in the vicinity of ISs) during the project implementation. Therefore, it was deemed unsuitable for the evaluators to reach out to host community members and explore their perceptions. Informants from the local municipality were asked instead about host community perceptions and attitudes towards the ISs and water treatment.

- Recall bias and response bias of some respondents from the community posed another limitation, which is frequent in participatory evaluation, especially of longer-term projects. Some informants may have been motivated to provide responses that would be considered desirable or influential in obtaining donor support (response bias), while others may have not clearly distinguished their experience with the evaluated project with other similar

interventions (recall bias). The team mitigated this limitation by triangulating data from various sources.

- Sludge assessment for Batch 3 could not be conducted due to the novelty of instalment and the slowness of sludge production by these systems, which usually take time to mature, assuming they are already fully operational and functioning well (6 months at least).

- Certain elements of the WWTPs were disconnected and not functional at the time of the study, and the Evaluation Team tried to mitigate these dysfunctions by an ad-hoc selection of other systems nearby in order to make up for gaps.

Below is a summary table of the limitations encountered and the mitigation measures taken against them by the ET:

Limitations	Mitigation
Market validation limited due to lack of similar technologies on the market	Assessment based on data on investment cost obtained from partners and the suppliers on the project
Flow measurements unmonitored vs varying context, or other technical measurements	Theoretical calculations with defined assumptions, or calculations using givens from past empirical inputs similar or same project
Limited data on desludging frequency and cost due to limited time for operation of Batch 3 DEWATS	Assessment based on data from partners and B2 reports that already used desludging services
Variations in measurements from different labs	Validation of results with a second campaign
No FGDs with host communities neighboring ISs due to limited engagement during the project	Data on host communities' perceptions obtained from municipalities and IPs
Non-collaboration with contentious stakeholders (informal sector, landlords)	Attempt to check if MoU had any practical effect on dynamics of collaborations between parties
Recall bias and response bias of some stakeholders	Triangulation of data sources

3. FINDINGS

3.1 Relevance

EQ1.*How relevant is the project to the urgent needs of the refugees and host communities in Lebanon?*

The STDP programme is highly relevant, meeting critical needs of refugees and host communities in Lebanon.

The project has addressed and met critical needs in informal settlement and host communities by piloting a large scope contextualized solution for the wastewater management crisis. The critical needs met by the programme is reducing the operational challenges and the huge recurring costs of cesspit desludging; and improving environmental conditions to prevent environmental and public health hazards. The STDP has made some limited advancements on contributing to other critical needs, potentially addressing livelihoods improvement in the future (should the wastewater be used in a widespread way for agriculture) and reducing latent tension between peer communities.

The advancements contrast the previous situation where poor management of basic primary or no-treatment of rudimentary sewage collection tanks or cesspits, led to risk of disease. Previously, there were very limited wastewater treatment projects undertaken in the humanitarian sector. In IS, it was typical for septic or holding tanks to be constructed leading to high desludging costs, or sewage was discharged into waterways. The costs for desludging were high. All respondents from both refugee and host beneficiaries stated that the intervention enhanced their quality of life in some way. Female Syrian refugees who participated in FGDs emphasized the systems were important due to problems with flooding, bad odours, and infections prior to the intervention.

The host community targeted by the project, in Menjez Municipality-Akkar, also found that the installation of DEWATS was highly relevant. In the host community of Menjez, the untreated water prior to the intervention used to contaminate surface and underground water. Previous to the STDP, the wastewater of the 30-35 households that were selected for the intervention was directly disposed of in the river, causing pollution and complaints from people living downstream.

Quotes from KIIs demonstrating refugee and host community relevance:

“By far it has a positive impact on the people residing in the ISs through improving the health conditions, reducing the stress on the environment of the host community by sustainable operation and maintenance of these systems” – IP Informant

“Residents used to suffer a lot from the bad smell and the floods as they had no good access to the latrines and were exposed highly to diseases of skin rashes, breathing irritation, and diarrhea Also, there were high masses of insects and flies in the site.” – Refugee

"The project relieved us from septic tanks that used to flood, as well as from odours, which used to affect the health of children in the IS.” – IS Shawish

STDP relevance is further demonstrated in wastewater treatment being determined as a priority in national emergency plans. The STDP has maintained its relevance throughout the unfolding multi-dimensional crisis, by initiating a slow and long process of establishing services and building trust. It provides a relevant example of a humanitarian-development nexus approach.

On a strategic level, the STDP meets needs set out in successive Lebanon Emergency Response Plans[15], principally meeting the needs of Syrian refugees and host communities. The potential risks of wastewater contamination were described, demonstrating the continued humanitarian needs in this area:

"The multiple crises afflicting Lebanon have led to a severe deterioration in people's standard of living. Basic rights are being denied as people are unable to afford or access basic goods and services including health, food, education, electricity, water and wastewater management."

"… public water supply and wastewater treatment systems, which are heavily reliant on fuel, have drastically reduced their operations across the country, leaving millions of people without continuous access to safe water and exposing them to environmental and public health risks amidst the COVID-19 pandemic."

On the ground, as the multi-dimensional crisis (MDC) deepened, following the instigation of the STDP, the interventions broadly remained relevant to meet urgent needs on the ground. After the STDP began, Lebanon experienced additional deepening crises, including the Beirut port explosion, the COVID-19 pandemic. Limited government accountability and weak institutions of Lebanon have had a worsening impact on the state's ability to provide basic public services, which includes wastewater treatment. In spite of this, the STDP has made attempts to start a slow and long process of building a service by establishing relationships and trust between partners; it has addressed accountabilities across stakeholder, service provider and refugee and host populations groups. Given the protracted and complex nature of the crises, the concept to build infrastructure and service resilience as a means to incrementally transition from short-term humanitarian response to long term development strategies has been highly relevant example of a humanitarian-development nexus approach.

On a technical level, the evaluation team finds that the DEWATS intervention was relevant in terms of the policies for temporary settlements. The STDP approach is also found to be nationally relevant, aligned with national level policies for host communities.

A main challenge of the SDTP, was that it needed to address concerns of the GoL, and its policies for temporary settlements. Due to this policy, the Ministry of Energy & Water (MoEW) has been cautious to allow for permanent infrastructure to be constructed for any temporary settlements in the refugee context. The STDP has taken this factor very seriously from the start, managing to design the DEWATS so that it could be easily removed, transferred, and repurposed, whilst maintaining good treatment efficiencies that are adaptable for various wastewater contexts and end-uses ISs and host community). It should be noted that the MoEW tried to avoid a scenario whereby its bureaucracy would contribute to further project delays given the project's humanitarian and developmental sides. As such, taking into consideration its innovative aspect and small scale, the project was not subject to major objections.

The STDP is aligned with several national policies and strategies. The National Strategy for the Wastewater sector had a target of 95% of connection and treatment by 2020 (currently, only 15%

[15] OCHA Lebanon Emergency Response Plans: Plan for 2017-2020 and 2021-2022 were reviewed.

of the total population is connected to a functioning treatment plant). This target was considered as not possible to be met in time, but the MoEW claims to continue to work toward achieving it. In addition, the MoEW had expressed its interest in this project to complement and strengthen the policies around wastewater.

The STDP meets various stipulations under the national regulatory framework, including a decision (Decision 8/1) from the Ministry of Environment (MoE) dated 8th January 2001 which defines the Standards of Environmental Limit Values (ELV) for wastewater discharges into surface water where standards must be adhered to, and which set the limits for this project in discharging to the environment. The STDP is also designed in accordance with the Water Code dated 13th April 2018 modified by Law number 192 dated 16th October 2020, and Lebanon's wastewater strategy (as a chapter in the National Water Sector Strategy (NWSS)), which includes plans for cost recovery within new schemes piloting in some governorates. Although the enactment of the new Water Code lacks implementation decrees and it remains unclear how it (and any cost recovery scheme) can apply within humanitarian contexts, the STDP provides relevant evidence for its ongoing implementation.

Widely in the WASH sector, and government authorities in Lebanon have come to welcome decentralized wastewater treatment technologies (DEWATS). DEWATS are being made available through international exchange and are locally customized since they can be designed to meet Environmental Limit Values (ELV) dictated by Decision 8/1 of 2001, and Food and Agriculture Organization (FAO) regulations[16] for Wastewater Reuse for Irrigation currently accepted by the Government, and thus safeguard the environment from further pollution loads.

According to the project document, UNICEF aimed to promote the use of ISO/DIS 30500, a voluntary international product standard for non-sewered sanitation systems (NSSS), which "addresses basic sanitation needs and promotes economic, social, and environmental sustainability through strategies that may include minimizing resource consumption (e.g. water, energy) and converting human waste to safe output". This was seen by UNICEF as a starting point for the reinforcement of the policy making in order to ensure that all the prefabricated integrated treatment units are safe and efficient.

3.2 Efficiency

EQ2.*To what extent has the intervention been cost effective?*
EQ3.*To what extent did the partnerships with IPs, institutions and the private sector facilitate the achievement of the project outcomes?*

The investments into WWT are justified and a high emphasis on cost-effectiveness has been placed in design and implementation of the STDP. Emerging reports suggest that desludging services are reduced.[17] Although the return on investment has not yet been achieved, value for money is found to be good should the lessons be available for the wider humanitarian sector.

The cost-effectiveness of the STDP has been reviewed in terms of the investment into DEWATS, and the avoided cost of desludging resulting from the intervention. Due to lack of statistical evidence on environmental and public health costs related to wastewater treatment in Lebanon,

[16] These standards are found in the Annex reference.
[17] Data on frequency was not available at the time of evaluation. Sufficient data is needed over a longer period.

cost-effectiveness in this area was not considered (i.e. wastewater intervention as a cost-effective means to serve the needs of public health and environmental protection). Despite this, the evaluation accepts that the environmental/public health cost associated with not addressing wastewater issues are high as outlined by the following:

..The cost assessment of water resource degradation in the LRB was estimated at US$ 227 million/year, which corresponded to 0.5% of the national GDP in 2012. Additionally, the costs associated with the health bill resulting from the burden of waterborne diseases is high (US$ 49 million/year in 2012)

- Ref: SOER, 2020 -

In terms of the technology development, the complex economic crisis has impacted on the cost-effectiveness of the programme as a whole. The DEWATS technology development has been experimental, particularly in terms of the biological system developed where different material and treatment options were trialled. The technical trials also experimented with different options to suit humanitarian-development needs. Previous to the STDP, Lebanese standards and prototypes existed for large-scale development, but not for humanitarian contexts, therefore an extensive amount of trialling was needed. Limitations on materials, and the need to develop non-permanent solutions further impacted on costs as the solutions needed to be explored (i.e., after trialling the use of sheet metal which were vandalised or stolen, more expensive polypropylene sheets are now being used to construct settling tanks).

The fact that public investment is not possible and that the potential for any type of investment is coming from loans and overseas development assistance; and the fact that the multi-dimensional crisis has impacted on the return on investment of public service infrastructure, has meant that understanding the benefits of such investment, in a financial sense, is very complex. In addition to the financial crisis, the energy and fuel crisis means that overall costs to run WWTS are high, with many people relying on generators to run such systems. The knock-on impact of the crisis is that solar panels to run the DEWATS have been affected by theft as well.

Despite the complex operating environment, the points of achieving a return-on-investment had been planned well in the project design, based on normal operating conditions. UNICEF had considered a return-on-investment period of 5 years. The costs considered for investment are only the estimated prices of the WWT systems, ranging from US $4,000 - $9,000 in locations with no groundwater contamination risk comprising 92 sites: and up to US $1,308,628 in locations with groundwater contamination risk comprising 120 sites. For the former group, the investment amounted to US $1.9 M, and was forecasted to reduce the yearly desludging cost from around $320,000 to a bit under $30,000. For the latter group, the investment amounted to US $9.44 M, and was forecasted to reduce the yearly desludging cost, bringing it down from more than US $1.4 M to around $107,000. Therefore, as described in the Sanitation Action Plan (2021), 289 sites were expected to be cost-effective with a return on investment of less than 5 years. However, if ROI is to be realistically taken into account for any reason, it would be on a site-by-site basis where some sites might be returning costs in less than a year. Further analysis may also show cost reduction benefit from economy of scale if mass produced.

Though high capital costs have already been invested, the aim of the desludging cost savings has already started manifesting in reports of low desludging needs, which is likely to continue/ improve assuming systems are treating well. Two of the partners interviewed provided some updates due to the recent launch of Batch 3 systems. Although the intervention has very good potential for the wastewater to be very well treated, the system still needs to be matured and standardized and the evaluation team understands that substantial work is underway to do this in terms of the Lebanese context and in UNICEF design standards. A lot more work is needed, although results are good and there is strong potential to reach impact on the large desludging costs. The proof of concept has been achieved, and more needs to be done to standardise.

Even though UNICEF has made all the efforts to roll-out its sustainable vision in a very precarious situation based on well-founded calculations related to real savings and data proving the high treatment efficiency of B3 systems, a solid cost-benefit analysis cannot be completed. The reason being is that the economical fluctuations form one hand and informality of the sector, namely the desludging service providers, on the other, necessitates more validation which could be available soon. Partners currently estimate operation and maintenance costs in the ISs in the range of US $500 per month, which is not a negligible cost in the Lebanese context. However, the value of US $500 per month does not correspond to steady state operation; once that state is reached, O&M costs decrease to about US $165 per month.

A market validation was also not achievable to ensure the capacity of the local markets to build and operate the new innovative sanitation solutions. However, back of envelope calculations[18] demonstrate that assuming an investment cost of around US $10,000 per system and an operation cost under US $1,000 per system per annum, there is potential for scale-up in host communities and ISs (see Annex 1).

In the long term, UNICEF and partners have made every effort to ensure that costs are recovered in some way, on many different levels. This aspect further justifies the investment. For instance, UNICEF has worked with several local SMEs to trial materials and moulds that can be produced on the local market, or in the region. SMEs are now active in further refining the precision design for local production. This includes on developing moulds so that plastic tanks can be manufactured in country. UNICEF is also working (through a new grant) on improving tertiary treatment so that all waste can be treated on site. They are launching a market assessment to further develop creating resources from waste products, for instance producing a local compost (instead of relying on imported fertilisers).

The SMEs that UNICEF worked with have developed capacities to sustain production, given market demand. Although the cost of the systems of Batch 3 fell into the range stipulated in the Sanitation Action Plan (2021), heading towards mass production in the upcoming batches will decrease the cost of the modules, leading to the decrease in the CAPEX of the system.

Feasibility wise, it yet remains to be explored whether or not the continuity of the project can be sponsored by international NGOs and bring CAPEX down, securing the required OPEX which is supposed to be affordable on the short term, and eventually sustainable on the long term if NGOs, civil societies, or governmental institutions (if they do regulate and adopt) soon enough, find long term support frameworks for these systems, be it for Lebanese or any informal community.

A participatory approach to working with partners was shown throughout implementation, enhancing efficiency. UNICEF's strength at managing partnerships with IPs and relevant authorities has led to positive project outcomes.

Partnerships formed with IPs and relevant partners is found to be strong. Data collected from programme IPs and authorities has shown the value and appreciation of UNICEF's ability to manage effective partnerships towards the achievement of project outcomes. On a technical level, this was shown in the process of establishing a modular, context-specific design specifically for ISs. This aspect forms an overwhelmingly positive finding with IPs (with the highest number of positive respondents), as well as Ministry and local authorities. Positive aspects mentioned were the familiarity of the UNICEF team with the context, which is to say that its team members had

[18] Undertaken by the evaluation team.

extensive fieldwork experience that made them approach the technicalities of the project from an informed and empirical perspective

The project took participation seriously with local knowledge and history of the area, informing design and implementation. Social and community considerations were also respected where both IS and host communities were approached during needs assessment, which was based on WAP, identifying technical, social and cultural factors. As an example, the design considered a local religious practice; the system could not be placed in the Qiblah direction either facing towards or directly away from it.[19] During implementation a number of problems arose, and several situations were discussed where UNICEF partners were quick to respond due to close ties with the community. By the responses of most beneficiaries, host communities (including municipalities and landlords), communicated that critical or valid issues or troubles related to the systems seem to have been always considered seriously and followed up on diligently and immediately with a hands-on approach by UNICEF and collaborative IPS. The sector apparently had faith in UNICEF's technical and financial management capacities.

Evidence of participation on the technical approach is found throughout, where partners learn together and develop solutions collectively. Sector stakeholder feedback, whether communicated through formal or informal channels, or whether they were basic informative roundtable discussions, learning curve workshops, or implementation planning were taken seriously and always documented.

The GoL has been involved from the onset of the STDP, showing a willingness to follow up. However, this willingness was reduced with the deepening of the various crises taking place (e.g. the port explosion, the economic crisis). The MoEW became more supportive when the systems were showing signs of effectiveness. The project also seemed to have avoided developing a strong partnership with the MoE due to the fact that even informing it of any activity would ignite long bureaucratic procedures (with demands for the prerequisite environmental examinations and impact assessments).

Communities/beneficiaries were less involved, particularly in initial stages which is reasonable given the programme concept. However, a lack of early engagement in communities may have led to some setbacks, specifically with theft and problems with landlords.

In the initial stages there were some complications, as some of the IPs stated that engagement of local stakeholders took place with local authorities and landlords rather than beneficiaries. This caused a problem with the community and led UNICEF to adopt a more bottom-up participatory approach through creating community mobilizers, WASH committees and engaging more the *Shawishs*. Respondents discussed the change in approach was able to resolve problems, such as siting of the WWTPs, in relation to tents and community assets. Several informants believed the "participation" stayed at the level of awareness raising and informing. UNICEF believed this to be sufficient. In fact, such participatory approach is bound to remain limited since the implementation of wastewater treatments especially in piloting stages cannot engage beneficiaries beyond focal points and managing agents given the safety and technical precautions to be upheld.

