Installation of Rainwater Harvesting Systems in Akkar: Research Study

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Introduction

Water that is clean and easily available is essential for individual and community wellbeing. However, in many parts of Lebanon, multiple populations, especially vulnerable groups such as refugees living in Informal Tented Settlements (ITSs) lack access to safe water (UNICEF, 2021). The inflow of Syrian refugees, as well as the accompanying increase in demand for clean and secure water and wastewater services, has placed further strain on the water resource management system. The Water, Sanitation, and Hygiene (WASH) situation among Syrian refugees in Lebanon is characterized by water scarcity, as well as poor sanitation, with varying circumstances depending on the type of shelter (VASYR, 2021). Families living in non-residential and non-permanent buildings such as ITSs, who do not have access to adequate WASH facilities are among Lebanon's most vulnerable groups (UNHCR, 2021).

Since 2012, World Vision Lebanon (WVL) had been providing water-trucking services for vulnerable communities in areas where there is a shortage of clean and accessible water sources. Equitable access to a sufficient quantity of safe water for drinking, cooking, personal and domestic hygiene in Informal Tented Settlements (ITS) was guaranteed, in alignment with both the strategy of the WASH sector and donors' requirements, and depending on the availability of alternative water sources. In addition to the water-trucking services, WVL rehabilitated wells to ensure WASH Sphere minimum standards are met. WVL also provided rehabilitation/construction of latrines, site sludge removal and wastewater pilot programming.

Even though water trucking can be a valuable method in addressing short-term water supply challenges, particularly in emergencies, it is important to consider its:

- **Cost** as it is expensive, especially when considering the fuel, maintenance, and labor costs associated with operating the trucks. It might also involve the expense of treating water to meet health and safety standards.

- **Environmental Impact** as it contributes to carbon emissions and air pollution due to the fuel consumption of the trucks. Additionally, the extraction of water from natural sources can impact local ecosystems.

- **Limited Capacity** as the amount of water that can be transported in a single trip is limited by the capacity of the truck's tank. This can lead to multiple trips, increasing costs and environmental impact.

- **Infrastructure Dependency** as relying solely on water trucking does not address the root cause of water scarcity. It is important to work towards establishing more sustainable and reliable water supply infrastructure.

- **Weather and Road Conditions** can affect the ability of water trucks to deliver water on time and in the desired quantities.

Therefore, long-term solutions that focus on establishing reliable water infrastructure and sustainable water sources have to be pursued to address water scarcity more effectively in Lebanon.

In this context, and to find more sustainable, efficient, and environmentally friendly methods, WVL conducted a pilot project in ITSs for refugee communities in Akkar, where it is installing rainwater harvesting systems in two sites. This intervention aims to increase access of vulnerable communities to water supply and it aligns with some of the Sustainable Development Goals (SDGs) such as SDG 3 (good health and well-being) by providing a safe water supply to avoid disease transmission, as well as SDG 6 (clean water and sanitation for all).

On the contrary, rainwater harvesting systems are important for a variety of reasons, ranging from environmental benefits to practical applications, especially:

- **Cost Savings** for the vulnerable communities, as less money will be spent on purchasing water.

- **Water Conservation** as rainwater harvesting systems allow for the collection and storage of rainwater that would otherwise flow away as runoff. This collected water can be used for various purposes, such as irrigation, flushing toilets, washing clothes, and more, reducing the demand on water trucking.