Most respondents highlighted that programme blockages were caused by landlords who would either obstruct the installation of systems, request additional rent, threaten to confiscate installations, or would seize them outright. According to the legal framework, the landlord may

[19] Meccah, the direction of prayer for Muslims around 162° from the north in Lebanon.

oppose an installation made on their property. Therefore, suggesting that a landlord was able run a system was sometimes problematic and could only be circumvented by soft power: *"MoUs with landlord and municipalities are kept in the loop of everything that is changing in the design and the location and impact of the project, and sometimes they took advantage of this" - IP* The cooperation with the municipalities as the local representatives of host communities was limited to drafting *MoUs* developed with landlords.

On-site, an element of disruption has been the theft of systems as a result of the deteriorating economic situation in the country and the rising poverty. On several sites, the testing could not be completed following incidents of theft, vandalism or intentional disconnection of the systems by the landlord. To counter that, UNICEF and IPs have increased their investment (whether material or in terms of follow-up) in fencing and security arrangements, with partial success on that front.

Some quotations demonstrating the complexity of working at community level, including with landlords and the threat of theft:

"Right now the installations have fences and roofs, so somehow they have become secured, but in some cases they have been stolen, and the refugees would refuse to disclose who has stolen them due to fear of eviction, esp. when the thief is the LL himself." – UNICEF

"On the ground, the greatest challenge has been to find a landlord on any site who is willing to allocate land on her/his land for this project, starts wanting fresh dollars. Oftentimes in Batch 2, we'd start, but then would have to withdraw due to this.

On another site, the installation process worked, but then the landlord stole the installation that we had placed. UNICEF was supportive of us in that incident and this was documented, but the greatest challenge has been the landlords because, unfortunately, nobody thinks of the environmental aspect of things." – IP

"At first site, we followed the standard procedure of consultation, which is about the installation as a whole but not the design. Then we realized that there was opposition from the community, so we tried to engage the community more by creating WASH Committees that would do awareness and hygiene promotion and serve as focal points to get referrals on-site and, ideally, to be involved in the MEAL process of the systems' installations and operations." -IP

The STDP has been designed as a PPP, and a variety of private entities were engaged. There are some good outcomes in terms of setting the foundation for SMEs to take on services or manufacturing, encouraged by the launch of the open-source designs.

At the level of SMEs, UNICEF engaged several private companies in the project with variety of backgrounds: manufacturers, suppliers, contractors, and service providers (e.g. labs). SME engagement was primarily for implementing the DEWATS as designed by UNICEF, or for providing expert advice on systems performance and potential for local manufacturing and scale up plans through prefabrication of DEWATS. Some SMEs got more invested by adopting DEWATS designs and developing their own learning curves in the course of the project.

Overall, there was no clear framework on PPP developed as part of the STDP, and an iterative process was taken. This has meant that a good effort was taken on the part of UNICEF to build relationships, and involve SMEs in advancing innovations. The process has meant that a "loose and informal" way of working was taken, relying on relationships and in hopes of interest that would be developed for SMEs to collaborate.

SMEs were generally either service providers (including considering desludgers, although informal) or manufacturers (described in the finding above), and expressed high interest with the product development as well as in manufacturing or further developing businesses with some active engagement and even proposing innovative tweaks. UNICEF released the precision design as open-source, so that SMEs could take advantage of the R&D process and build on the progress.

Other SMEs were already manufacturing similar tanks and sized systems of the conventional types, which they still believed "would be more efficient". Still, those SMEs got interested mostly in the low energy attributes of the DEWATS that can prove to be efficient in the current crisis context of the country. Additional collaborations included labs, and a semi-autonomous public institute LARI that worked on testing how bacteria can be involved in water treatment and culturing inoculums.

Positively, there are some signs that an SME is now building on the innovation process and is now experimenting with wind power instead of solar, for instance. This will be useful as the solar panels are the subject of theft.

3.3 Effectiveness

EQ4. *To what extent was the intervention successful in implementing effective, financially feasible and innovative technological solutions to treat wastewater in emergency context?*
EQ5. *To what extent was the project able to build institutional knowledge and strengthen the capacity of stakeholders to improve global humanitarian responses in similar emergency context? What are the lessons learned in the process?*
EQ6. *Did project activities show signs of creating unintended positive or negative outcomes? If yes, which activities contribute to this?*

The technical assessment of the 13 sites has shown that the selected technologies demonstrate good performance as per international design standard and guidelines[20], with an average of 90% treatment efficacy of organics in Batch 3.[21] The systems are doing exceptionally well in terms of removal of organic pollutants. Further, the systems can be considered robust with 79% of the systems actively treating wastewater (to various degrees).[22] Keeping functionality stable and reaching tertiary level treatment remained challenging, however continuous refinement was still in progress at time of evaluation.

This finding summarizes the key findings of the technical assessment of 13 sites containing 16 DEWATS installed systems selected based on criteria described in the methodology and cross compared with other information gathered by other methods and from project reports. The evaluation finds that the effective transition of the technology (DEWATS) where newer systems demonstrated better performance than older ones which was in line with what was mentioned in the efficiency results shared by UNICEF.

In terms of the technical/ process findings the intervention delivered:

[20] e.g. BORDA15
[21] This pertains to the organic contaminants of water – the main target for treatment
[22] Defined by having some form of active treatment, not necessarily high-functioning or high level of contaminant removal. Systems that are in basic operation. Vandalism is huge impact on functioning of systems, and was not factored in.

1. High removal rates, 65-95% of BOD_5 and COD were observed over all three Batches, indicating excellent performance within DEWATS standards. The final design systems didn't possess any disinfection element.
2. Metal elements of the units were in a poor condition. Most locks for the systems were corroded (and had to be pried open to access the chambers) due to low quality and prolonged exposure to the elements.
3. BAF and sometimes AWs were exhibiting foaming.
4. Dissolved Oxygen (DO) levels measured in the BAFs of 3 systems were lower than the desired value.
5. The reduction of nitrogen was observed in systems without aerobic chambers.
6. Some systems exhibited an increase in effluent turbidity.
7. Some biological aerated filters in most sites were exhibiting foaming issues typical of low nitrification or perhaps influent overload.
8. Malfunctioning of tipping buckets.
9. Tertiary treatment units (slow sand filters and constructed wetlands) were not performing to the desired levels in most of the visited sites due to problems such as:
    a. Uneven distribution of wastewater due to Malfunctioning tipping buckets (due to corrosion).
    b. Use of sand with incompatible characteristics.
    c. Inappropriate scrubbing of the surface layer.
10. Effluent COD, TN, and TP, although within the DEWATS expected range, were still above the National wastewater discharge environmental limit values in some sites.
11. None of the systems exhibited significant odor problems.

In terms of the operational/ management findings:

1. Out of 13 sites assessed on field, 2 were inoculated.
2. The systems were not being routinely tested except for 2 sites.
3. Effluent reuse was not applied to most systems due to availability of irrigation water and possible cultural barriers, even though irrigation from the highly polluted Litani River as well as sewage outlets is a common practice.
4. Occasional blockages were occurring due to solid waste being improperly disposed of into the network by the refugees.
5. Fencing was not always sufficient to provide the recommended safety for the system or IS inhabitants.

Technical assessment by the evaluation team showed that the selected technologies demonstrated good performance as per international design standards and guidelines (e.g., BORDA[23]). Treatment efficiency is relatively high in functional systems, ranging between 70 to 90% on average, and in some achieving around 95% removal rates of BOD_5 and COD as was observed in the newer systems of Batch 3. Such compliance was not apparently affected by variations in strength and/or fluctuations in the number of users as is the norm in IS context, a testimony to the systems' robustness.

The majority of the installed systems from the three batches were operational (46 out of 58 systems or 79%)[24] at the time of the evaluation, according to IPs, and many have remained so. The highest success rate is in Batch 3 (100% with minor problems reported on two sites), noting that these systems were relatively new, installed several months before the evaluation and their status may change by the end of the project. The lowest success rate was recorded at Batch 2, where only 40% of the installed systems were still operational. However, it is important that Batch

[23] Namely for ABR and AnF

[24] 2 systems installed by a local SME with funding from another donor are included in this list.

2 systems were disconnected due to external factors and not their technical malfunctioning. The reasons mostly relate to:

(i) Eviction of IS (2 systems)
(ii) Problems with landlord or intentional disconnection of the system by a third party (4 systems),
(iii) Theft and vandalism (4 systems),
(iv) Other reasons (3 systems, of which 2 Mrüna systems funded by another donor).

Batch 1	Batch 2	Batch 3
73% operational	40% operational	100% operational (Few issues in couple of systems)

According to a rapid performance assessment, the majority of the 16 evaluated systems demonstrated good performance according to DEWATS standards, high chemical oxygen demand (COD) and biological oxygen demand (BOD_5) removal rate ranging between 65-95%, indicating expected success from similar DEWATS track records found in literature. The systems produced an average effluent COD of 218.45mg/l in Batch 3 which reflected an average 91% treatment efficiency. It was observed that the tertiary treatment has not fully matured yet.

To assess robustness of the systems, a worst case and best-case design validation exercise was performed to test if the base components (ABR+ AnF) can handle load variability. The systems, as they are designed, can handle the incoming loads (TA Report , Annex 1).The treatment chains evolved throughout the three batches of the process where inadequate technologies, such as the trickling filter and UV, were wisely discontinued from consideration, and technologies that proved to be more feasible (treatment efficiency vs. power efficiency) and less prone to theft or vandalism were promoted to the final design chain options (such as the BAF and SSF).

There are some effectiveness issues in certain contexts. One respondent noted that all systems installed in the Bekaa Valley initially suffered from the Bekaa's high water table, which meant that the empirical experience of topography and water had another dimension to it, hence the better performance of Batch 3 systems. In Batch 3, the process was effective in achieving the objective of testing improved designs. The water table was not a factor in Batch 3, because all systems were now underground to reduce energy cost. The presence of land with agricultural status was not a major factor, and only one partner added a pump-facilitated soak-away pit after tertiary treatment to discharge the water away from saturated soil layers.

The evaluation team notes that there is now a precision design for the treatment and mould design is now being completed. This will impact on removal of COD and BOD and other parameters.

The experimental approach to the programme – which includes the selection, design and contextualization is found to be very good (a strength of the programme). This aspect has been enhanced by an adaptive/iterative approach where learning is input through successive batches. Despite this, better integration of criteria in Batch 3 could have been applied given the complex problems on the ground that were encountered.

The iterative nature of the experimentation was necessary (from Batch 1 to 3) in solution development to reach a model that was context-relevant, low-energy, mobile, and not prone to theft or vandalism. Both UNICEF and IPs respondents emphasized the fact that the design maturation and improvement in treatment efficiency of the technology followed an evidence-based process. The project was divided into three batches where each batch advanced the technology

of the solutions. For instance, solar panels are being used to mitigate the problems of supply and demand of electricity. The move from opportunity identification to development and testing and into ready DFM was relatively a robust process that overcame many inherent and emerging complexities.

The technology suitably adapted to suit the size, location, and implementation to be relevant to the communities. It achieved the installation of innovative technology that is non-permanent infrastructure in line with the Lebanese government policies that is able to reduce the load of wastewater generated by the refugees. The design of the technology took into consideration many contextual factors including the type of land, available space at the site, environment status of the water in the vicinity of the sites, water table, characterization of the wastewater generated, and the size of the population at the site. An example of design adaptability at the innovation level is presented in the site *Majdal Anjar- 008***,** where a prototype of modular DEWATS systems was developed to serve small groups with equal number of tents. UNICEF was aiming to eventually standardize several concept designs in terms of size and material for the sake of better stackability, practicality and rapidity in installation, and eventually reduced costs at economy of scale. During the time of the evaluation and write-up of this report, SMEs were already applying for tenders to produce molds for the established designs of pre-fab systems.

UNICEF and IPs stated that the turning point of the process was the workshop organized by UNICEF and supported by UPM, in which participants assessed the performance of Batches 1 and 2 technologies through integrating an expansive sampling campaign and expert and local insights using a weighting matrix. All IPs agreed that the solution development went through different phases where designs were set, experimented with, then adopted, was successful. Three batches of systems were designed and piloted where designs of each batch informed the enhancement of the one following it until unified designs were reached. The designs were therefore available for validation and sites were selected for the testing of these specific designs.

IPs were generally satisfied with the innovation process, yet some challenges with efficiency were reported. Despite the positive design approach to integrate learning, the insufficient integration of some contextual criteria in the selection of Batch 2 and Batch 3 systems (i.e. related to the use of components and materials susceptible to theft) may serve as an indicator that the learning from the partners' experience was effectively captured but not systematically applied on time. The main constraint was presented by the infrequent testing of the installed systems, which delayed the identification of problems and the necessary adaptations. Several IPs mentioned that filter media[25] technologies failed to deliver in such a setting, given the high concentration of wastewater from ISs, and was too large in footprint. Other constraints noted has been the options developed for the tertiary treatment (e.g. UV treatment), and the limited support for alternative energy supply beyond solar panels. The impact of theft (described in further detail below) has also impacted on these considerations as the energy infrastructure (solar panels) were often debilitated by theft.

Quotations demonstrating the iterative design process:

"The project itself is an innovation, it is a learning process of experimentation to reach a model that can be standardized and that was achieved through this project" - Implementing Partner

"They tried many options in Batch 2 and Batch 3, in B3 there were significant changes in the project, we got to a very solid prototype that has needed no maintenance for more than six months now, and in fact the tests done at WW lab have been producing good results." – IP

[25] Using BioRock

Institutional knowledge and capacity of local stakeholders were built, and lessons are being captured that are relevant for global humanitarian response.

Although some implementing partners were not so familiar with DEWATS, others had substantial experience in decentralized wastewater treatment generally and in the Bekaa specifically, and UNICEF bridged a wealth of contextual and technical insights which helped build capacities and standards. In addition, the engagement of specialized international experts (UPM / BORDA as well as external healthy experiential feedback with similar active projects[26], and valuable and innovative exchanges took place. This conducive atmosphere supported the customization and refinement of DEWATS with localized innovative improvements integrating local NGOs and CSOs knowledge and promoting relevant capacity build-up. Others confirmed receiving sufficient training, guidance and are already handling own and future responsibilities with no worry aside from the aspect of funds maintained for the purpose.

The current expansion from four to eight NGO IPs was driven by the localization agenda, and the commitment of UN agencies to contribute to the localization of humanitarian aid. Whilst newly contracted national NGOs recruited qualified staff, they continued to face three main challenges:

- The systems of national or local NGOs are generally weaker compared to INGOs, and procurement, MEL and financial management may not be as robust and transparent as they should be, affecting overall performance.
- Capacities for innovation at national NGOs are more restricted due to the smaller number of technical staff and limited experience with such processes.
- Organizational culture in some national NGOs is fairly hierarchical and less conducive to reflective processes and sharing challenges and limitations with partners and donors.

Despite this, knowledge sharing and learning has been enhanced throughout the process. The UNICEF team has continuously planned for and furthered plans to share lessons with the Global WASH Cluster, UNICEF Supply Division and other relevant learning forums.

The SDTP has seen the emergence of major unintended negative (issues with landlords and theft) and some hints of positive (potential reuse of wastewater for irrigation) consequences.

The largest unintended negative consequence of the SDTP has been the materialization of theft and community discord as a result of introducing a valuable infrastructure asset into host communities. Although the evaluation team sees that these issues are typical of those represented in complex emergencies and where governance/economic crises are faced, more could have been done to address these serious community level problems that emerged. This includes potentially, working with community leaders, and directly with landlords and municipalities from the early stages of design.

A high degree of unexpected difficulties that were faced in obtaining approval from landlords due to their concern about pipes being laid on the land in Batches 1 and 2 (report profile Batch 3). Reports mentioning how "*solar panels being abused by some landlords to power their own households*" for active systems. The crisis gave justifications for unsolicited behaviors, theft and vandalism which were reported from field interviews, direct observations, and KIIs in the evaluation study. A worst case scenario understood (but not necessarily fully realized) was that

[26] For e.g., Mercy Corps had an active BMGF contract and was collaborative.

the installation of the system would have an indirect ramification on the security of the refugees; the presence of the system (especially if fabricated from attractive material) would encourage some landlords to forcefully evict the settlers to sell the system as reported by UNICEF, IPS, and community stakeholders.

Members of the host community issued concerns related to the devaluation of the lands following the installation of the systems, extending not only to the assets where the DEWATS were installed but also to the neighboring plots. Some landlords were interested in financial gains wanted to evict the refugees residing in their lands for the sake of taking possession of the systems, dismantling them and/or selling their items.

The MDC amplified disruptive challenges (such as the landlord challenge) which UNICEF tried diligently, and to a good extent, successfully to circumvent as reflected by most partners. However, project delays and lack of responsiveness at the early stages of the project or systematic follow-up even from IPs became the norm during the rough phases, not to mention other stack ups including COVID epidemics.

Furthermore, the crisis also led to variations in the designs and implementation of the systems to cope with the increased cost and reduced availability of electricity. The discarding of Trickling Filters for less power-hungry systems such as the BAF, although they did show some good results in the first batches, and the decision to limit systems towards underground installations (which incurred more costs and more considerations for water table), and replacing power-intensive systems such as the trickling filter as triangulated from the KIIs, Field Assessments and progress reports.

A range of other unintended consequences resulted from the introduction of the WWTPs throughout implementation, for instance on energy use, as summarized by an SME:

"…. There's also the problem that when the power generated by the solar system is not used by the end of the day, the users tend to use it within their household, which paralyses the WW treatment system itself." - *SME (Manufacturer)*

An unintended positive consequence (although limited and unconfirmed) has been reports of reuse of wastewater from the DEWATS in agriculture. Technical assessment and field observations found that one camp from the older batches (Kamed El-Lawz) used effluent water for irrigation, in addition to one camp from Batch 3 (Ouadi El-Jamous). It was noted from the technical assessment that the effluents produced by the systems are adequate to be discharged into sewer networks and are therefore safe for WWTP handling.

There are also emerging reports of the impact on potentially less desludging needed on the informal sector, with likely unintended negative consequences to be experienced by some groups (i.e. those that economically benefit form desludging activities) and unintended positive consequences for other (i.e. communities/beneficiaries and IPs and donors that pay for desludging). The nature of this consequence has been difficult to understand, with a wider analysis of the interrelationships between communities, informal SMEs and other groups is needed.

3.4 Sustainability and Barrier to Scale

EQ7. *To what extent are the implemented solutions likely to remain operational following the closure of the project? What are the conditions to maintain their sustainability?*

Given the worsening multi-dimensional crisis in Lebanon, sustainability is subject to factors outside the scope of the STDP and cannot be expected with typical activities and outcomes. The risk of vandalism is negatively impacting on sustainability.

Further to ownership issue, the Lebanese wastewater sector and its management on the national scale (after decades of neglect) in jeopardy and at risk of re-collapsing, with public funds dried up even to sustain the operations of the already faltering centralized treatment plants. With the lack of capacity and the political will to focus away from the immediate impacts of the financial crisis, decision makers in this sector are in a state of paralysis:

> *"There are very limited capacities in the ministry at the moment. From a financing perspective, [this capacity] is very low. Most public institutions are in this situation" - MoEW*

The existing barriers to promoting PPP for innovation in the water sector have been exacerbated by the economic and political crises, and effective capacitating of state institutions to enter framework partnerships with SMEs and facilitate the update of DEWATS is going to be a long-term process. The unexpected theft and problems with landlords further adds to barriers. Nonetheless, UNICEF's momentum has geared up potential collaborations between humanitarian and development actors on the one hand and SMEs on the other, instigating potential for developing local market for DEWATS with evidence-based success stories, as well as open-source designs, capacity building, and information sharing.

Positively for sustainability, the refinements that are being discussed rely almost completely on low-input design aspects, and passive systems are being explored. These include the use of solar (or wind) power, as current market power deficiencies have allowed for power friendly green technologies to flourish (for example, photovoltaic). Similar fate can await the DEWATS since:

- Systems minimize power requirements by relying as much as possible on anaerobic systems that do not require power, and by operating the systems by gravity to minimize pumping requirements[27]
- The minimized power needs are provided to the systems by on-site solar panels which negate the need for municipal electricity[28]

Quotations demonstrating innovation and will to continue despite barriers:

"In Batch 2 we were using electricity (we installed solar panels), in B3 we were using 3.5 KW for four systems around 400 Watt per system. So, we lowered the energy intensity, and now we are heading for completely passive[29] systems. This year we got a new site (from ACF 804), two systems by gravity, despite the site being flatland. Certainly, we have problems, but these problems need little maintenance. I would say that in 90% of sites, a completely (autonomous) system would be applicable." - Implementing Partner

[27] Field observations; Design documents; UCKII; TA; Tech. KII
[28] Field observations; PR2; UCKII; TA; Tech. KII
[29] Here the IP meant to say Passive as in not requiring external energy input. Difaf confirmed this with respondent.

There is evidence that partnerships now operate beyond UNICEF's involvement, although some partnerships may not continue supporting the SDTP. The programme is not yet recovering costs, and donor funds will likely be needed, partially because an O&M system is not fully realized.

Furthermore, it was mentioned that some concerned Ministries were not involved from the start such as the Ministry of Environment, while the MoEW has been the go-to collaborating partner from the government side. Although this is understandable given the projects "Piloting" nature on the one hand, and UNICEF's leading role in developing various aspects of the water sector in Lebanon on the other, and given the public sector deflating roles in the current crisis, UNICEF's commitment to strive towards reaching ELV's through DEWATS is not an easy feat as a main project objective in the eyes of the donor.

The Evaluation Team has conducted further clarifications with the MoE in order to gauge their feedback on this matter, and the MoE replied with the following: "*if any wastewater is thrown in the environment, maintaining ELVs is a necessary requirement for any project regardless. however since it is a piloting project under the close look out of the MoEW, and given the transient nature of an informal humanitarian context, and since we have not been officially involved from the start, we cannot force UNICEF at this late stage to go for IEEs / EIAs, nor disrupt the good impact of the project which has and may have good impact on the environment*". Given the lack of an alternative suggestion, the MoE is allowing for a grace period currently, "*if UNICEF maintains a promise not to make these systems permanent, and a strive to reach better results that satisfy ELV standards*". On the government side, the MoEW is communicating some scepticism on this process, and maintains a "looking forward to see how all this will unfold" attitude.

Some IPs mentioned there is no clear exit strategy yet. Although UNICEF confirmed the intention to completely withdraw after a certain point, it asserts that this hand-over will not be instantaneous but a rather gradual phasing out, and claimed to still be committed to maintain technical backstopping and oversight on operating and maintenance required by IPs for DEWATS in place. UNICEF also mentioned clearly that the exit strategy shall aim at decreasing the spread out through involving fewer IPs and personnel on the ground hence lessening expenditures and inefficiencies down the line. This will also allow for more centralization of data and information for more efficient management and troubleshooting of the DEWATS, and which also justifies the piloting of IoT sensors to monitor their performances.

According to UNICEF, ideally, the facility should belong to the refugees and should eventually be operated by them. However, currently the main tasks for all O&M measures are being delegated t to respective site IPs, who in turn are either hiring and training technicians for this purpose or considering subcontracting private firms for this purpose. Such solution seems to be simmering in the WASH sector meetings.

It would appear that IPs have managed to move from a phase where they coordinate through the unique intermediacy of UNICEF and towards one where they exchange knowledge directly through meetings and a WhatsApp group created particularly to facilitate communication amongst the IPs. The bilateral relations between IPs are thus starting to materialize beyond UNICEF's intermediacy.

IPs are also showing initiative to resolve new problems as they arise. In-house sampling was done by several partners, which allows for better adaptation of the working conditions of the systems should problems arise allowed for quicker fixes compared to others. According to some partners, directions were not always received in a timely manner, especially when the team was facing challenges related to the context, such as theft or vandalism.

There is some minimal evidence that communities will sustain some aspects. Local communities are only involved in maintenance through representatives and quite minimally for safety reasons, and possibly, for avoiding further unnecessary tensions with respective landlords. Through the Shawish, Community Mobilizers and WASH Committees, their engagement is currently limited to watch over, light maintenance and operations, and issue reporting to IPs. Until the time of the evaluation, UNICEF was also still directly intervening in technical troubleshooting and resolving emerging issues when claims have not been addressed by the IP for a reason or the other.

The main bottleneck identified on this level is that there is no budget specified for maintenance and operations, but only for installation of DEWATS. Some IPs already took initiative and created SOPs for basic operations and maintenance procedures and communicated them with UNICEF for review and approval, while others prepared a maintenance checklist that is currently being used by their technical team and "*that will be handed over eventually to community mobilisers". Some SMEs who were contracted for implementation readily provided what they referred to as "guidebook for system operation*" to the IP concerned, but it is uncertain if this book was useful as their specific system has been disconnected.

Most IPs mentioned the useful and developing role of identified Community Mobilizers for the current and future O&M of the systems, and few already confirmed having mobilisers undergone technical trainings mainly for "*in light maintenance for latrines*" and basic fixes and operations (turning on solar power, preventing anyone from entering site). However, such mobilizers are still limited to being only responsible for security and/or reporting system checks or incidents.

Some of the IPs also mentioned the potential of using WASH committees for "*hand-over of operations provided that [they] provide them with budget (…) because one blocked pipe can seriously hinder the entire system*." UNICEF agrees to this possibility mentioning that the partial operation of the systems can be handed over to the WASH committees on the condition of financial support by IPs, "however, IPs/private companies would still need to intervene in maintenance since the issue is sensitive."

Most of the respondents have identified the presence of IS in private lands and at the mercy of the landlord as the most singled-out deal breaker for any system's success at any site. Since it is implemented on private lands, acceptance of both landlord and users is a critical precondition for success, and IPs have gained the acceptance of the latter through community engagement, awareness campaigns and trainings. However, at the local level of the landowners of the plots which are rented to refugees, the approval for the system installation was a critical precondition and post condition for the systems to be piloted and eventually sustaining functionality.

The policy framework on the refugee crisis does not directly assign responsibility for the management of ISs to any institution, and thus leaves wastewater management at the camps dependent on donor funding. Institutions responsible for water and wastewater management, whether local authorities (i.e. municipalities) or central government (i.e. MoEW) and the regional water authorities, do not consider themselves responsible for neither management, nor regulation and oversight of ISs.

However, the context of ISs in Lebanon offers a unique opportunity for the development of new conducive frameworks in a context of a decentralized wastewater management and regulation. Furthermore, Lebanon's "weak state" coincides with a relatively sophisticated labor force which is technically apt and receptive to adopt environmentally sound and innovative solutions. As it has been experienced with new policies being developed that address critical environmental issues (eg. Hospital and hazardous waste), NGOs and large donor funded projects have precipitated the

formulation of guidelines and standards which ultimately were adopted by the government and translated into legislation.

Open systematic communications have led to improved institutional knowledge, which will extend beyond completion of SDTP.

Systemic knowledge sharing has taken place through round table discussions involving sector partners government (namely MoEW), private sector suppliers or implementers, were maintained as routinely as possible, with regular minutes and accessible documentations and valuable information being made available post-sessions. Finalized design drawings were developed and made open-source, accessible to anyone who would like to develop or adopt the designs or use them for research and development, educational purposes, etc.

The open channel communication has contributed to the emergence of a conducive and creative environment for the exchange of experience in the design process. More specifically, the project's innovative edge created healthy competition which encouraged the collaborative exploration of previously uncharted (technological) territories.

As of 2022 UNICEF utilized the remaining funds to share its findings with the Ministry of Energy and Water and the Ministry of Environment for endorsing the final technical solution and complete the Precision Design report informing the DFM report for the production of molds for further production in the country.

Quotations demonstrating improved interest and capacity:

"Results and discussions disseminated, created a new momentum in the market, created new material for courses in academia, knowledge acquisition for civil society, and this was further established by publishing final system designs as open-source for anyone to use". – IP

"[The opportunities to use this project to build capacity for innovation have been] tremendous, because you've forced IPs to look for things apart than metal, so they went to other suppliers and technologies, 3D printing. You've forced engineers to investigate into fiberglass, see what the treatment steps are, what works for irrigation, sanitation and water quality engineering." – UNICEF

"..there's opportunity to strengthen the water establishments is to have a private company to take the responsibility of the systems and then to hand over to the water establishments when they acquire the capacity to handle them on their own, keeping in mind that the WEs have lost a lot of employees or are coming at a part-time basis. The other part is in terms of the WE, where for now, we will have a private firm taking over the process of monitoring and operations for a year whilst building the capacities of the WE team." - MoEW

3.5 Gender

EQ8. To what extent has this initiative's design and implementation taken gender into consideration?

The project design made no clear reference to gender considerations and did not establish gender related indicators, although some women's participation in the programme was noted. This can partly be explained by the low interactive element of DEWATS.

On a less direct level, with respect to Gender, and although STDP's project documents made no reference of gender and establish no gender related indicators. Based on document review and primary data collection, it can be concluded that the project had some impact on women's rights and gender equality, although this was not clearly foreseen in the design. The primary reason is in the nature of the innovation in wastewater treatment technologies, which have no interactive element and which, according to KIIs, did not require change in hygiene practices. This is because the innovation in wastewater treatment technologies is in the user backend and thus has no interactive element with the latrine users. As such, the innovation, according to KIIs, did not require change in hygiene practices. It should be noted however that women's access to sanitation, safety, and participation were taken into consideration in the implementation of STDP.

Despite this, women reported improved health and sanitary conditions, and some FGD participants remarked that the improvements were better experienced by women, who are traditionally tasked with cleaning and had therefore been more vulnerable to contamination before the intervention, when latrines used to flood frequently. Women were also found to be engaged in community consultations and in WASH committees in some ISs – depending on the intervention strategy of individual IPs. They were informed about the systems and involved in awareness sessions on sanitary and hygiene practices.

Women were also included in monitoring, and according to one IP that conducted gender disaggregated FGDs, the results from the men's and women's groups were identical, which led the organization to conducting mixed FGDs in later stages.

"We took into consideration gender aspects, for example making the water points and latrines not far from dwelling to minimize sexual exploitation, latrines have locks and lights to provide a level of safety" – Implementing Partner

"Females and children used to have the highest exposure because women are the ones who were supposed to clean after the flood occurs and they were the ones to accompany their children to the bathrooms when they are flooded to ensure they don't touch any contaminated surface." – FGD

Despite a poor gender inclusion, minor benefits to women and children resulting from the programme were noted.

Women's access to sanitation, safety, and participation were tangentially influenced in some areas of implementation. Some positive aspects noted by the evaluation team include:

- In some sites, the installation of DEWATs was accompanied with rehabilitation of latrines, including improved lighting. In these settings, women reported in FGDs that they felt safer using the facilities.
- Women reported improved health and sanitary conditions, and some FGD participants remarked that the improvements were better felt by women, who are traditionally responsible for cleaning and had therefore been more vulnerable to contamination before the intervention,

when latrines used to flood frequently. Additionally, women reported they did not have to ration the use of water, once the new systems eliminated the risks of flooding. The latter change, however, has recently been reversed with reduced access to water in ISs during the summer months, which has also affected host communities in many parts of the country.

- Women were engaged in community consultations and in WASH committees in some ISs (depending on the intervention strategy of individual IPs). They were informed about the systems and engaged in awareness sessions on sanitary and hygiene practices, yet the limited consideration of gender in the design did not allow for specific contribution to transforming gender power dynamics.
- Women were included in monitoring, and according to one IP that conducted gender disaggregated FGDs, the results from the men's and women's groups were identical, which led the organization to conducting mixed FGDs in later stages. The reason for these results is in the nature of the installed systems, being underground and not affecting the users directly.
- IPs maintained that in all their project activities on IS grounds they guaranteed the involvement of 50 % females.
- The Female Shawish of Tell El Abbas el Charqui Camp presented an exemplary case of women's leadership.

4.0 CONCLUSIONS

The STDP has made commendable achievements in establishing and refining an innovative technological solution to treat wastewater generated by and discharged from informal settlements (IS) in Lebanon. The programme is especially commendable given the timeframe of the programme and the deepening challenges faced in the operating environment resulting from the political and economic crisis. The STDP has successfully developed a WWT option that is appropriate for the complex emergency, meeting the needs of both refugee and host communities; and has been developed collectively by a wide range of stakeholders for refining and advancing. It has been successful in establishing proof of concept. The DEWATS can be further scaled up given the lessons and findings described. Should an honest representation of lessons (successes and challenges) be distilled and promoted globally, the case can serve as a prime example of the challenges and successes in implementing a humanitarian-nexus approach.

The evaluation team finds that there is an evident potential to decrease desludging frequency in ISs, based on data from IPs and analysis of bacteria growth. Improved sanitary conditions in sites where sanitary problems existed prior to the intervention are noted. Technologies were suitably designed as low-maintenance (especially the low-energy ones), and efforts are underway to put a system of sensor monitoring in place. In the absence of a policy regulating the ISs however, the systems will continue to require routine check-ups and maintenance by the IPs.

The project has successfully piloted a technology in one host community in Akkar, where the users' buy-in and the interest by the municipality to replicate such systems have been notable. The project could not respond to similar needs in host communities living next to ISs in the Bekaa, which, similar to the ISs, use septic tanks and pay for desludging.

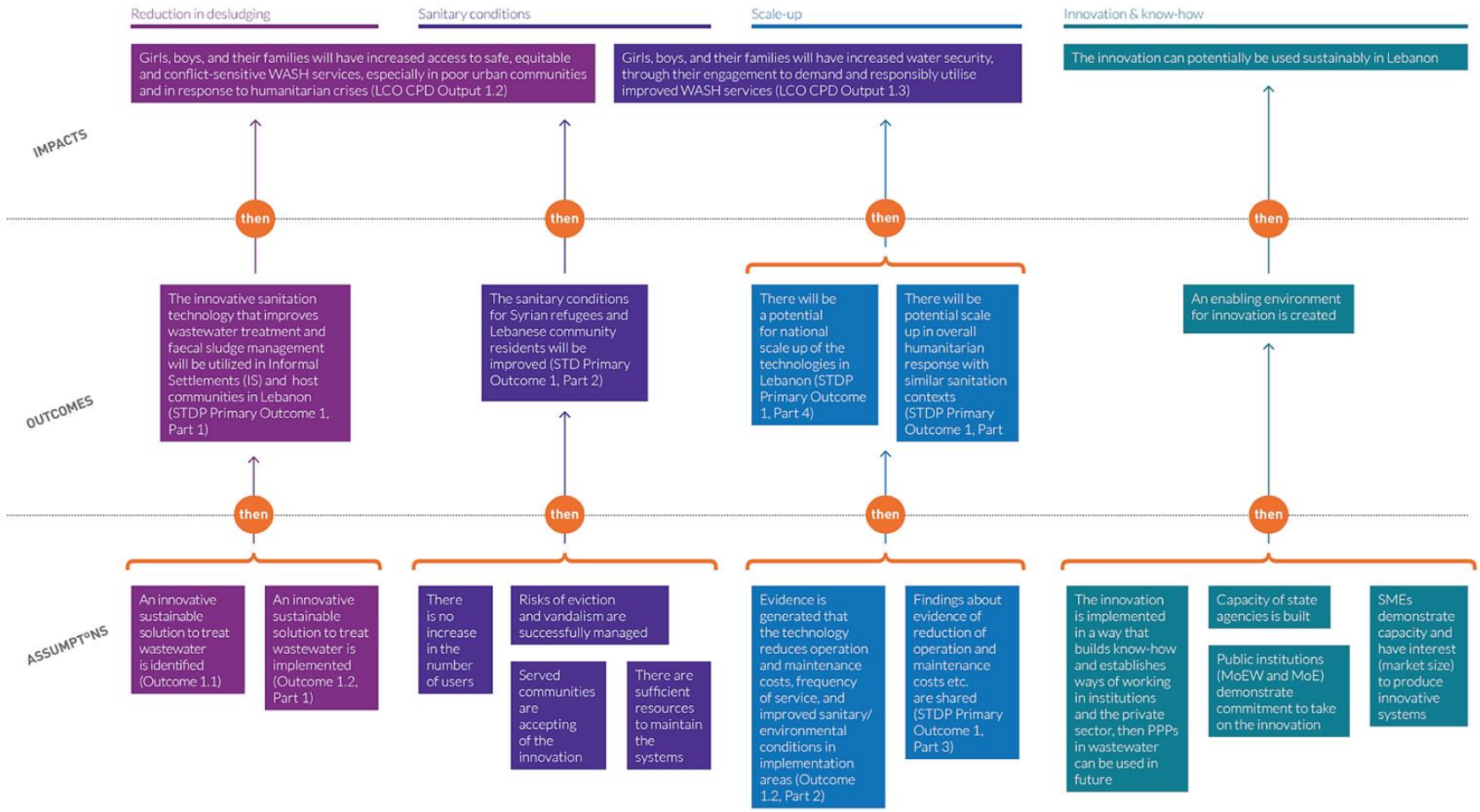
The evaluation team finds that of the three outcomes of the STDP, two have been met and one outcome has been partially met. The two outcomes met include:

- Innovative sanitation technology that improved wastewater treatment and fecal sludge management was utilized in informal settlements targeted by the project and in one host community;
- The sanitary conditions for the targeted Syrian refugees and Lebanese host communities have improved as a result of the technology, in areas where sanitation problems existed.