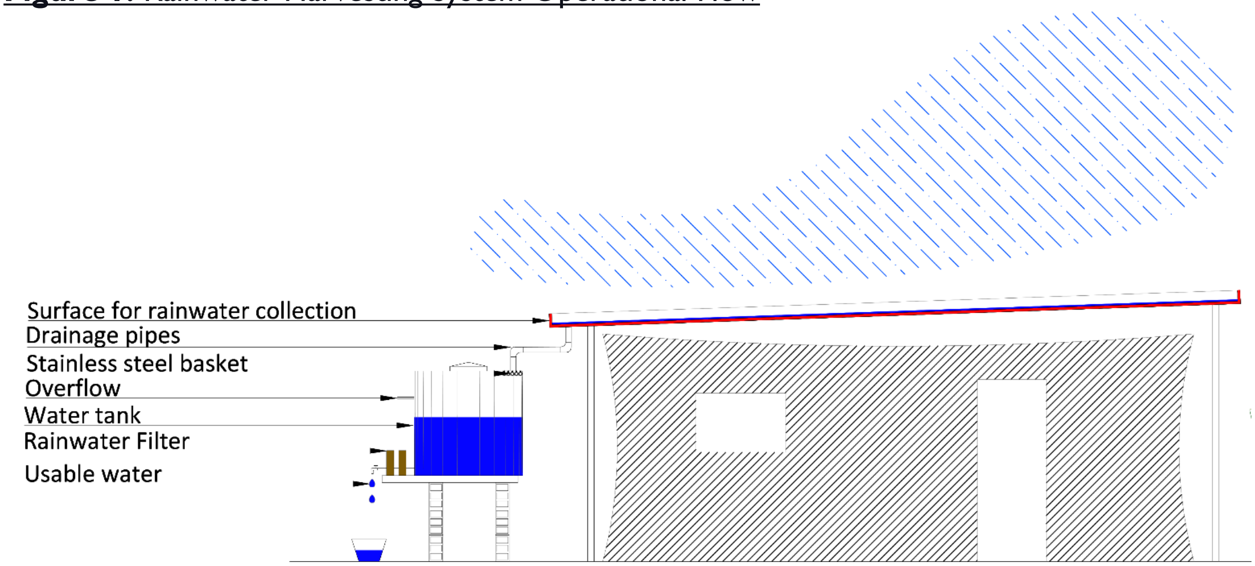
- **Sustainable Water Management** by utilizing rainwater that falls naturally.

- **Reduced Strain on Infrastructure** by alleviating the burden on centralized water treatment and distribution systems, which is highly impacted during peak demand periods such as summers.

- **Climate Resilience** as capturing rainwater provides a decentralized water source that can be more reliable during weather-related challenges. which aligns with World Vision core value "We are Stewards" (*We are stewards of God's creation. We care for the earth and act in ways that will restore and protect the environment*).

Conceptually, rainwater-harvesting systems collect, store, and provide filtered rainwater (see figure 1). The systems (1) collect rainwater through placing a roof-like structure above the tents, which in turn (2) transport the water through gravity in a tube, leading to (3) a container where the water is stored, where it finally (4) passes through a filter and becomes accessible. Collecting and storing this water for use during rainy seasons is important, especially when water is scarce, as it presents a simple and potentially low-cost and sustainable method for collecting and storing rainwater for everyday use (Ltd, 2019).

Figure 1. Rainwater Harvesting System Operational Flow



It is fairly easy to get the rainwater harvesting systems parts, in case of maintenance, as all components exist in the market and are produced locally. The maintenance cost will range between 3 to 5% per year (out of the total system cost, which is equal to 166 USD per year on average).

The supply and installation costs are as follows:

- Surface cost is 3500 USD
- Structure cost is 250 USD
- Gutter cost is 50 USD
- 1000 Liter-tank cost is 100 USD
- 2000 Liter-tank cost is 150 USD
- Filter and fosset cost is 100 USD

Lebanon has a Mediterranean-type climate characterized by hot and dry summers (June to September) and cool and rainy winters (December to April). The mean annual rainfall on the coast ranges between 700 and 1,000 mm and about 70% of the average rainfall in the country falls between November and March (Ministry of Environment and UNDP, 2022). The number of rainy days usually varies between 60 and 80, while the number of snowy days can exceed 30 at high altitudes. According to the official website of the Lebanon Meteorological Service, the rainfall quantity for 2022 was 845.5 mm in Tripoli alone, a city located in the country's north. Monthly climatic parameters for Lebanon's capital, for the duration of the pilot, are presented in table 1.