The third immediate outcome: “findings from the use of the technology are shared with relevant national and humanitarian stakeholders” was partially met at the time of the evaluation, and can be fully met by the project’s end with continued monitoring and reporting on the performance of the systems and sharing the results to inform the WASH sector. Both this evaluation and testing that was ongoing at the time of evaluation generate evidence that can inform the WASH sector in Lebanon and broader humanitarian actors working in similar contexts.

The reconstructed Theory of Change (ToC), based on the findings of the evaluation is demonstrated below:

Basic premises of reconstructed ToC – Sanitation Technology Demonstration in Emergency Settings in Lebanon



The following section concludes aspects inherent in the design of the STDP:

Innovation and markets:

The innovation process was fit for purpose and resulted in identifying effective technologies that have the potential to majorly reduce the costs of humanitarian WASH annual operations, namely desludging and hidden environmental and public health costs for both IS and Host communities. design. At the technical level, the innovation process was centered on the use of locally produced technologies, and the engagement of manufacturers who can market successful designs.

At economy of scale, the costs of investments in CAPEX of these DEWATS are expected to be cheaper than the R&D phases, naturally, and more so if produced in mass or bulk quantities. Furthermore, local NGOs and CSOs are also going through their own development and are increasing in technical capacities, and more relevantly with respect to DEWATS and wastewater sector, given the high need and drive present in spite of the layers of challenges. The market, if one is to look beyond the current crisis, was indeed developing fast and expanding, whether in Lebanon or in neighbouring Levant countries.

Additionally, the hybrid role of the SMEs on this project – between partners, suppliers and beneficiaries – provided an interesting example of what could be called an organic partnership. SMEs are generally interested to invest in the business development side of things but also showed interest in manufacturing or even active engagement and even proposing innovative tweaks. Thus the collaboration with the private sector showed an emergent phenomenon contributing to an innovation process in small side projects, whilst also benefiting from the know-how and open-source designs to expand its products and markets, some of which already sold their first system in UAE market based on UNICEF designs.

Perhaps opportunity presents itself on that level with active SMEs or specialized agencies and consultants in the water / environmental field who are also becoming more prominent, which could take part in adopting, commercialization not necessarily for a currently chaotic market locally, but of near by markets. Here one can note that similar side programs such as CEWAS, Waterlution, as well as entrepreneurial platforms such as Berytec and Agritec, Fastforward2030, etc. are indeed keeping innovative momentum alive in support of start-ups on those fields. This not to mention donor programs besides both EU and non-EU related, which are still very much engaged in developing the water sector in Lebanon and mobilizing funds for the same, and many of the new donor programs are now including SMEs as a target in their eligibilities for service and projects bids.

Others were are already manufacturing similar tanks and sized systems, though using more conventional types, which they believed “would be more efficient”. Still those interested most in the low energy attributes that can do will in the current crisis context of the country

Technology:

The evaluation established a high degree of COD removal in Batch 3 systems, with more than 50% of evaluated systems demonstrating 90% removal rate, although this is all indicative due to lack of flow measurements, and the sampling campaign is limited. Enhancing secondary and tertiary treatment through small tweaks can facilitate the compliance with existing standards. Based on analysis of bacteria growth and TSS, there is a strong potential for sludge volume to decrease to an extent that desludging would be required once or twice per year at most.

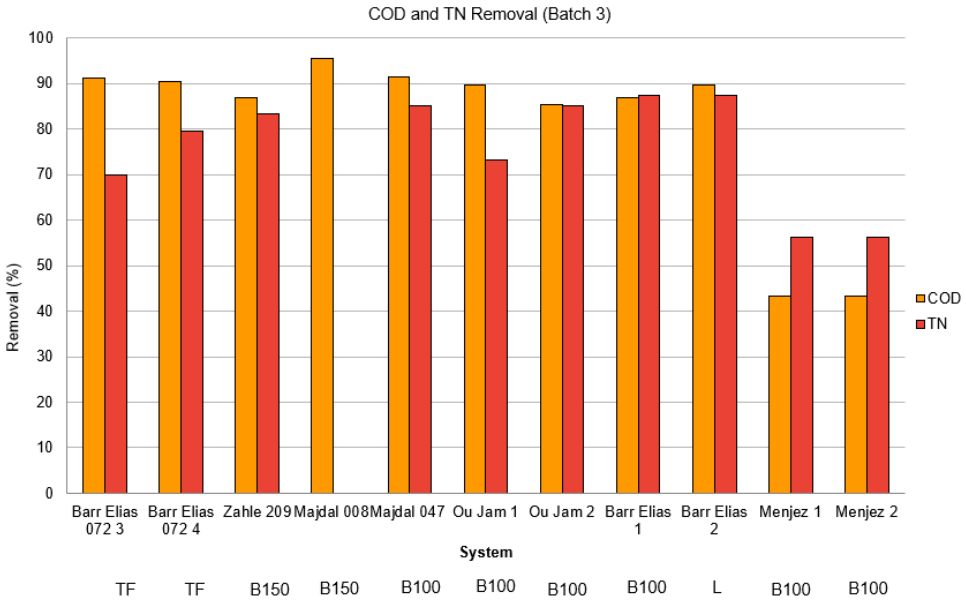


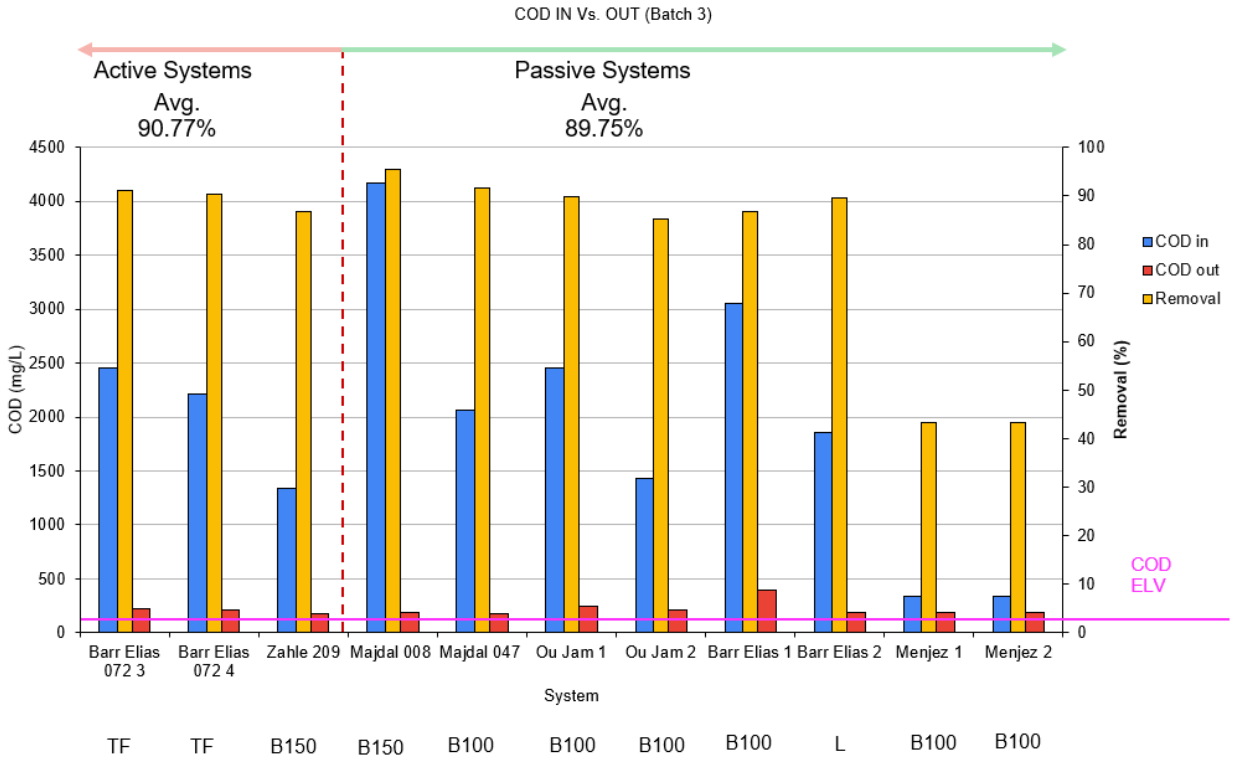
Figure 3:COD and TN Removal Rates

Design adaptations responding to the socio-economic context have been successful. Low energy systems produced similar results for COD removal as high energy systems, which makes the choice of low energy systems relevant and holding potential for scale up. The shift to using materials that are not attractive for resale was also highly relevant to the context and effective (metal was more customizable for treatment, yet susceptible to corrosion and vulnerable to theft). A summary of the results of the technical evaluation has demonstrated the following:

- While most passive and active systems displayed similar treatment efficiencies (mostly high when functional) , active systems, as expected were able to meet more ELVs
- At least one system from each chain passed several critical ELVs
- Aerated wetland has shown some promising TSS removal results
- Aerated wetland has shown some promising TSS removal results
- Tertiary systems must be analyzed for under performance and re-adjusted accordingly
- More attention should be given to high-level technical performance monitoring to draw more conclusive results in terms of causes and improvement.

Technologies were suitably designed as low-maintenance (especially the low-energy ones), and efforts are underway to put in place a system of sensor monitoring. In the absence of a policy regulating the ISs however, the systems will continue to require routine check-ups and maintenance by the IPs.

DEWATS systems, by definition, are rugged and robust systems designed initially for the adoption in communities lacking access to proper sanitation infrastructure, and their designs, development, and though we saw very high treatment efficiencies, they fell short of meeting ELVs as shown in the graph below.



Legend for fixed-bed filter media (for ANF and BAF)

TF	Prefab Trickling Filter Media
B100	Bioblock 100 m2/m3
B150	Bioblock 150 m2/m3
L	LECA

From all the preliminary initial stage analysis[30], although all our calculations prove that the systems are very well designed to handle both loads and variabilities in question, we surmise that this is happening due to the following factors:

1. Source waters are extremely variable: shifting of flows, inconsistent quality and highly variable strengths, no control on inputs, etc., leading to very probable often system-shocks and short-circuiting, or other problems symptoms that were spotted (eg foaming)
2. The management and handling context is extremely variable: projects, self-interests, emerging needs are conflicting, with little control on managing them or negating their negative effects
3. Environmental variability: as temperatures in the Bekaa are characterized for their extreme variability between day and night as well as seasonality.

Flows and temperature variabilities have been identified as main causes behind the faltering of biological systems as per all leading designers and promoters of DEWATS globally.

[30] The inability to reach sufficiently conclusive and technically binding results due to the requirements of lengthier and more detailed performance assessments

However, good governance practices must acknowledge the high positive impact of the current DEWATS on the Lebanese environment and the public health although national standards have not been necessarily met on all levels.

To demonstrate the current and potential impact of the STDP on the environment and public health cost, the Evaluation Team has made a simple calculation with reference to the SOER based on empirical gathered data as well as three levels of treatment efficiencies (worst case vs best case scenarios for analyzed systems):

Givens	*BOD_5 generated by Lebanese =0.06 Kg/cap.d* *BOD_5 generated by Refugees = 0.03 Kg/cap.d*	**Current**	**Projected**
DEWATS INFLUENT	**Host Community PE**	50	200,000
	ITS PE	6,582	98,500
	Total BOD5 generated (Kg/yr)	**73,168**	**5,458,575**
DEWATS EFFLUENT	**% BOD Removal Rate for Functional Systems**	**Removal Potential for 56 Systems (Kg/yr)**	**Removal Potential for All Planned (Kg/yr)**
	Low Treatment Efficiency Rate @ 60 %	**43,901**	**3,275,145**
	Av. Treatment Efficiency Rate @ 75 %	**54,876**	**4,093,931**
	High Treatment Efficiency Rate @ 90 %	**65,851**	**4,912,718**

As per the table above, if all the systems are working at a low treatment efficiency of 60%, around 3000 tons of BOD would be removed. If however the systems are working at a high treatment efficiency of 90%, around 5000 tons of BOD would be removed. As per the SOER, and perhaps as a very rough estimation, the former would roughly cost 0.5 M USD in environmental damage while the latter would cost US $1.6 M in case of no action. For the sake of reference, if the STDP was to cover all its potential market size[31] and assuming a treatment efficiency on 75 % average of all systems operational, this would equate approx. to US $40 M in environmental cost saving in comparison to a state of no-action i.e. no treatment at all. This is a bleak but also a realistic warning approaching current state if one is to consider the amounts incurred globally i.e. including the Lebanese populations, since only around 11 % of all collected wastewater in Lebanon is considered to have been undergoing safe treatment (Karnib,2016), and this figure was pre-crises era; currently, WWTP operations are at almost in complete stall due to high fuel and consumable costs vs. economic meltdown.

If we are to consider only the ISs Syrian populations, then the environmental cost incurred would be in the range of US $3.3 M, out of 7 to 8000 persons live in ISs which discharge directly into water bodies, resulting in around 50,000 USD in environmental damage per year. In terms of technical feasibility, through triangulation of literature reviews, field studies, as well as qualitative feedback, it is the ET conviction that the systems' choice and combination of treatment chains thereof are well selected, designed, developed on evidence-based approaches, developing them into robust options that can be adapted to various circumstances.

Replication:

At the level of intermediate outcomes, the evidence of the technology's effectiveness established in this evaluation as well as the existing capacity of private sector actors to produce the systems locally indicate a potential for national scale-up of the technology, particularly among host communities, where the buy-in and potential for sustainability is

31 As indicated in Inception Report: 200,000 Lebanese (40,000 households) & 98,500 Syrian refugees

higher. The potential scale-up of the technology in overall humanitarian response with similar sanitation contexts could not be assessed, as only limited findings have been shared with humanitarian actors outside of Lebanon (and only internally within UNICEF) at the time of the evaluation. Example of the SME that produced technologies on the project selling similar products in other countries in the Middle East indicates a potential for the systems use in similar contexts.

Potential for replication in Lebanon and other humanitarian contexts can be confirmed based on the final production costs of successful technologies. The analysis confirms a potential for up to 96% decrease in desludging costs, which when analyzed against the costs of technology, demonstrates a potential for uptake by humanitarian actors.

The relevance of STDP owes itself first and foremost to several *raisons d'être*, namely:

- The high financial costs incurred by UNICEF and WASH sector partners to carry out frequent desludging for ISs.
- The dire environmental and health costs incurred of the Business-As-Usual (BAU) (or no action) situation of wastewater treatment for both ISs and host communities, and surrounding area and inhabitants of of target sites
- The particular relevancy of low to energy systems dire need in Lebanon, in a much underdeveloped and now faltering sector, and,

Lastly, and perhaps most importantly, the case for replicability remains closely linked to the potential for sustainability of the systems in ISs outside donor-funded program, which was discussed above. Systems minimize power requirements by relying as much as possible on anaerobic systems that do not require power, and by operating the systems by gravity to minimize pumping requirements. Although willingness of the users to operate the system, willingness to use the effluent for irrigation have been witnessed by many recounts, however, such approvals do not seem to stem from interest in sustaining the operation of the systems or having a cleaner environment for their own lands or community for that matter. To the contrary, problems with landlords are the leading factor for some of the installed systems to become dysfunctional. Problems range from site eviction, through misappropriation of the systems or parts thereof (usually solar panels), to intentional disconnect of the system Therefore, the only main finding by the ET is that there is a common understanding by all stakeholders of the general idea of the exit steps, and that UNICEF is in the process of slow hand over of functional systems to IPs as well as new systems as they mature operationally, and the IPs will eventually hand them down to local NGOs and WASH committees. UNICEF have also succeeded, in collaboration with IPs on some instances, to produce and disseminate SOPs for:

1. O&M of the system
2. Communications & Problem Handling Guidelines
3. Inoculations & Start-up procedures

Concluding statement:

The above conclusions have demonstrated that the STDP has successfully offered ways to turn crisis into an opportunity for both host and IS communities. The development hypothesis of reduced desludging is showing strong signs of being achieved. Indeed, most of the identified barriers may be surpassed making them enablers rather than obstacles if, and within due time, successful project elements are safeguarded and developed, while the contentious elements are clinically addressed as shown in the recommendations section. In this respect, the STDP can prove to be an exemplary illustration where a humanitarian approach can address development issues and contribute to reach sustainable outcomes in the wastewater sector on a national and international levels.

5.0 LESSONS LEARNED

UNICEF has the resources, knowledge and capacity to further refine DEWATS technologies in other similar environments, particularly protracted emergencies where needs for refugees/ displaced people and host communities are high. The following lessons learned were gathered in the process of conducting the evaluation, in discussion with UNICEF, its partners and other stakeholders to the STDP should other similar programmes be implemented:

The social, economic and physical environment conditions must be analyzed in depth as critical enabling factors for DEWATS in protracted emergencies. These conditions must not only inform design, but continuous refinement.

The STDP has characterized technology innovation and demonstration in a complex operating environment. As such, understanding ground conditions has been necessary. Designs must take into account the security and social context. In the context of ISs, low energy systems using materials that are not valuable and easily replaceable are more relevant, and equally effective: COD removal rates of low energy systems are comparable to those of energy requiring DEWATS systems.

Since DEWATS are typically implemented on private lands, acceptance of both landlord and users is a critical precondition for success, and IPs have gained acceptance through community engagement. Other social factors include willingness of the users to operate the system, willingness to use the effluent for irrigation, incidence of crime and vandalism in the area, and inform the implementation (operation plan, securitization of the system).

In terms of physical factors, observed functional DEWATS systems which matured with design efforts fit the topography, accommodate for water table depth, and soil type, to ensure that systems are robust enough for seasonal variations of population served. Topography (the presence of slopes 1%) and soil type, and the availability of a proper location to discharge the effluent are such factors considered in the STDP. The limited access to electricity has been a barrier to the functioning of active systems, and therefore the switch to low energy systems has acted as an enabler of successful operation.

These aspects were a step in the process especially when using a technology that was used in a different context as a basis for the innovation. Technical data such as yearly water flow, temperature curve, ground water table, type of land (agricultural or nor) and soil is needed alongside data on social factors such as land ownership and tenure, use of wastewater for irrigation, ability of users to operate the systems, and safety risks (theft, vandalism) to successfully adapt the designs.

Continued observation has that although only systems in operation were selected for the evaluation visits, certain elements were disconnected and not functional at the time of the study when field visits were conducted for a deeper look. Metal elements in particular were in a poor condition, indicating that other materials were more suitable for the conditions on the sites. This made UNICEF's decision to move away from metal even more valid.

Local manufacturing capacity and strong SME capacity is an enabler for production and potential scale-up. Providing open-source designs was instrumental in igniting SME involvement.

UNICEF is currently supporting efforts to reduce the final production cost of the systems, thereby ensuring there is a potential for these systems to become available and attractive for local use. This has been part of the creation of a DEWATS culture. It has also encouraged

SMEs to develop and test innovative techniques which some of them have exported to other countries.

UNICEF providing designs as open source has been instrumental in furthering the trialing of DEWATS. An SME interviewed verified that they would not have been able to trial ideas had this not taken place, and they were able to "leverage the experience of all consultants, IPs, UNICEF" due to the designs being made available. The SME eventually sold these designs to their counterpart in the UAE, so they effectively cashed in on the R&D that had taken place. Ideas need to iterate, and there is no "one size fits all" solution, therefore the SMEs were able to take advantage of the work done and further possibilities for manufacture.

Cost recovery and replicability is extremely challenging in complex, protracted emergencies. It is also not possible without a clear enabling environment. PPP is seen to be instrumental to ensure long-term sustainability.

In the short to medium term, availability of donor funding and the continuous presence of WASH sector partners is needed for both piloting of the systems and their continued maintenance and oversight. This is despite the fact that there are some clear enablers of replication. For instance,
in host communities, the lack of access to centralized WWT systems, environmental awareness and leadership are enabling factors for scale up. The investment cost of individual DEWATS units is also an enabler, and the ability of local companies to manufacture and install the systems.

Widespread replication is unlikely where there is not a clear provision for some form of recovery of operation and maintenance costs. In protracted emergencies there are many factors running against the possibilities for sustainable operation of the DEWATS, principally the poverty of the users and unpredictability of local markets are a main barrier for cost recovery and thus for financial sustainability. Wastewater management beyond the boundaries of the local neighborhood a public good, and it may therefore be appropriate for the policy to encourage indirect cost recovery, for instance through property taxes or surcharges on the water supply tariffs. It may also result in the provision of facilities and services for which there is no real demand or commitment to operate and maintain them. Although cost effectiveness of the solutions as an alternative to existing wastewater treatment services is another enabling factor, and the shorter the period needed to demonstrate reduction in desludging costs, the higher the likelihood to successfully raise funds for installing DEWATS in ISs.

Promotion of a PPP is seen to be the way to ensure long term sustainability, however existing barriers to promoting PPP for innovation in the water sector have been exacerbated by the economic and political crises, and effective capacitating of state institutions to enter into partnerships with SMEs and facilitate the update of DEWATS is going to be a long-term process. In the short-term, potential collaborations between humanitarian and development actors on the one hand and SMEs on the other, holds potential for supporting local production, and the utilization of open-source products by businesses. However, in the long-term funding for the piloting, testing and follow up on the systems will be needed.

To support innovation of DEWATS and in terms of trailing different processes for its roll-out, partnerships with multiple IPs with clear SOPs have enabled the piloting of technologies in different contexts.

A smaller number of partners and the presence of an external technological expertise (like UPM) have been enablers of the innovation process and capacity building of IPs. Development and enforcement of clear SOPs, regular testing and collaborative problem

solving, and lesson sharing are also enablers of innovation and potential scale up through WASH sector partners.

Working with experienced practitioners has helped to support innovation. Innovation requires the efforts of teams of practitioners, combining experience from different contexts. Fresh graduates may have the technical knowledge but need guidance and support from colleagues with field experience for successful innovation.

Using clear SOPs for all partners, is needed to ensure a unified process is followed. SOPs need to outline all procedures for design, installation, effluent testing, performance monitoring and data sharing.

In addressing some of the complex problems in insecure environments, where assets are brought into communities, forming partnerships with local leaders (municipalities in the case of Menjez) has been instrumental in dealing with problems such as theft.

Based on the case of Menjez, it can be said that the municipalities are prime candidates as the case showed that in host communities, the potential for sustainability is higher, even though MDC is still in effect. The enabling factors for the sustainable operation include:

1. The buy-in of the residents and the municipality, based on awareness of the environmental impact of the lack of treatment and the lack of affordable alternatives
2. The presence of a local leader, in the case of Menjez that being the mayor, who acts as a 'champion' of these technologies
3. The strong *raison d'être* for the installation of such systems, given the tension that untreated water creates with downstream communities; and seeing that the Menjez municipality, like most others, receives very limited assistance, which means that creating a success story could usher in funds from donor agencies.
4. The clearer legal framework surrounding who owns the systems (in comparison with ISs), a more stable institutional arrangement, and the permanent nature of the systems' users.

An iterative approach, collecting frequent monitoring data and regular testing was crucial to further innovation. The 3-batch approach was a success.

In the testing phase of new technologies, frequent testing is necessary for adapting systems and producing successful innovation. Proper and regular sampling, including validation of test results, is important in the innovation process.

The iterative nature of the experimentation was necessary to reach a model that was context-relevant, low-energy, mobile, and not prone to theft or vandalism. Input of learning from Batch 1 (no tertiary treatment) and 2 into the precision model developed in Batch 3, which included discarding poor performing elements was seen to be a success. This process included continuous testing.

Several IPs, for instance, mentioned that some filter media[32] technologies failed to deliver in such a setting, given the high concentration of wastewater from ISs, and were too large in footprint. In the last batch, the SSF was developed for a lower footprint, but the aerated wetland might be taking a bit more space than the SSF. In other words, no ready model was pre-existing, and the selection process is a natural element of the Project.

Through this iterative approach, several technical innovations emerged:

- The tipping bucket (this contraption allowed the distribution of flow without the need for electricity)

[32] Using BioRock

- Introduction of the Biological Aeration Filter (BAF): This unit is not typical for DEWATS chains, its addition helps improve organics and nutrients removal
- Introduction of aerated wetlands (tertiary treatment)
- Solar panels introduced to mitigate the problems of supply and demand of electricity.
- Filter Media try-outs
- Seconded trials from side projects (on the systems) for experimenting with different renewable energy sources (windmills) and or IoT for monitoring purposes
- Tank Material Type in different materials to avoid theft

An open, learning culture of sharing both successes and failures, involving wide stakeholders from IPs to communities, was important to support the innovation process.

Successful innovation requires a culture of transparency and willingness to share challenges and failures with partners and collaboratively seek solutions. Open-source design which promoted knowledge sharing and build-up on adopting such solutions within and outside ISs context helped bring private sector actors into this process. Iteration of Design and Solution Development is to large extent participatory and uncommon in Lebanese context within time-bound wastewater projects and was seen to be highly effective. This creation of an awareness and participatory culture around wastewater will strengthen sustainability in the long term, in the protracted crisis where provision of adequate services will be a long way off.

The STDP has shown that DEWATS is a suitable technological intervention in the transition from humanitarian to development (nexus) work through the Menjez case.

One aspect that sets STDP apart from other comparable projects is the potential that it carried to commit a transition from humanitarian to development work. The case of Menjez shows that this transition is feasible, and the following subsequent STDP phases need to cash on this success.

The Technical Evaluation team has verified that the design was matured (though it is still undergoing continuous improvement) and has notably gained. This was in part gained through the following features:

1. Acceptance by both ISs and host communities.
2. Transferability since the system is a non-permanent installation and may be easily moved as per the requirements set by the MoEW.
3. Efficiency given that the system has proved to be able to treat high strength organic load.

It should however be noted that dealing with the high-water table of the Bekaa in some regions might still be a challenge (as it is the case to all exposed and simple wastewater systems), even though UNICEF has always considered it as a critical factor in the development of the design.

6.0 RECOMMENDATIONS

The following recommendations have been developed by the evaluation team based on careful consideration of the evaluation findings and stakeholder discussions on potential areas for improvement. Overall, the recommendations consider outcome-level improvements focused on **replication, complex operating environment, host-community and technical level-improvements:**

Recommendation 1: Replication

Problem statement: A culture of DEWATS has been activated and based on Batch 3 technologies, DEWATS can progress at full speed. Capacities being built are in progress, awareness is now strong. To enhance sustainability and further-roll out, SOPs and operations should be strengthened.

Detailed recommendations **Lead:** UNICEF **Expected Timeframe:** 3-9 months **Priority:** High-Medium	• Closely monitor the implementation of all systems and enforce a developed sampling and analysis campaign leading to systematic and efficient testing and reporting. Compile evidence and present it in an accessible and transparent fashion for efficient O&M • Perform calculations which can portray cumulative effect of treatment in removal of pollution loads per day from the Lebanese environment and include in communication plans. Results can be shared with all stakeholders as well as the neighboring host communities to counteract perceptions of ISs polluting the environment • Developing and enforcing strict system of documentation and logbooks for all stages (installation, operation, maintenance) and SOPs, with systematic reporting structure • Develop a decision-support matrix taking continuously into consideration such circumstances, namely: Water Table Level (mostly mitigated through first two Batches); Securing minimal energy requirements; meeting standards for treated wastewater end-use; Overcoming Security matters; and securing minimal human and financial resources for O&M. • At the national level, share learning from the process with other sector actors and stakeholders, such as agriculture, shelter and energy • At the global level, write up the good practice points on how UNICEF and partners was able to contextualize the DEWATS (key enabling factors), to communicate through the Global WASH Cluster

Detailed recommendations Lead: **MOEW** Timeframe: **3-9 months** Priority: **High-Medium**	• Develop a marketing/communication strategy can further establish its elements, with particular focus on low energy/low opex features vs high treatment efficiency and protection of the environment.

Recommendation 2: Complex operating environment

Problem statement: The operating environment is highly volatile. Considering current economic crisis (and the increasing risk of humanitarian crisis with the complete faltering of centralized WWTPs) There is a need to further refine the DEWATS innovation.

Detailed recommendations **Lead:** UNICEF **Expected Timeframe:** 3-12 months **Priority:** High	• Consider systems replication in host communities, which can further prepare the grounds for a proper exit strategy in case of changing dynamics in refugees' resettlement or project closure • Set up plans with IPs for the continued maintenance and operation during and after the project closure • Further refining Business Development, although currently challenging with economic situation and prioritization of government, continue collaboration with the private sector both on production and on adaptation to fit available material, yet with close follow-up on reporting • Continued stakeholder engagement with securing government support, as well as secured local ownership plans and approval from main (new stakeholders).

Recommendation 3: Host-community improvements

Problem statement: Aspects of working in host communities present continuous challenges to effectiveness and in scale-up. In ISs, the landlord's approval and good will is required for the installation of DEWATS, as well as the acceptance of the technologies by the refugees and their informal leader (Shawish).

Detailed recommendations **Lead:** UNICEF **Expected Timeframe:** Immediate **Priority:** High	• Identify municipalities where host communities have no access to WWT and where the leadership is supportive of piloting DEWATS and pilot technologies in developmental context, as the conditions there differ from ISs and in no-economic crisis mode, can guarantee sustainability and scale-up systems in societies • To the extent possible, reduce/avoid using attractive material • Consider incorporating landlords into side benefits (service agreement) • Seek support from legal experts about finding mechanisms that would off-setting self-interest that would compromise systems functionality • Due to security risks, the use of low-cost materials reduces risk of theft. Considering that the type of material used did not affect the quality of treatment, use of low-cost materials enables the continuity of system operation.

Detailed recommendations **Lead:** Water Sector and IPs	• Take further actions to establish ownership and community level benefits & acceptance • Ensure that the IS community fully understands the needs of the project to ensure its protection, and to avoid misuse and theft • Continue to establish landlord acceptance of the technology is a critical enabler in ISs, and the presence of trust and regular communication between the implementers and the landlords is

Expected Timeframe: Immediate **Priority:** High	more important than the signed documentation (Memoranda of Understanding), as the latter are not legally binding. • Changes in refugee / host population needs to be monitored as it is another enabling factor that would prevent variations in the influent volume and quality (technological level). (i.e**.,** municipalities, union of municipalities, water establishments, LRA, semi-governmental bodies, water user associations and even perhaps considering farmer cooperatives if waters are going to be reused for irrigation).

Recommendation 4: DEWATS technology.

Problem statement: The DEWATS installed have achieved proof of concept, however further improvements are needed.

Detailed recommendations **Lead:** UNICEF **Expected Timeframe:** 6 months **Priority:** Medium-High	• Improve tertiary systems, which can be essential step to meet ELVs required by MoE • The SOPs need to be refined and standardized regarding: a. Communications and problem handling guidelines b. Inoculations and start up procedures • Develop and establish additional SOPs regarding: a. Deeper systematic technical auditing of the systems for a full picture of the exact performance of each installation. b. A detailed O&M Manual, with complete list of SOPs, including installation, monitoring, troubleshooting, performance evaluations, sampling, validation, and reporting procedures of various sorts, along with templates • A monitoring and evaluation programme needs to be set up with set tools and data gathering guidelines • Legal framework still needs to be developed where different scenarios are developed as to the systems' ownership, the determination of the technical and financial operation responsibility and the solutions in case of systems disconnection, handover etc. • Different effluent standards need to be established for wastewater reuse (i.e., for irrigation) and for discharge into the environment. Social factors for wastewater reuse also need to be better understood. These factors would require different approaches to the design of DEWATS as they would need to meet different effluent standards. • Establish procedures for performance monitoring • Develop an exit strategy for IPs managing the systems, including handing-over requirements • If confirmed by different systems, consideration of additional anaerobic treatment capacity or a whole module for additional nutrient removal if required • Consider adding small irrigation schemes for productive crops (e.g., fruit trees) which would allow for easier reach of nationally accepted standards for re-use in agriculture (FAO), or consider other reuse schemes that would secure some benefit and justification in maintaining the systems by beneficiaries • For the tertiary treatment component prioritize implementation with a smaller number of IPs, and pair this with closer follow-up and

	more regular testing and validation of test resultswould compromise systems functionality

Detailed recommendations **Lead**: MOEW-MOE **Expected Timeframe:** 6 months **Priority:** Medium-High	• Legal framework still needs to be developed where different scenarios are developed as to the systems' ownership, the determination of the technical and financial operation responsibility and the solutions in case of systems disconnection, handover etc**.** • Different effluent standards need to be established for wastewater reuse (i.e.**,** for irrigation) and for discharge into the environment. Social factors for wastewater reuse also need to be better understood. These factors would require different approaches to the design of DEWATS as they would need to meet different effluent standards.

Detailed recommendations **Lead:** WATER SECTOR IPS **Expected Timeframe:** 6 months **Priority:** Medium-High	• Develop an exit strategy for IPs managing the systems, including handing-over requirements • If confirmed by different systems, consideration of additional anaerobic treatment capacity or a whole module for additional nutrient removal if required • Consider adding small irrigation schemes for productive crops (e.g.**,** fruit trees) which would allow for easier reach of nationally accepted standards for re-use in agriculture (FAO), or consider other reuse schemes that would secure some benefit and justification in maintaining the systems by beneficiaries

REFERENCES

Tawfik, M. H., Hoogesteger, J., Elmahdi, A., & Hellegers, P. (2021). Unpacking wastewater reuse arrangements through a new framework: insights from the analysis of Egypt. *Water International*, *46*(4), 605–625. https://doi.org/10.1080/02508060.2021.1921503

Haddaoui, I., & Mateo-Sagasta, J. (2021). A review on occurrence of emerging pollutants in waters of the MENA region. *Environmental Science and Pollution Research*, 28(48), 68090–68110. https://doi.org/10.1007/s11356-021-16558-8

Ait-Mouheb, N., Mayaux, P.-L., Mateo-Sagasta, J., Hartani, T., & Molle, B. (2020). Water reuse: A resource for Mediterranean agriculture. *Water Resources in the Mediterranean Region*. Elsevier Inc. https://doi.org/10.1016/b978-0-12-818086-0.00005-4

Litani River Basin Management Support Program (2013). 1(7).