Table 1: Averages of the climatic parameters from December 2022 to April 2023 in Lebanon

Parameters	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23
Max temperature (Celsius)[1]	23	24	24	27	26
Min temperature (Celsius)	11	10	11	7	7
Mean temperature (Celsius)	N/A	13.4	14.1	16.5	20.4
Sunshine duration (hours)[2]	N/A	5.1	6.1	7	8.4
Rain quantity (mm)	N/A	160	123	99	45

Evaluation Criteria

The governorate of Akkar, located in the country's north, is home to more than 500,000 vulnerable Lebanese living below the poverty line, as well as more than a quarter-million Syrian and Palestinian refugees living in terrible conditions (UNICEF, 2021).
Akkar area was selected for this pilot as the rainy season in the North of Lebanon, and its coastal areas, tends to be more intense with recurrent rainfall compared to inland regions and those in mountains. Additionally, the underground water in the selected area is polluted and salinized, as reported by WVL WASH Technical Specialist. Finally, it is worth mentioning WVL's good presence and relation in the area, and the expressed interest of communities to participate in the pilot which was also accounted for.
Community members of the two sites selected to receive the intervention were interviewed in February (mid-term) and May 2023 (end-line) as part of WVL's monitoring effort. The interviews consisted of semi-structured interviews with the "Shawish" or landlord of each site and informal talks with community members, coupled with the team's observations.

Results of this monitoring efforts are reported under each of the OECD-DAC components.

1. Relevance: is the intervention doing the right things?

Access to safe and clean water and sanitation is recognized as not only a fundamental right but also as fundamental for full life enjoyment as well as other human rights, including the right to health (United Nations, 2015). Trucked water provided by the UN or NGOs was the most common drinking water source (28%), followed by bottled mineral water (11%). Furthermore, just 12% of people living in non-permanent shelters have access to a flush toilet, with the majority (55%) relying on an improved pit latrine with a cement slab (VaSyr, 2021). For this reason, installing these proposed systems represents an essential response to water needs in the community, and this was corroborated following our interviews.

After interviewing members of two different ITSs during February 2023, it became apparent that the intervention responded to a priority need in the community. When community members

[1] https://weather.com/
[2] https://www.weather2visit.com/middle-east/lebanon/beirut-january.htm

were asked about their feedback on the intervention, their responses highlighted the challenges it helped them overcome and the gaps it filled in their community. Many mentioned that the system helped them save money as their general water supply became independent of other purchasing sources; the household can save around 25 USD per month on water.

The above figure is calculated based on the WASH sector's standard where an individual needs 35 liters of water per day to cover the drinking, cooking, and other domestic use. Thus, as the rainwater is not drinkable due to the absence of minerals, the collected water will cover 27.5 l/c/d for domestic use like personal hygiene, cleaning, and washing purposes.

Access to clean water requirement (liters/p/d)	27.5
Total water required per year (liters)	10037.5
Direct cost of water (delivered to site) USD/beneficiary/year	27.60313
Cost of direct staff relating to the service USD beneficiary/year	17
Cost of running the operations (fleet, fuel, office rental and stationaries…) USD beneficiary/year	5.75
Cost of indirect staff relating to the service USD/beneficiary/year	6
Total cost USD/beneficiary/year	**56.35313**

The overall amount of saved money stands around **28 USD per person** per season (6 months) and usually the average number of Syrian households is six people; therefore, by using the rainwater harvesting system, more than **168 USD can be saved per household per season on water**, which can be used to cover needs that are more urgent.

"The installation of the system is saving us a lot of money, we are not paying as much as we used to, to get water", Male community member, site 2

"Before the rainwater harvesting system, I was required to turn on the water pumps, which need diesel. This is very expensive these days", Shawish, site 1

End-line data collected in May 2023 confirm that the system met a critical need in the community. Members of both ITSs believe that the system is a good solution to water scarcity during the winter season. Community members in both sites reported using water mainly for drinking, despite being instructed not to, as they believe that the quality is better than other sources they have access to.

2. Coherence: How well does the intervention fit?

Considering the crucial environmental factors and recent observable reductions in funding, the rainwater harvesting system intervention fits well with the humanitarian context in Lebanon. This is because it is repeatedly being argued that WASH services such as water trucking are increasing the dependence of vulnerable groups in ITSs on humanitarian aid, without strengthening their coping mechanisms and resilience. In this regard, this intervention has the potential to overcome this challenge as, under the right circumstances, it could significantly decrease the reliance of ITS residents on WASH-related services provided by humanitarian organizations and improve their self-sufficiency in terms of accessing water.

Furthermore, rainwater-harvesting systems allow vulnerable households, in ITSs and generally, to save money usually spent on water so that it used elsewhere (on expenditures that are more urgent).

Add to that, coherence also considers the involvement of relevant stakeholders. This proposed activity engaged key stakeholders appropriately (the ITS residents and Shawishes in this case who expressed interest in the innovative service). WVL ensured that the aforementioned perspectives and needs are taken into account.

Finally, the rainwater-harvesting systems' impact aligns with WVL strategy (mainly the WASH, Livelihoods and Child Protection sectors), which would allow the mission to further serve the most vulnerable populations.

3. Effectiveness: is the intervention achieving its objectives?

In terms of effectiveness, the intervention is largely accomplishing its goals by providing a source of clean water for domestic use in ITSs. As stated by members at both sites at midterm, they observed a dramatic reduction in the amount of water purchased from other sources when the tanks are filled with rainwater. The large reliance on wells and pumping water was eliminated when the tanks were filled.

"We're not buying much water, we used to buy a lot but now the tank is getting filled all the time", Female community member site 1

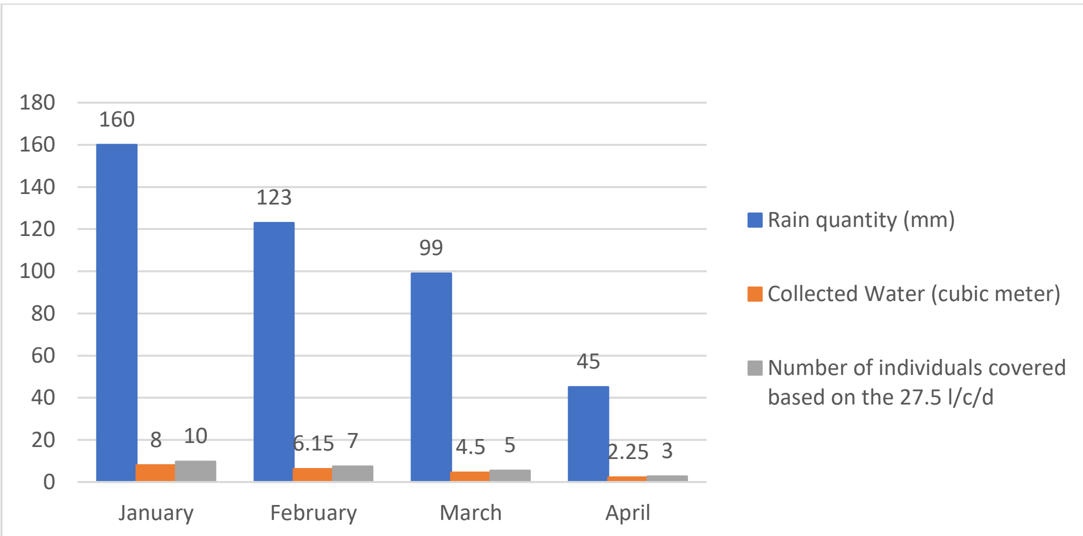
End-line data were congruent, as a household representative in site 1 mentioned,

"After having the system, our water costs decreased as we are purchasing less water." Female ommunity member site 2

Generally speaking, this means that the intervention is to a large extent accomplishing its main goals of improving access to water, albeit partially and seasonally. This is because it remains to be seen whether or not this water can be used for purposes other than merely domestic use. Another reason is because the systems are effective as long as there is rain, and in its current form, it has little utility during periods of drought beyond it being used as a water container. It is therefore important to find alternative methods to avoid water waste during rainy times and thereby better storing them for periods of drought.

Parameters	Jan-23	Feb-23	Mar-23	Apr-23
Rain quantity (mm)	160	123	99	45

Collected water in 50sqm surface (cubic meter)	8	6.15	4.5	2.25



4. <u>Efficiency: how well are resources being used?</u>

The intervention's resources appear to be used efficiently. Community members noted that there is seldom any wasting of water, and that the water given is being used largely for sanitary purposes. However, community members in one site stated at midterm their desire for the water to be chlorinated for it to be safe for drinking, while those of the other site mentioned drinking the water despite being warned of its lack of safety for drinking.