Ait-Mouheb, N., Mayaux, P.-L., Mateo-Sagasta, J., Hartani, T., & Molle, B. (2020). Water reuse: A resource for Mediterranean agriculture. Water Resources in the Mediterranean Region. Elsevier Inc. https://doi.org/10.1016/b978-0-12-818086-0.00005-4

BORDA. (2016). Technical Specification for Decentralized Wastewater Treatment System (DEWATS). Pp. 1–8.

Betts, A., & Bloom, L. (2014). Humanitarian Innovation: The State of the Art OCHA POLICY AND STUDIES SERIES. November. www.reliefweb.int

Bill and Melinda Gates Foundation. (2015). Water, Sanitation and Hygiene Strategy Overview.

De Jong, M., Marston, N., & Roth, E. (2015). The eight essentials of innovation. McKinsey Quarterly/

Decentralized, P. (2016). Lessons Learnt from Afghanistan, Indonesia, and India. 1–11.

District, S., Governorate, E., & Region, K. (1982). Key facts DEWATS at Abdulrahman School.

Eid-sabbagh, K., Roukoz, S., Nassif, M., Velpuri, N., & Mateo-sagasta, J. (n.d.). Analysis of Water Reuse Potential for Irrigation in Lebanon.

Environmental, M., & Assistance, T. (2005). The Cost of Environmental Degradation (COED) Our health and future at risk?

European Union Parliament. (2019). Technological innovation for humanitarian aid and assistance (Issue May). http://www.europarl.europa.eu/thinktank

Fry, K. G. (2018). Preparing to Be Digital. 78–89. https://doi.org/10.4018/978-1-5225-4059-5.ch005

Gotzenberger, J. (2009). Praxis-Oriented Training Manual DEWATS. 1–119.

Haddaoui, I., & Mateo-Sagasta, J. (2021). A review on occurrence of emerging pollutants in waters of the MENA region. Environmental Science and Pollution Research, 28(48), 68090–68110. https://doi.org/10.1007/s11356-021-16558-8

CDD (2020) Handbook on Operation and Maintenance of Decentralized Wastewater Treatment System (DWWTs).

K. Bonel, M. Wehbi, S. Halabi, 2021, "WaSH Assessment Platform Report", UNICEF, Lebanon.

Kader Yettefti, I., Aboussabiq, F., Etahiri, S., Mountadar, M., & Assobhei, O. (2013). Evaluation des performances des filtres a sable pour le traitement tertiaire de l'effluent secondaire des eaux usees: Effet de la charge hydraulique. Physical and Chemical News, 68(January), 106–113.

Karnib, Ali (2016) Sanitation and Hygiene for Development: Case of Lebanon. Journal of Water.

USAID (2021) Lebanon Water Project: Final Report

Mahatyanta, A., & Razif, M. (2016). Alternative Design of Wastewater Treatment Plant with Anaerobic Baffled Reactor and Anaerobic Filter for Romokalisari Flats Surabaya. 9(11), 195–200.

Mcheik, M., Toufaily, J., Haj Hassan, B., Hamieh, T., Abi Saab, M. T., Rouphael, Y., Ferracin, E., da shio, B., Bashabshah, I., & Al Hadidi, L. (2017). Reuse of treated municipal wastewater in irrigation: a case study from Lebanon and Jordan. Water and Environment Journal, 31(4), 552–558. https://doi.org/10.1111/wej.12278

Metcalf & Eddy, Inc. (2003). Wastewater Engineering : Treatment And Reuse. Boston :McGraw-Hill,

Ministry of Energy and Water. (2022). Roadmap to Recovery of the Water Sector in Lebanon. May, 1–19.

MoEW. (n.d.)., Wastewater Treatment Regulation Lebanon

Molle, F., Nassif, M.-H., Jaber, B., Closas, A., & Baydoun, S. (2017). Groundwater Governance in Lebanon The case of Central Beqaa. Iwmi, March, 36.

Monvois, J., Gabert, J., Frenoux, C., & Guillaume, M. (2010). How to Select Appropriate Technical Solutions for Sanitation. Water and Sanitation for All Methodological Guides No. (4), 140. https://www.pseau.org/outils/ouvrages/pdm_ps_eau_cms_guide_n_4_how_to_select_appropriate_technical_solutions_for_sanitation_2010.pdf

Nielsen, B. F., Sandvik, K. B., & Jumbert, M. G. (2016). How Can Innovation Deliver Humanitarian Outcomes? 12. https://www.prio.org/utility/DownloadFile.ashx?id=73&type=publicationfile

Pietruschka, B., Thandeka, D., & Buckley, C. A. (2015). OPERATIONAL MEASURES TO COPE WITH HIGH FOG WASTEWATER IN. November.

Reuter, S., Gutterer, B., Sasse, L., & Panzerbieter, T. (2009). FB-DEWATS_Guidebook_small. 49(0).

Rodrigues Mesquita, T. C., Pereira Rosa, A., de Oliveira Santos, T. F., Carraro Borges, A., Calijuri, M. L., & de Paula Souza, F. M. (2021). Decentralized management of sewage using septic tanks and anaerobic filters and its potential to comply with required standards in a developing country: a case study in Brazil. Environmental Science and Pollution Research, 28(36), 50001–50016. https://doi.org/10.1007/s11356-021-14172-2

Rush, H., & Marshall, N. (2015). Case Study: Innovation in Water, Sanitation and Hygiene. May, 1–62.

Sasse, L. (1997). Developing countries. Euratex Bulletin, 4, 126–191.

Bonel, K. (2022) Sanitation Action Plan (All Versions)

Sasse, L. (1998) Decentralized Wastewater Treatment in Developing Countries. A Publication of BORDA.

Schellenberg, T., Subramanian, V., Ganeshan, G., Tompkins, D., & Pradeep, R. (2020). Wastewater Discharge Standards in the Evolving Context of Urban Sustainability–The Case of India. Frontiers in Environmental Science, 8(April). https://doi.org/10.3389/fenvs.2020.00030

Shaban, A. (2020). Water Resources of Lebanon (Vol. 7, Issue October). https://doi.org/10.1007/978-3-030-48717-1

Special, W. A., On, E. Policy Guidance Manual on Wastewater Management & Treatment, D. W. (2015)

Sphere Association. (2018). The Sphere handbook: Humanitarian charter and minimum standards in humanitarian response. In CHS Alliance, Sphere Association and Groupe URD (Vol. 1). www.spherestandards.org/handbook

Tawfik, M. H., Hoogesteger, J., Elmahdi, A., & Hellegers, P. (2021). Unpacking wastewater reuse arrangements through a new framework: insights from the analysis of Egypt. Water International, 46(4), 605–625. https://doi.org/10.1080/02508060.2021.1921503

The, O. F. (n.d.). Introduction and Methodology A SOER REPORT LEBANON STATE OF THE ENVIRONMENT AND FUTURE OUTLOOK: TURNING THE CRISES INTO OPPORTUNITIES.

Thomas, E., Andrés, L. A., Borja-Vega, C., & Sturzenegger, G. (2018). Innovations in WASH Impact Measures: Water and Sanitation Measurement Technologies and Practices to Inform the Sustainable Development Goals. In Innovations in WASH Impact Measures: Water and Sanitation Measurement Technologies and Practices to Inform the Sustainable Development Goals. https://doi.org/10.1596/978-1-4648-1197-5

UNDP. (2014). Assessment of Groundwater Resources of Lebanon Assessment of Groundwater Resources of Lebanon.

UNICEF. (2014). Sanitation Monitoring Toolkit. December 1–90. http://www.sanitationmonitoringtoolkit.com/

UNSD. (2018). Lebanon voluntary national review (VNR) on sustainable development goals (SDGs). 94.

URT. (2018). Guidelines for the Application of Small-Scale, Decentralized Wastewater Treatment Systems. December, 16.

UNHCR. (2020). Practical Guidance for Refugee Settings.

Venhuizen, D. (1991). Decentralized Waste-Water Management. Civil Engineering, 61(1), 69–71. http://cedb.asce.org/cgi/WWWdisplay.cgi?69099

Oxfam (2021).Water-Wastewater Tariffs In Lebanon Survey Report Prepared For Revision 0h Introduction Of Consumption Based Water-Wastewater Tariffs In Lebanon Survey Report Prepared For In Lebanon.

WHO, Margane, A., & Steinel, A. (2011). P R O J E C T N O . : 2 0 0 8 . 2 1 6 2 . 9 Proposed National Standard for Treated Domestic Wastewater Reuse for Irrigation Proposed National Standard for Treated Domestic Wastewater Reuse for Irrigation. http://applications.emro.who.int/dsaf/dsa1184.pdf

UNICEF Lebanon (2022). Water as a Tool for Diffusing Socio-Political Tension.

World Health Organization (WHO), & United Nations Children's Fund (UNICEF). (2019). Lebanon Water Quality Survey. https://washdata.org/sites/default/files/documents/reports/2019-06/Lebanon-water-quality-survey-2016.pdf

وزارة البيئة (2002) قانون رقم 444, حماية البيئة

ANNEX 1: TECHNICAL ASSESSMENT REPORT

Objective

The object of this technical assessment is was to further support technical findings by STDP project retrieved through qualitative research methods, as well as develop technical insights which could provide UNICEF with some update on the systems and their condition or an indicative idea of their performance. These field insights may further be used in developing some recommendations if enough evidence emerged.

Limitations

This exercise is not and should not be considered as a technical audit, as it might, on the one hand, conflict with the general evaluation of the project as a whole, and on the other hand, such audits would require a much more in depth and extensive technical performance checks on a much longer period for results to give. It is important to note, that for scientific credibility, the following limitations are to be acknowledged due to the following conditions:

1- The variable and challenging informal context within which the sites preside, with demographic shifts and variable habits affecting systems' influent;
2- The multi-dimensional crisis which affected fuel availability, respondents' collaboration, consumables availability to labs, lock-downs and various other disruptions which at times hindered progress or necessitated mitigation;
3- The above situation also affected sudden disruptions in systems visited (theft, vandalism), to which a plan B was always ready with alternative sites to replace the discarded.

- Findings are limited to systems that were operational at the time of data collection
- Lab overload, use of multiple labs and discrepancies in lab data
- One-grab sampling in one point in time this was only enough to give indicative assessment technically
- Technologies' suitability to climate/ season variations could not be assessed in real-time
- Cost-effectiveness of the technologies & market validation is inconclusive due to the absence of baseline data on CAPEX & OPEX of traditional systems & to unstable market conditions
- Quantitative assessment of exact volumes of desludging reduced is based on estimates, due to reluctance of SMEs to share data on costs and changing market prices
- Recall bias and response bias of some respondents from the community
- Flow rates could not measured on-site

Furthermore, and ideally since it is of certainty that refugee camp context presents many challenges which might prevent it from happening, an extensive Technical Audit would be advisable to be conducted prior to projects evaluation, and which should be performed based on:

- Proper flow measurements and calculations of HRT
- Composite samples for certain stages
- Several sampling rounds, and over an extended period of time, enough to cover identified variabilities (source water, environmental, ..)
- Results assumed after careful selection of third party labs through reviews of their methods, certifications, and performing validation tests, as well as quality control validations taken through random split samples during the campaign.
- Prolonger study and documentation of social and household habits related to WASH to screen in terms of both quantities and quality. their effect on influent variabilities

Methodology

This report will try to edify on systems status on-site lab results, physical check-ups, lab analyses, and brief discussions with responsible personnel on operational challenges or other social or technical observations. The systems are expected to be well designed and implemented according to standards, and perform well while robust enough to handle expected variations in population, seasons, and influent quality. In addition, the systems should be made of materials that are durable enough to withstand environmental factors such as corrosion, pressure from ground water, and weathering, as

well as suitable in general from preselection phase with respect to water table levels and ground water vulnerability, end use purpose (including field evacuations), and energy or other operational requirements. It is supposed to reach indicative yet useful conclusions which mostly help in validation of qualitative input of the main evaluation. Systems and site selection were based on The final selection of systems for the technical evaluation (16 out of 56 systems) was based on a set of criteria including:

- Inclusion of ITSs and host community
- Inclusion of all types of treatment chains
- Mostly following Batch 3 Model, but include few from B1 & B2
- Inclusion of one system from each chain from Batch 3
- Technologies & Treatment Chains discontinued or not functional
- Sites where eviction was flagged as a possible risk
- Environmental vulnerability (high water table)
- Robust vs. suboptimal performance of systems

Lab Analysis

The samples were taken following documented EPA methodology. They were obtained from inlet and outlet for all systems, some systems were sampled in-between units as well i.e., after ABR and after ANF).Systems from Batch 3 were given priority due to the matured design of these systems, which was informed by the trials, tests, and results of previous batches. Ten sites from Batch 3 included in this sample 1 site from Batch 1 and 2 from Batch 1.
The evaluation team undertook a second testing campaign, which started on 27 July and completed it on 17 August, to validate the results of the first campaign. For few selected systems from both rounds, Difaf took samples of in between chain stages in order to record and attempt to assess, on a preliminary level, overall chain treatment performance for certain parameters, however the majority of sampling relied on in vs. out grab samples. The systems were sampled and measured for assessing removal efficiencies using the following water quality parameters using grab sampling method for influent vs effluent comparisons, and on some systems randomly chosen, perform in-between phases sampling:

- Using on-site multiparameter probe: Temperature, pH, DO, Turbidity, ORP, TDS
- Using commercial labs: COD, BOD_5 , TSS, TN, TP, TC, FC

Nevertheless, the Evaluation Team always had the above in mind, and did all possible to mitigate the limitations mentioned, and maintain quality of results and integrity of work, including cross-checking for common parameters which could be triangulated from B1 & B2 results as general references, performing random validations for self-checks in quality control, and same for third party lab results during the evaluation process, and using international references for comparisons when and if possible.

Reporting

Lab results were then analyzed and cross-checked for validity when required. Finally a report was put together for UNICEF's reference[33]. The next section present important background notes for readers, explaining why results of this Technical Evaluation are rather indicative and not assertively conclusive, and it is advisable that for UNICEF and project implementers to confirm them further if interested in in-depth analysis of performance or detailed monitoring and troubleshooting (or even research and development). The field visit report can be found as Appendix 1 to main Final Report.

Summary of Main Technical Findings

This section summarizes the key findings of the technical assessment of 13 sites containing 16 DEWATS installed systems selected based on criteria described before and cross compared with other information gathered by other methods and from project reports.

1. High removal rates, 65-95% of BOD_5 and COD were observed indicating excellent performance within DEWATS standards. The systems didn't posses any disinfection element.
2. None of the sites exhibited significant odor problems.

[33] For detailed report of analyses and data tables refer to the annex of this report

3. Metal elements of the units were in a poor condition Most locks for the systems were corroded (and had to be pried open to access the chambers) due to low quality and prolonged exposure to the elements
4. Some biological aerated filters in most sites were exhibiting foaming issues typical of low nitrification or perhaps influent overload.
5. Dissolved Oxygen (DO) levels measured in the BAFs of 3 systems were lower than the desired value
6. Tertiary treatment units (slow sand filters and constructed wetlands) were not performing to the desired levels in most of the visited sites due to problems such as:
    a. Malfunctioning tipping buckets (due to corrosion)
    b. Use of sand with incompatible characteristics
    c. Frequent scrubbing of the surface layer
    d. Uneven distribution of wastewater
7. The reduction of nitrogen was observed in systems without aerobic chambers.
8. Some systems caused an increase in effluent turbidity.

Summary of Management / Operational Findings

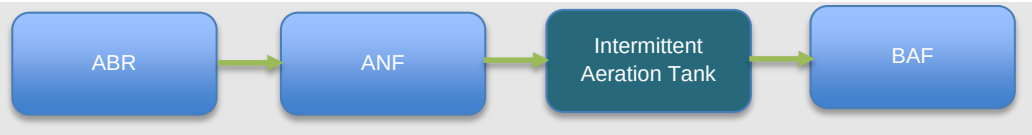
1. Out of 13 sites assessed on field, 2 were inoculated.
2. The systems were not being routinely tested except for 2 sites
3. Effluent reuse was not applied most systems due to availability of irrigation water and possible cultural barriers, even though irrigation from the highly polluted Litani River as well sewage outlets is a common practice.
4. Occasional blockages were occurring due to solid waste being improperly disposed of into the network by the refugees.
5. Fencing was not always sufficient to provide the recommend safety for the system or ITS inhabitants.

Recommendations

1. Effluent COD, TN, and TP, although within the DEWATS expected range, were above the local wastewater discharge environmental limit values; this is mainly due to the stringency of such values and their inapplicability to refugee situations
2. The frequently encountered increase in turbidity could be attributed to the high TSS load in the inlet, corresponding to relatively large suspended organic particles being transformed into much smaller particles that significantly contribute to turbidity; this indicates the necessity for properly functioning tertiary treatment.
3. Effluent COD, TN and TP may indicate the necessity for longer retention times in the secondary treatment, and therefore more modules could be needed in addition to a fully functional tertiary treatment.
4. Development of clear and structure and standardized SOPs per system category for all chain of product development and monitoring
5. More in-depth campaigning should be administered by all IPs or any agency managing the systems for (preferably following already standardized SoPs) for conducting systematic:
    A. Routine checks: designed for routine two weeks gram samples and on-site measurements
    B. Performing performance evaluation checks: for detailed check up every other month in order to understand the systems stages performances, or can be done for troubleshooting purposes.
6. Data Management and analysis system to be developed for monitoring and evaluation prupose, for the duration of the project and beyond, to be handed over along with systems profiles, performances, and SOPs to respective authority.
7. As denitrification seems minimal if indeed occurring (e.g. BAF), an additional treatment step is required to reduce the effluent nitrate in sites with high ground water vulnerability and low potential for irrigation use.