"We are utilizing the water to wash fruits and vegetables, to do laundry, to shower, and to clean the house", Female community member, site 1

"They (WVL) informed us that they will be adding chlorine to the water so we can drink it… We want it to be safe for drinking", Female community member, site 2

Many members mentioned wanting the rainwater to last longer. Based on estimated calculations, in the first site, 2 community-level systems containing 2 tanks (each with capacity to hold 2,000 liters of water) are being used by 10 households, an estimated 80 individuals, with water lasting for around an estimated 7 to 10 days. In the second site, the rainwater is lasting between 15 to 20 days, for approximately seven households using four individual-level systems containing four tanks (each with capacity to hold 1,000 liters of water). ITS residents expressed a need for installation of additional rainwater harvesting systems as a way to increase their water reserve, pointing specifically towards the need to have additional containers of water. The cost of the tanks is affordable and stands at 100 USD for a tank of 1000 liter-capacity and at 150 USD to a tank of 2000 liter-capacity. A big tank of 2000 liters can serve up to 100 persons a day in emergency settings (based of the Sphere recommendation, 20 liters are required per day per person).

"It is fortunate that all the tanks are filled with enough water within 2-10 minutes of rain" Shawish, site 2

"We are approximately 7 families, and the rainwater lasts between 15 to 20 days, but if we had bigger tanks it would last longer," Male community member, site 2

This means that the intervention could be a lot more efficient in terms of value for money should each site contain one community-level harvesting system, which is quite costly, and instead of installing multiple household systems, the money could be allocated to purchase more containers which cost significantly less than the rest of the system. In this regard, every system could have multiple containers connected to it to reduce wasting of rainwater and to contain more water for longer periods of time. The calculation of the needed should be linked to the population number and not to the number of tanks to be purchased

At end-line, members of both ITSs said that whenever rain falls, rainwater fills the whole tank and lasts for an average of 7 days. Moreover, participants were asked if adding more storage to the system would help, and responses varied between the two ITSs. Site 2 residents and landlord agreed that more space for storage would allow water to last longer, while site 1 residents and landlord disagreed with this.

"Providing more tanks will make the system sustainable as the tanks are protected in a shielded area, which preserves water quality." – Landlord, site 2

"Water quality will no longer be good if stored for longer periods, so increasing the size of the tank would not help." – Male community member, site 1

5. Impact: what difference does the intervention make?

At the community level, the intervention seems to be making a positive impact, although it may be early to ascertain this claim given the implementation timeline. This is partly demonstrated by the fact that community members stated that having a clean water supply saves them money (as mentioned before the savings on water are equal to 25 USD per person and to an average of 150 USD per household) on buying water and on pumping water from wells. Furthermore, even when the tanks are empty of rainwater, they can still be used for other purposes such as containing water from other sources such as water trucking. Another indirect benefit is the roofing protection that the system provides to shield from rain and sun, which based on observation, provided additional benefits. When asked about encountering any infections, community members stated not having any associated with using water from these systems. This indicates that the water retrieved from the system so far is not associated with any health problems. In addition, the lack of reports on health issues arising from the use of rainwater may indicate an increase in sanitary practices.

"When the rainwater is done, we still fill the tank again with water from the communal tank since the filter will purify the water", Male community member, site 2

"We have not faced any health issues because of the water", Female community member, site 2

Community members are peacefully sharing the tanks, and no major tension has been reported so far between community members. However, the Shawish of one site mentioned that a neighboring site also wanted a similar system, which is understandable at this point given its potential to improve access to water. WVL will closely follow-up on the situation to avoid any tensions.

"There are no problems whatsoever, we are all a family and we share water" said one resident. "There are different tanks in the site to use". Female community member, site 1

"They think the tanks were installed in my land because my uncle works in the municipality" Shawish, site 1

At end line, community members benefitting from communal and household systems in site 1 did raise the need for water trucking during the summer. They suggested the use of the system tanks for storage of trucked water. Besides, a community member in this site said that they use system tanks for storage of borehole water. Water testing results show traces of chlorine due to past water trucking, revealing that households utilized the system to store water from other water sources, namely water trucking. The chlorine detected through water testing limited the ability to collect information on water quality provided by the system.

As data and observations show, households residing in site 1 removed the filters connected to the system as members believe it reduced water quality by changing its color to black. Based on the above mentioned, it is recommended to implement awareness raising activities that aim at clarifying the goal of the filter and what to expect.

Power dynamics between landlord and residents were noticeable in site 2. While it is perceptible that the system functioned better when landlord conducts regular follow up, data show that the landlord gets to say who can benefit from the system. Site 2 is an ITS built on land shared by two landlords, and includes one communal and two household systems, built both on one landlord's property. Interview results reveal that the landlord for which the systems were built did allow access to water only to ITS residents with tents built over his land, two in total, preventing other tents in the same ITS from accessing water. It is also to note that at end line, the communal system in this site was not operational as it was broken while cleaning, and a pipe was stolen. This shows the need for frequent follow up from World Vision as well as provision of awareness sessions on system cleaning.

6. Sustainability: will the benefits last?

The current model has strong potential for sustainability; however, it is a seasonal solution (only applicable in winter when it comes to the access to water). This is because availability of water in the system is dependent on the presence of rain, which presents a major limitation to the intervention. Nevertheless, this limitation could be addressed by increasing the number of containers/tanks, which is a more affordable option when compared to purchasing additional harvesting systems. The cost of the tanks is affordable and stands at 100 USD for a tank of 1000 liter-capacity and at 150 USD to a tank of 2000 liter-capacity. In this regard, it is recommended to allocate more budget, in future similar interventions, on procuring more water containers as opposed to more systems within a given site.

"As long as there is rain, there is water in the tanks, but otherwise I have to supply them water and I have to pay for diesel to turn on the water pumps of the site, it is expensive and concerning for summer", Shawish, site 1

Additionally, number of months where the system can be used can stand at **six months per year**, depending on the rainy season in Lebanon (from October until April) which will alleviate the water dependency of vulnerable communities on NGOs or personal spending. The total savings on water per household per year is more than 150 USD, which accumulate to 1.5 times the minimum monthly wage in Lebanon (almost 100 USD during the month of the data collection).

Add to that the **lifetime use of the system** based on the international standards is 15 years, which allows vulnerable communities to benefit from a sustainable solution for longer periods of time, without depending much of relief and life-saving activities from NGOs.

Another concern in sustainability is vandalism or theft of rainwater harvesting systems. However, this can be addressed by having a focal point in each community who oversees such risks. This was observed in both sites visited, whereby the Shawish of both lands had good control of this issue and no vandalism or theft of the systems was observed.

"I have strong control over the people who work here, I warned them that if any tank is missing I would be removing 20,000 LBP from their daily stipend, this is why they don't touch the tanks, but this is not the case in other lands".

With that said, it is important to consider that an essential component of this intervention's sustainability is associated with capacitating community members preferably or at least assigning a couple of focal points from the community to watch over the systems.

Finally, this intervention has much potential for sustainability since this method of harvesting rainwater is eco-friendly by virtue of it reducing usage of fuel to pump water and fueling trucks used to transport water.

At end line, site 1 landlord agreed that sustainable water solutions are essential, given the current situation. He added that households are using the system as containers during the dry season. However, he mentioned that the installation of a solar system for the borehole connected to the members' tanks would provide more benefits to the community.

Cost-Efficiency Analysis

A comparative analysis was conducted for household and communal rainwater systems against traditional water trucking service. The analysis covers the comparison of costs per person per year, and the assessment of sustainability aspects for each system. To break it down:

Cost analysis

Communal rainwater harvesting system costs 10.42 USD per person per year.

Calculation logic: this system costs 12,500 USD in total (as per the market rate at the time), it supplies 14 households, with an average of 80 individuals, and the system lasts an average of 15 years.

HH rainwater harvesting system costs 51.6 USD per person per year.

Calculation logic: This system costs 3,870 USD in total, it supplies one household, with an average of five individuals, and the system lasts an average of 15 years.