Additional Suggestion

For recommendation 7, Difaf would like to suggest an additional suggestion for exploration as a replacement or an improvement in current stages (AW, BAF, SSF) or The tertiary treatments designed, theoretically should provide a good level of nitrate removal as per classical references. However, and mostly due to the many variations in environmental and contextual factors affecting the systems in humanitarian settings, as well as their sensitivity to maintenance requirements, we presume this variability in context, added to the Bekaa variable daily and seasonal temperature variability, may always present challenge to meet very high standards for effluent wastewater quality in terms of TN (meeting ELVs or very high and stable values). Furthermore given the high biological loads in influents at ITS, removal of nitrates might still remain challenging even if the tertiary systems are working at optimal efficiencies. DEWATS designs, here or elsewhere, might merit from the following consideration: the introduction of intermittent aeration step for systems using aeration treatment options, in the aim of performing better denitrification. We surmise that this can not be avoided if DEWATS are meant to be under ELVs scrutiny. This suggestion may be far from innovative, and would certainly further challenge the feasibility given that these systems are also meant to be simple and adding complexity is maybe defeating the purpose, but we are not sure how far was it explored or considered, it at all, and maybe an option to be explored and tested.



An intermittent aeration tank could be added before the ANF. The tank will be equipped with blower that alternates between operating and idle intervals (on/off). This may promote denitrification before the BAF stage.

ANNEX 2 EVALUATION CASE STUDIES

CASE STUDY 1 : HOST COMMUNITY OF MENJEZ

Location: Menjez, Akkar
Implementing Partner: Solidarités Internationale
DEWAT Chain: Anaerobic Baffled Reactor + Anaerobic Filter + Slow Sand Filter
Wastewater Flow / Population Equivalent: 7.5 m3/d / 50 PE
Energy Requirement: Passive (negligible)
Date of Installation: November 2021
Date of Operational Maturity: February 2022
O&M Responsible: Implementing Partner + Menjez Municipality
Project Holder: UNICEF
Donor: Bill & Melinda Gates Foundation

Context

Menjez is a small village of around 1,000 registered voters, located at an altitude of 350 m above sea level in the Governorate of Akkar, Northern Lebanon, and close to the Syrian border.
The Menjez Municipality had originally been in contact with UNICEF in 2017, when the latter provided the former with a grant to prepare a study about the situation of wastewater in the village, with an eye to implement a comprehensive decentralized wastewater treatment system. The study was approved by MoEW, but when the funds were diverted due to the Multidimensional crisis that gripped Lebanon since 2019, which effectively slowed the momentum of the larger project albeit its continuous progress on many levels.
Menjez lacks a sewage network, which means that each house disposes of its wastewater in a pit that ultimately flows into a nearby river. The aforementioned group was no exception to this state of affairs, but its upstream location meant that its pits resulted in odors, mosquitos, and other insects downstream, which caused tensions and complaints amongst the village dwellers.

Menjez DEWAT System[34]

The system installed in Menjez belongs to Batch 3 of the STDP project, and was installed in November 2021. For secondary treatment, it uses filter media technology (100 m^2/m^3), comprising of an Anaerobic Baffled Reactor and an Anaerobic Filter (ABR + AF); while for tertiary treatment, it relies on Slow Sand

[34] All the designs are the result of designing works of UNICEF WASH Expert (Mr. Kevin Bonel) and were based on the DEWATS Decentralised Wastewater Treatment in Developing Countries guidelines (BORDA, 1998) and ensuing R&D works, Constructed Wetlands Manual (UN-HABITAT, 2008), Wastewater Engineering: Treatment and Reuse (Metcalf and Eddy, 2003) in addition to UPM valuable support).

Filtration (SSF) and is thus gravity-based. The system is passive in terms of energy input, and has been in matured operational status since early 2022.

System number	Energy intensive	Secondary Treatment	Media Secondary Treatment	Type	IoT	Tertiary Treatment
1	Non-intensive energy	ABR AF	Bioblock 100 m^2/m^3	Steel	NA	SSF
2	Non-intensive energy	ABR AF	Bioblock 100 m^2/m^3	Steel	NA	SSF

Results of Technical Assessment

According to the Technical Assessment Report found in Annex 1

- 43% removal rate of COD was observed
- 82% removal rate of BOD5 was observed
- FC not detected

These systems are handling relatively low strength influent wastewater streams which do not reflect ITS conditions, but domestic wastewater characteristics. This might explain why the treatment efficiency was almost half that of systems handling ITS waste; if the incoming concentration is lower, and that value is used to calculate removal efficiency, then the removal efficiency would be less. What is important however, is that the effluent produced is similar to those produced by other systems handling stronger wastes with lower hydraulic loads of ITS context (35 L/cap.d), while also treating higher hydraulic loads corresponding to higher wastewater generation rates of Lebanese citizens (150 L/cap.d).
Although not sufficiently conclusive, Menjez DEWATS passed BOD, TP, and FC, close to passing COD in terms of national standards for environmental limit values (ELVs) at the time of sampling and this evaluation.
The system tanks being steel type had one of its compartment covers was stolen, and while originally the SSF compartment was kept uncovered by way in keeping in line with the unified design of Batch 3 systems, SI will be installing covers for the SSF compartment in order to eliminate odors currently emanating from it. Still the system can be said to be operational and effective. In fact, the Menjez Municipality will be cashing on this success story to attract funds for a larger-scale intervention.

Community Acceptance & Engagement

UNICEF put the Menjez Municipality in contact with its Implementing Partner, *Solidarités international* (SI), which proceeded to carry out consultation sessions first with the Municipality and then, with facilitation from the Municipality, with the dwellers of the pilot group. The Mayor and the dwellers interviewed by the Evaluation Team mentioned that the consultation sessions attempted to probe them for feedback on the designs, but that the respondents did not have the technical know-how for this, which made the sessions more informative than consultative.
From the interviews made, one can confirm that the rate of social acceptance of the intervention is high; it is recognized that the installed DEWATS have effectively solved the problems that were at the origin of the intervention (odors, insects, general pollution hazard).

Sustainability / Scale-up Potential / Environment

The intervention at Menjez was successful primarily due to the existence of a **personal champion** for it, namely the Mayor. In such as Lebanon's, characterized by personal rather than institutional policy-making, the personal role of mayors, especially in smaller, rural contexts such as Menjez, becomes key to the thriving or detriment of a project. Apart from that, one could point out to three other success factors:

1. The **legal framework** (Municipal Act of 1977) endows municipalities with agency for a wide scope of sectors, including wastewater treatment, even though in terms of mandate, it is still under the Water Establishment of Ministry of Energy & Water.
2. The small size of the municipality translates into an efficient **decision-making structure** with respect to innovation and new DEWATS.

3. In and following its implementation, the intervention was accompanied by a high degree of **social acceptance by the villagers of Menjez**. This in turn owes itself to a seemingly high degree of institutional trust in the Mayor/Municipality, and to the fact that the intervention was not parachuted onto the site, but rather arose from the grievances felt by the dwellers in a genuine bottom-up instance.
4. Technically, this particular design for **two of the systems is now considered design-obsolete**, although it was still performing well at the time: Trickling filters have been later discarded by final profile selections due to the requirements of energy for high aeration in constant operation. So was fiberglass, as per government requirement, justifying that with the possiblity of cracking in high water table environs. So sustainability wins with the other two, however a comparative analysis can still be very interesting down the road in that respect and for streamlining purposes.

The Menjez Municipality approached UNICEF again with a view to implementing a pilot project for a new host community group of 30-35 houses whose upstream location made them particularly susceptible to complaints.
The Mayor mentioned available funding of the intervention partially through municipal taxes evoking the “wastewater maintenance” as a municipal tax. The municipality is in accordance with the IP in terms of hand over soon, and is technically ready to do so. If a PPP framework is developed here, there is good potential for sustainability and scalability in the Lebanese host community context for DEWATS.

Brief Look at Feasibility

Based on the calculations and projections made by the technical team, and the information provided by the interviewed informants, it was found that

1. As per the SAP, a system will cost around $10,000 (CAPEX) to be installed. Taking both systems into consideration in the Menjez municipality, around $ 20,000 were invested in the installation process.
2. The maintenance and operation of the system will cost an average somewhere between $ 500 and $ 1000 per year per system so we have an annual average OPEX of around $1500 for both.

It is important to note that the desludging also requires paying fees for the sludge treatment (e.g. at Zahle WWTP) and the consideration that the life span of one system is estimated at 10 years. Energy feasibility analysis was discarded due to the fact trickling filter, the main energy requiring component, has been later discarded, on top of the black market take over on economy of both fuel and material.

	Total sludge generation rate (m3/d)	Total sludge generation rate (m3/yr)	Annual Desludging cost - Low ($)	Annual Desludging cost - High ($)
Before implementation DEWATS	7.5	2737.5	30112.5	68437.5
After implementation	7.5	1.83	18.07	41.06

Desludging costs presented in the table above were calculated based on a low- limit desludging cost of $11/m^3 and a high-limit desludging cost of 25$/m^3.

Relation to STDP Theory of Change

On average, and as we are not sure of the market, the reduction in cost ranges between 90 % and 95 % thus confirming targets of SAP being reached.
Secondly, this intervention testifies to the applicability of the unified model developed by the STDP project at the level of host communities, something that makes sense in theory given that municipal wastewater is less concentrated than its counterpart, and thus that a system that can treat ITS wastewater must be able to treat municipal wastewater. That said, Menjez has been the only case so far where the unified model has been used in a host community context. This means that the applicability of the model in larger municipal contexts is yet to be validated.

CASE STUDY 2: ITS COMMUNITY OF BAR ELIAS

Location: Bar Elias 072
Implementing Partner: World Vision
DEWAT Chain:
1) Anaerobic Baffled Reactor + Anaerobic Filter + Biologically Activated Filter + Aerated Wetland
2) Anaerobic Baffled Reactor + Anaerobic Filter + Sand Filter
Wastewater Flow / Population Equivalent: 10 m^3/d / 260 PE
Energy Requirement: Active (Requires Energy) + offset by PV installation
Date of Installation: 2021
Date of Operational Maturity: 2022
O&M Responsible: Implementing Partner
Project Holder: UNICEF
Donor: Bill & Melinda Gates Foundation

Context

Bar Elias is a large village of 222 registered voters, located in the West Bekaa Valey in the Litani River Basin, area characterized by relatively high water table. at an altitude of 350 m above sea level in the Governorate of Bekaa, east of Beirut.
Before the project started, septic tanks were often overflowing (the costing of desluging was high) and there were some reported incidents of children falling in the open pits. Reports of open pits infiltrating into the groundwater has led to contamination. Reports of breathing irritations, skin diseases, and diarrhoea amongst women and children led the community to believe that the contamination was a source. Although the NGO would pay for desludging services, residents stated that a high frequency of floods in winter, meant that residents would share the cost of desludging service with the NGO..
Poor faecal sludge treatment also created aesthetic problems, and flies on the site and bad smell were common.

Bar Elias Municipality has the highest refugee numbers in Lebanon. More than half of its residents are refugees. Both the host communities and refugee populationis do not have adequate access to solid waste collection and wastewater treatment, although many host populations in Bar Elias has its own septic tank.

The municipality has been cooperative in improving conditions for refugees as mentioned by a former municipality engineer. However, at the time of evaluation, municipality representatives was not present and the evaluation team could not reach the Mayor. However, a former staff member stated that the municipality was supportive of creating joint initiatives that benefitting both refugees and host communities, linking them in a better way that might reduce the tension between these two communities.

Bar Elias DEWATS

Four systems for Decentralised Wastewater Treatment (DEWATS) were developed and tested by World Vision under the UNICEF STDP 35 in the ITS 072 in Bar Elias, where 260 are served by the installed systems. The World Vision staff selected the site based on the environmental context and the cost of desludging. After obtaining consent from the landlord, they refined the initial prototype design in terms of space, networks, and system parts and communicated with the municipality for further approval. A Bill of Quantity (BOQ) and a market study were done by the logistic department of the NGO for procurement and the system was installed in March 2022.
Four DEWATS were installed with the following specifications:

35 All the designs are the result of designing works of UNICEF WASH Expert (Mr. Kevin Bonel) and were based on the DEWATS Decentralised Wastewater Treatment in Developing Countries guidelines (BORDA, 1998) and ensuing R&D works, Constructed Wetlands Manual (UN-HABITAT, 2008), Wastewater Engineering: Treatment and Reuse (Metcalf and Eddy, 2003) in addition to UPM valuable support).

System number	Energy intensive	Secondary Treatment	Media Secondary Treatment	Type	IoT	Tertiary Treatment	Filter Media
1	Energy intensive	ABR ANF BAF	Bio block 100 m2/m3 + Chips	Plastic (PP)	BiomWeb Light	Aerated Wetland	Gravel
2	Energy intensive	ABR ANF BAF	LECA [8 - 16 mm]	Plastic (PP)	BiomWeb Light	Aerated Wetland	LECA
3	Non-energy intensive	ABR ANF	prefab trickling filter media	Fibreglass	No	Slow Sand Filter	Sand
4	Non-energy intensive	ABR ANF	prefab trickling filter media	Fibreglass	No	Slow Sand Filter	Sand

Innovative Aspects

- Has both energy requiring and passive systems, two from each, as a step towards modular developments.
- Aerated Wetlands are relatively considered innovative technologies, bringing down footprint requirements from 3 m^2/ cap to 1 , 0.5 m^2 and or less. As a polishing or “tertiary” step, UNICEF has proven that it can be as low as 0.06 m^2 / cap. However they would still require energy for aeration.
- BAF is relatively a new player in the treatment chain, and as such following ABR – And , can be considered an innovative set-up.
- Solar power provision can be considered innovative in such contexts feasibility wise, however it came with its own challenges in the crisis context.




Results of Technical Assessment

The former municipality engineer stated that the biggest achievement is that the treatment is working. Residents stated that if the system was not installed they would have flooded every two weeks, with all the bad odors; now all of these problems are gone. Desludging used to be done once monthly as confirmed by the desludging vendor and sludge used to be disposed of in WWTP in Zahle or Job Jannine. Now, as stated by the IP, desludging occurs only per request occasionally.
No major modifications were made to the systems after implementation, however, the *Shawish* stated that in case of any issue he calls the hotline and communicates with the staff that which then proceeds to immediately resolves resolving it, which was also the case for the inhabitants who assured that in case of any issue, they would report to the *Shawish*, and he would report to WV.
The system was installed in the first three months of 2022 and started functioning in April 2022. From the IP's perspective, the system is working well yet not fully achieving its desired results due to the system still being in the start-up phase. Although each system was designed to serve five to seven tents, some families left the settlement after the installation and vacated six tents. However, this did not drastically impact treatment efficiency of the systems at least in this instance.
Residents of the settlement who participated in a focus group discussion stated that they had not used any desludging services since the system started operating. It is expected that desludging will be reduced to once every six months. However, the system had to be unclogged once in May 2022.

- 82% to 92% removal rates of BOD5 were observed
- 87% to 92% removal rates of COD were observed
- Variable TSS removal rates were observed (14% to 88%)
- Turbidity observed in the outflow is higher than in the inflow in all systems
- 70% to 88% removal of TN was observed
- 36% to 70% removal of TP was observed (except for one system where no removal was observed due to malfunctioning of blower)

The systems are achieving high efficiencies of organics removal and nutrients. Unfortunately, however, the inconsistency of TSS and turbidity removal makes it difficult to accurately assess the performance of tertiary treatment units in terms of filtration capabilities. In addition, the tertiary treatment units remain underperforming when it comes to pathogen removal.

Community Acceptance & Engagement

The community was engaged in the needs assessment, which was the initial stage of the project for the site selection where the site was assessed. WV approached the community the Shawish of the 072 sites in the first month of 2022 and introduced the project to him and asked him to get the consent of the residents. They also scheduled a meeting with the residents to explain the project in more detail. At first, the inhabitants were reluctant about the project because there was another IS where a system was installed and didn't work properly. WVI explained the benefits of the decentralized wastewater treatment and why the other project did not work.
"They showed us the maps, the locations, how far from the tents, the children, how the project will enhance their protection (underground installations, cover systems, how they will take care of the maintenance), they showed us everything." – ITS Shawish
The field staff was in regular communication with the inhabitants and the Shawish and they were informing him of the implementation process and his role in keeping it safe.
It was communicated by the NGO staff that approaching the landlord and negotiating with him was an essential step in the process. However, it was noted that the consent of the Landlord depends highly on the level of background and knowledge he has. The NGO staff stated that after agreeing with the landlord an MOU is signed with them and with the municipality. Then, both parties were kept informed of everything of any changes or developments.
After being approached by the staff and the awareness-raising campaign, the community welcomed the approach. They no longer had concerns and developed a sense of ownership and felt responsible for keeping it functional, especially that at urgent critical flooding instances they seem to have to contribute to desludging costs:
"We were highly interested because we viewed this system as a solution to the septic tank flood that used to happen weekly causing us sometimes to get desludgers at our own expense." - Female ITS Refugee
Also, it was mentioned by the residents that the treated water is discharged to a small channel that is used downstream for irrigation purposes by other people. The main irrigation water at source is a well in the landlord property. However, no frequent sampling and testing were done for the treated water

to inform its suitability for irrigation although this was a targeted purpose and hence testing was expected.