The rainwater harvesting system, particularly the communal option, with estimated cost of 10.42 USD per person per year, proves to offer significant cost savings when compared to water trucking, with estimated cost of 63.88 USD [3]per person per year. The household rainwater harvesting system is a more expensive option, estimated at 51.6 USD per person per year, yet proffers a better alternative to water trucking when it comes to costs (see table 2). WVL MEAL team observed that neighboring tents were also benefiting from the household rainwater harvesting system; this proves the positive impact of the household system and can positively affect the social cohesion within ITSs.

Table 2. Comparative Cost-Efficiency Sustainability Analysis

Aspect	Rainwater harvesting system	Water trucking
Cost (per person per year)	Communal system: 10.42 USD Household system: 51.6 USD	63.88 USD
Sustainability	Minimizes carbon emissions and air pollution.	Increases carbon emissions and air pollution.

[3] WVL WASH team calculated the water trucking cost based on actual numbers from 2021 and 2022. Do note that the cost analysis includes the suppliers' humanitarian salaries yet excludes maintenance costs and WVL staff salaries.

	Conserves water sources/ ecosystems.	Puts pressure on water sources.
	Minimizes dependency on external water sources.	Not suitable for limited water sources.
	Requires less funding for inspection and maintenance.	Requires continuous funding for water delivery.

Conclusion and recommendations

Overall, the system appears to be benefiting members of selected ITSs in Akkar. When asked about further recommendations that may improve the intervention, community members expressed their satisfaction with the system with no further comments other than the ones mentioned above. It was therefore made clear that this pilot project resulted in positive outcomes. Many of the stated limitations in this report have the potential to be prevented, including focusing more on installing multiple lost-cost containers instead of multiple household systems per site, ensuring proper monitoring of the systems, among others. In general, this project has the potential for scalability and has the potential to provide better value for money when compared to alternatives modalities such as water trucking.

Recommendations include:

1- Prioritizing installation of one community-level system per site, over household-system, while increasing the number and volume of tanks and containers. It was apparent from the monitoring effort that the value of the system is in how much water it can preserve as opposed to collect. The aim should be to increase storage capacity of water per site and reduce wasted rainwater.

2- Combining the rainwater harvesting system with other alternatives, especially in the dry seasons (summers), such as solar panels and/or pumps (in case boreholes exist in the areas of implementation). This tandem approach will ensure the access of vulnerable communities to water during the entire year and will reduce the costs needed to reach similar states (efficiency).

3- Ensuring creation of adequate systems and eliminating the risk for theft and vandalism. Based on current findings, it is important to allocate a focal point in each site, which in many cases could be the Shawish of the site or other active men and/or women. However, power dynamics should be considered to ensure fair access to water.

4- Considering that communities largely share resources among each other, this means that it is futile to install household-level systems. Therefore, the focus should be on the community in general. This is because findings showed that even household-level systems were shared by the community. Additionally, no community tensions were noticed.

5- Building on the communities' appetite to using the rainwater harvesting system as a gathering point as it provides shade in the spring and summer seasons. Based on the MEAL (unannounced) field visits to the implementation areas, many residents (especially men) were sitting and chatting under the system. This was later confirmed during the interviews with Shawishes.

6- Finding solutions to make the water potentially better suited for drinking purposes; this could be by distributing chlorination tablets, while reminding the community of the need to refrain from using rainwater for drinking until solutions are provided. For future projects, it is important distribute chlorination tablets at the beginning of implementation to mitigate the risk.

7- Conducting frequent maintenance and follow-up by World Vision Lebanon to pilot sites.

8- Educating both men and women on the importance of hygiene and sanitation practices related to rainwater usage and provide training on water purification methods.

9- Ensuring that rainwater-harvesting infrastructure is easily accessible to all community members regardless to their sex and disability. Design pathways, taps, and storage facilities in a way that is convenient and safe for women and People with Disability (PWD).

10- Involving women in the monitoring and follow-up on the system by establishing committee that include men and women. Additionally to use the feedback from both men and women on the overall system to continuously improve the situation.

11- Raising community awareness on the role of filters, chlorine and system cleaning.

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