Sustainability / Scale-up Potential / Environment

- Residents' recognition of the importance of such an intervention resulted in the observed Increased hygiene and improved health conditions for refugees
- Proper management and acceptance of the systems by the community resulted in the elimination the pollution risk on the underground water, especially since these areas are agricultural.
- Engaging women in the topics related to the intervention led to better consideration of gender aspects, for example making the water points and latrines not far from dwelling to minimize sexual exploitation, latrines have locks and lights to provide a level of safety.
- Awareness sessions + HP (hygiene promotion) team is always split equally so that the female HP members could undertake responsibilities to engage with female beneficiaries in discussions.
- The drastic situation of wastewater in the site prior to the project and the frequent floods that used to occur, the availability of space for the installation of the systems, and the landlord's acceptance of the technology implementation on his land, all formed the enabling environment for the success of this intervention in this site.
- Energy wise was modified for supply by PV solar energy, however this also affected security as all locals both ITS and Host are now suffering from shortages.
- The SOP with Landlord in terms of striking a deal involved exploring the idea of supplying some power from the solar panels in exchange for security of system, however, this remains to be confirmed if it actually did help in that respect.
- The fact that the systems can be eventually used for irrigation gives them a higher chance for sustainability especially in agricultural regions as the Beqaa.
- At least on a preliminary assessment level, the system has demonstrated "Robustness" in ability to withstand variability of loads of shocks, and even more the variable temperatures of the Bekaa.

Brief Look on Feasibility

Based on the calculations and projections made by the technical team, and the information provided by the interviewed informants, it was found that

1- Desludging frequency to be reduced from once per month to once per year reducing the cost of desludging from an average of 85,410$ per year to 154$ per year, which is equivalent to reducing the cost by 98.2%, in line with what was stated in the sanitation action plan (SAP) presented by UNICEF.
2- As per the SAP, a system will cost around 10,000 $ (CAPEX) to be installed. Taking 4 systems into consideration in the Bar Elias 072 site, 40,000 $ can be considered as investment without economy of scale.
3- The maintenance and operation of the system will cost an average of 1,500$ per year per system. which might be around $ 3,000 for the 4 systems considering same location scale, adding to it the desludging cost which is $154 per year we have an OPEX of $6154.
4- Noting that the desludging also requires paying fees for the sludge treatment at Zahle WWTP and taking into consideration that the life span of one system is 10 years. Then the total cost of the investment will be in the range of $ 47,500

	Total sludge generation rate (m3/d)	Total sludge generation rate (m3/yr)	Annual Desludging cost low (11$/m3)	Annual Desludging cost high (25$/m3)
Before the systems were installed	13	4745	52195	118625
After the installation of the systems	-	8.54	93.95	156

Desludging costs presented in the table above were calculated based on a low- limit desludging cost of \$11/m^3 and a high-limit desludging cost of 25\$/m^3

In Relation to STDP's Theory of Change

On average, and as we are not sure of the market, the reduction in cost ranges between 85 % and 95 % thus confirming targets of SAP being reached.
At a first instance, this intervention testifies to the applicability of the unified model developed by the STDP project at the level of ITS communities in terms of both technical and social outputs:

- Well-designed systems with good treatment efficiency
- Well started up following a proper inoculation process
- Well protected systems
- Observable acceptance of the refugees on-site to the systems
- Proper linkage of Wastewater to each system
- Good example of system scaling by modularity for upscaling (in case of a malfunction in one system, the other systems functions properly)
- Energy supply was supplemented by PV panels which increased its sustainability in terms of energy need given the crisis in Lebanon
- Irrigation, as a circular economy aspect in DEWATS (and maybe the only one for the time being since treated sludge is not yet in the consideration) may contribute to feasibility and sustainability of the system in what UNICEF labelled as "water swap" possibility.
- The difference in performance between Active vs Passive on site merits long term monitoring, which also can include tank material performance evaluation.

In Relation to Host Community

Bar Elias is a famous farmer town, among neighboring ones who face social tensions with respect to water provisions. Every other year when shortage strikes, conflicting water rights emerge, with ones claiming older rights to downstream of others. The case is exemplary in this particular town, as it lies right downstream of the largest and newest WWTP of Zahleh. Bar Elias community claim it is fully their right to have the effluents for irrigation, disregarding even the farmers of Zahelh itself. Nested in its host community, the land lord, the municipality, or anyone in the area for that matter would be more than happy to receive 10 m3/d for reuse in irrigation. Proper DEWATS treating at high standards can play an important role in social conflicts, giving the ITS refugees a little more reason to manage it as it may provide the landlord with good justification to 1) not evict them (if they are indeed involved in its O&M) relieve them from further coercion, if not land rent.

ANNEX 3 EVALUATION MATRIX

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
Relevance & Coherence			Program Stakeholders Local Strategies	Desk review, KII, observation, etc.	Qualitative & Quantitative, Desk review, field visits/direct observations
Q1. How relevant is the project to the urgent needs of the refugees and host communities in Lebanon?	Q1.1 To what extent do the achieved results respond to the informal settlement and host communities needs in terms of wastewater management? How?	1- What was the situation before the intervention? How was wastewater treated before the intervention? What was the impact on the beneficiaries' health? What was the impact on the environment (soil, water basins)? How did the local/ neighbouring communities (neighbours, host communities in the area) react to this wastewater issue? Prompt: Were there any complaints, threats, protests? How frequent was desludging? Were there any complaints related to the desludging – if so, by whom and about what? How were these complaints addressed? 2. To what extent was the proposed innovation relevant to the local context? Was the design based on research/ assessments on site? Did the design take into account legal, social and climatic specificities?	SMEs, host and refugee Wash committee, landlords, Shawishes and desludging vendors, project partner at the site level, WASH and environment stakeholders (local NGOs committees, protection committees in ISs), institutions-ministries, LRI, BWE, municipalities, UNICEF and partners	KII, FGD, SGIs, Desk review, Technical Assessment Tool	Data will be triangulated with the secondary data and the community FGDs

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
		To what extent were the selected designs low-cost? To what extent did the selected designs require low-skill maintenance? To what extent did the selected designs take seasonality into account? 3. To what extent did key stakeholders see the intervention (the implementation of the innovation UNIT) as a need in their community? Why/ why not?			
Q1. How relevant is the project to the urgent needs of the refugees and host communities in Lebanon?	Q1.2 To what extent do the project results contribute to the achievement of UNICEF LCO child survival outcome 1 "Sustained use of safe water supply and sanitation services, and adoption of hygiene practices, by children and their families in poor communities vulnerable to climate change, conflict and public health emergencies".	To what extent are the technologies safe for the beneficiaries? (Probe for health, safe water, hygiene practices) To what extent are the technologies acceptable to the users and the communities? See also questions under 'Sustainability'.	WASH Team of the IPs, municipalities, , farmers, local communities, landlords , Shawishes and desludging vendors, project partner at the site level, WASH and environment stakeholders (local NGOs committees, protection committees in ISs), institutions-ministries, LRI, BWE, Municipalities, UNICEF and partners	KII and SGIs, field visits, Technical Assessment Tool	Data will be triangulated with the secondary data (WAP) and the community FGDs
Efficiency			Program Documents Local Strategies Other similar initiatives in the area	Desk Review KIIs & FGDs Review of records, lab tests	
Q2. To what extent has the intervention been cost effective?		See questions under 'Effectiveness' on cost-effectiveness of the technologies.	landlords, Shawishes and desludging vendors, project partner	KII, Technical	data will be validated through

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
	Q2.1 To what extent were services provided in time and results achieved within an appropriate time period?[36]	What are the main challenges in terms of the implementation timeframe? Did the delay cause any major issues?	at the site level, WASH and environment stakeholders (local NGOs committees, protection committees in ISs) , institutions- ministries, LRI, BWE, municipalities, UNICEF and partners	Assessment Tool	comparing with the result framework and the project reports
Effectiveness			Crosschecking between field and desk data	Desk Review KIIs & FGDs Field Visits Informal Interviews	
Q3. To what extent was the intervention successful in implementing effective, financially feasible and innovative technological solutions to treat wastewater in emergency context?	Q3.1.Did the implemented solution meet the legal, geographic, geological, physical, climatic and cultural criteria?	1. Effectiveness of the solution: To what extent does the solution meet criteria: compliance with MOE decision 8/1, suitability to topography, suitability to seasonal fluctuations, suitability to local practices, compliance with set targets for effluent quality, mobility, and cost-effectiveness	SMEs, host and refugee Wash committee, landlords, Shawishes and desludging vendors, project partner at the site level, WASH and environment stakeholders (local NGOs committees, protection committees in ISs), institutions- ministries, LRI, BWE,	KII. FGD, Technical Assessment Tool	data to be triangulated with the results of the technical analysis and the program documents

[36] Effectiveness criteria will be covering the cost effectiveness and the evaluation of the technology and the intervention

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
			municipalities, UNICEF and partners		
	Q3.2. How effective/evidence based was the selection process and filtering of technologies? Q3.3 Did the solution improve wastewater treatment and access to safe sanitation for Syrian refugees in IS and Lebanese in host communities? How?	Effective production of evidence of the effectiveness and efficiency of the systems: How robust was the testing of the systems? What were the methods and approaches used in testing the technologies? How robust was the assessment of cost effectiveness? In the sites where the innovations were selected based on other criteria, were alternative solutions explored?	this field will be solely technical as our technical team will conduct the relevant lab tests to determine the efficiency of the systems	Lab testing, desk review of the literature and results records shared, Technical Assessment Tool, direct observations, tests for water quality parameters will be conducted according to standard methods	The data analysis will be based on the CapEx and OpEx in the desk review, unit cost of treatment compared to existing databases and literature reporting documents.

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
		Effective wastewater treatment service: implementation of solution & effect on sanitary conditions Are there any barriers to accessing the wastewater treatment service? Are there any groups that do not have access/are excluded? What concerns do stakeholders have/ what risks do they see related to the new system? Are there any people whose interests are threatened by the new system/ service (i.e., vendors providing desludging)? How have they reacted to the implementation of the new system? How are problems and malfunctions of the system addressed? By whom? Have there been changes to the sanitary practices since the installation of the new system? . What are the lessons learned in the process? What need to be changed in the communities to enable the use of technology?			

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
		What are the lessons learned about the feasibility of adapting and testing successful innovations?			
Q4. To what extent was the project able to build institutional knowledge and strengthen the capacity of stakeholders to improve global humanitarian responses in similar emergency context? What are the lessons learned in the process?	Q4.1. How did the project build capacity for PPP in the WASH sector? Q4.2. How did the project affect the capacity for innovation in the humanitarian-development WASH practice? Q4.3. How effective were the design logic and management approach in engaging stakeholders and implementing the intervention successfully? Q4.4. What roles did organizational context, culture, and systems and processes play in what the project was able to achieve? Q4.5. What are the lessons learned about the feasibility of adapting and testing successful	1. Capacity for PPP To what extent did the project build knowledge of the innovation process in institutions (MOEW, MOE)? To what extent did the project build knowledge of products and process among SMEs? To what extent did the project establish mechanisms for institutions to engage the private sector on WASH innovation? How were findings shared with relevant ministries? How do MOEW, MOE view the potential scale up? What barriers exist to institutionalising the practice of PPP in WASH? Do SMEs have capacities to produce innovative systems (specify types)? How do SMEs assess the market and the feasibility to produce such systems? What are the barriers for production? 2. Capacity for innovation in the humanitarian-development WASH practice What efforts are being made in open innovation across existing development and humanitarian stakeholders? How do implementing partner arrangements enable and incentivise innovation?	SMEs, host and refugee Wash committee, landlords, Shawishes and desludging vendors, project partner at the site level , WASH and environment stakeholders (local NGOs committees ,protection committees in ISs) , institutions- ministries, LRI, BWE, Municipalities, UNICEF and partners UNICEF and partners	KII, FGD, lab tests, Technical Assessment Tool	Triangulation with case study, in terms of replicability, triangulation will be made from technical, economic social feasibility.

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
	innovations? (Enablers and barriers) o	How were findings shared with humanitarian actors? Prompt: if not yet, what are the plans for sharing and with what actors (related to the humanitarian response in Syria and/ or globally) What opportunities exist to use this project to build capacity for innovation? To create an enabling environment at the institutional level to produce and update innovation? Which aspects (innovation products, elements of the process) have the strongest potential to inform work on sanitation solutions in the humanitarian and development sector? How can learning in the sector be improved? 4- How is the innovation technology linked to the overall UNICEF strategy? Do innovation goals allow space for creativity and contextualized approaches? What is the role of senior leaders and ministries in driving and encouraging innovation across the department? Is there explicit attention to how existing modalities, procedures, and processes might inhibit innovation, and efforts underway to address or mitigate these issues? Is there a culture of rewarding and supporting innovation? How well do human resources practices support and enable a culture of innovation? What efforts are made to build communal capacity in innovation? (SMEs, industrials, local partners)			

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
		C5 What are the lessons learned about critical enablers to successful adaptation, demonstration, and measurement and learning, and what were their implications? (e.g., generating and presenting quality evidence, individual champions, technical assistance and capacity-strengthening support, partnerships, government engagement, role of BMGF, technically sound solutions) o What are the lessons learned about barriers and challenges encountered to successful adaptation, demonstration, and measurement and learning, and what were their implications? o How did the project highlight opportunities for improving organizational culture and capacity in the humanitarian sector to facilitate innovations' success? –			

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
Q5. Did project activities show signs of creating unintended positive or negative outcomes? If yes, which activities contribute to this?		How was the innovation perceived locally – by users, by host communities? How did it affect local power dynamics, relations with other NGOs, the relationships with landlords, with local authorities, with institutions participation of women? How did it raise environmental awareness and environmental activism (i.e., cleaning and recycling campaigns) in the area? Did the intervention create opportunities for collaboration with local committees/ groups from the host community? Were there any positive or negative effects related to the re-use of treated water? Were there any examples of SMEs using the open-source design commercially? Were there any positive or negative effects on livelihoods, for example to maintenance and use waste water?	host and refugee Wash committee, landlords, Shawishes and desludging vendors, project partner at the site level , WASH and environment stakeholders (local NGOs committees ,protection committees in ISs), institutions- ministries, LRI, BWE, municipalities , UNICEF and partners	KII , FGD, Technical Assessment Tool	data will triangulated with technical data to assess any intended or unintended impact on the effluent discharge to the discharge location
Sustainability			Program Stakeholders	KIIs & FGDs	

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
Q6. To what extent are the implemented solution likely to remain operational following the closure of the project? What are the conditions to maintain their sustainability?	Q6.1 How will the systems installed be managed/ maintained after the end of the project? Q6.2 What are the barriers to replicability/ scale up and how can they be addressed?	What is the cost and feasibility for local manufacturing What is the Potential for ministries to facilitate PPPs in wastewater What is the Potential for replication by humanitarian and development actors in Lebanon (diffusion of innovation in the Wash sector) What is the Potential for replication in Syria / other climactically similar refugee contexts What are the barriers to replicability/ scale up and how can they be addressed? What mechanisms exist to support further diffusion of successful innovations. What are the potential barriers to scale up in Lebanon or similar contexts, regulations and governance	SMEs, host and refugee Wash committee, landlords, Shawishes and desludging vendors, project partner at the site level, WASH and environment stakeholders (local NGOs committees, protection committees in ISs), UNICEF and partners	KII ,FGD, Technical Assessment Tool	data will be triangulated with the technical reviews made on the ability of the technology in technical team to assess how effective was the system in: minimizing unit cost for treatment minimizing desludging frequency minimizing footprint
	Q6.3 To what extent is the private sector showing signs of interest and ability to take initiative to continue supplying the innovation and improve it beyond the project period?	Has this innovation created a positive sum game between the public sector, private sector and local community stakeholders	SMEs	KII	Data will be triangulated through validating market potential

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
Q6. To what extent are the implemented solution likely to remain operational following the closure of the project? What are the conditions to maintain their sustainability?	Q6.4 to what extent the local supply chain can take on its account the implementation of such systems (probe for the manufacturing aspects, materials supply, affordable costs?) Q6.5. To which extent can the technological solution apply to other humanitarian situations globally? What are the enabling factors for a successful replication of this technology?	Are there specific barriers with standardisation and quality control of sanitation technology? Is the final price affordable from the demand side point of view? Is the final price affordable from the demand side point of view (price structure: final price, substitution effect, labor cost, maintenance cost, running cost, negative externality cost, energy, alternative energy, etc.)	local authorities, SMEs, individuals	KII	The data will be triangulated on the level of SMEs, stakeholders, and validating market potential
Gender			Program Stakeholders	KIIs & FGDs	
Q7. To what extent has this initiative's design and implementation taken gender into consideration?	Q7.1 To what extent are project objectives and activities aligned with UNICEF's strategy, especially on equity, gender, and human rights aspects? Q7.2 To what extent are the equity and gender aspects present in the design and implementation phases of the projects? What were the related constraints faced and what were their solutions?	Are both women and men able to safely use of water and sanitation facilities? Are of the sanitation practices of women and men having an impact on the waste water systems? To what extent have women been involved in the conception, management, decision-making, and maintenance mechanisms of the project? Are there any gender-sensitive complaint mechanisms within the project's framework? Are women and girls able to submit complaints and comfortable with the process?	All	all	Data will be verified with through comparing these questions among all the tools
Partnership					

Main Questions	Sub Questions	Suggested questions	Data Source (Stakeholders and population, etc.)	Data Collection Methods, Sampling and Tools	Data Analysis Plan
Q8. To what extent did the partnerships with IpsIPs, institutions and the private sector facilitate the achievement of the project outcomes		How were partnerships built? What are the lessons learned about the partnerships; decision making processes and partners' ability to adapt What are the lessons learnt about government engagement? What were the main successes and challenges in engaging the private sector? To what extent was the design process collaborative and consultative with the project partners? Which project partners/ SMEs grew and acquired new skill sets? What enabled the learning?	SMEs, institutions-ministries, LRI, BWE, Municipalities , UNICEF and partners	KII & SGIs	Triangulation

For further information, please contact:
Evaluation Office
United Nations Children's Fund
Three United Nations Plaza
New York, New York 10017
evalhelp@unicef.org
www.unicef.org/evaluation