39th WEDC International Conference, Kumasi, Ghana, 2016

ENSURING AVAILABILITY AND SUSTAINABLE MANAGEMENT
OF WATER AND SANITATION FOR ALL

Utilising solar water pumping for development-oriented relief in refugee settings in Uganda

A. Armstrong (USA) & R. Nakafeero (Uganda)

BRIEFING PAPER 2500

Roughly half of the world's refugees have been in exile for over ten years. In relief settings that have potential to become protracted, it is critical that WASH interventions aim for sustainable, even development-oriented outcomes. Since 2012, Water Mission has designed, constructed, and supported 10 solar pumping systems for potable water supply in refugee settings in Northern and Western Uganda in a development-oriented manner. This paper offers a summary of these experiences and the technical, financial, institutional, operational, and social considerations that went into the design of the intervention. Recommendations for steps that can be taken to encourage sustainability of solar water pumping systems in refugee settings, specifically with respect to local participation, ownership, and life-cycle cost recovery are also provided.

Background

Data from the past 35 years indicates that less than one in forty refugee crises are resolved within three years and become protracted in nature, usually lasting a matter of decades. Roughly half of the world's refugees have been in exile for over ten years (IMCD, 2015). As such, the case hardly needs to be made for sustainable interventions and approaches in refugee settings. It might even be argued that relief strategies in refugee settings should be *development-oriented* in nature by aiming to contribute to sustainable growth in the long-term, while still being considerate of contextual constraints such as limited livelihoods, available income, and mobility.

One example of how relief to refugees can be development-oriented is through long-term service provision of safe water. The United Nations High Commissioner for Refugees (UNHCR) now requires water facilities in refugee settings to be designed for long-term service, taking into account all dimensions of sustainability (UNHCR, 2014a). When poor water quality or high population density and growth limit the applicability of water trucking or boreholes fitted with handpumps in refugee settings, long-term service provision and system expansion has typically involved mechanizing boreholes with fuel-powered pumping systems where water is pumped from boreholes to elevated storage tanks and then fed into piped distribution systems.

Solar powered water pumping systems are replacing fuel-powered systems in relief settings at an increasing rate, especially as technological advancements make solar schemes more robust and photovoltaic modules more affordable. The broad applicability of battery-less solar water pumping systems, where energy storage takes the form of storing water in elevated tanks, and of hybrid systems, where solar power is utilised during sunlight hours and fuel power during periods of low to no sunlight in refugee settings has been reported (Kraehenbuehl et al., 2015). Life-cycle cost analyses have indicated that long-term operational savings on fuel and capital maintenance savings make solar pumping systems more cost effective than alternative mechanized pumping systems (Bannister, 2000; Odeh et al., 2006; Meah et al., 2008). Costs and sustainability of solar water pumping systems in refugee settings in East Africa have also been recently reported (Lorentz, 2014; Runo and Muema, 2014; Kraehenbuehl et al., 2015).

Although the technical and financial viability of solar pumping for potable water supply has often been debated, less has been documented about institutional sustainability and social preferences of such systems, especially in relief contexts. Short and Thompson have described a number of the social issues that might influence the applicability of solar pumping systems such as sense of ownership, social norms and cohesion, and gender roles (Short, 2003). The WASHTech *Technology Applicability Framework* has been applied to solar pumping in development settings in Uganda, Ghana, and South Sudan, where social implications of such systems in specific regional contexts were identified (NETWAS & WaterAid Uganda, 2013; TREND et al., 2013; VNG & IRC, 2014). Water Mission has also indicated the importance of a sound relationship between service population and management personnel, household financial status, and cultural norms in sustaining solar pumping systems (Check, 2015). Still, there is need for practical experience with solar water pumping systems in refugee settings to be shared.

Since late 2012, Water Mission has designed, constructed, and supported solar water pumping systems in Sudanese and Congolese refugee settings at 10 sites across Northern and Western Uganda. The names of these sites, along with respective districts and service populations, are presented in Table 1. This paper presents collective experience with utilising solar water pumping for development-oriented relief in this context. Recommendations for encouraging sustainability of solar water pumping systems in refugee settings with respect to demand generation, ownership, self-reliance, and life-cycle cost recovery are offered.

Table 1. Refugee sites serviced by solar water pumping systems in Uganda

Site Name	Settlement	Nationality of Refugees	District	Est. Population of Service Area
Ayilo 1	Ayilo	Sudanese[1]	Adjumani	5,400
Birra Health Centre	Boroli	Sudanese[1]	Adjumani	1,400
Boroli	Boroli	Sudanese	Adjumani	2,000
Kaihora C	Rwamwanja	Congolese	Kamwenge	2,000
Katiku 1 & 2	Rhino Camp	Sudanese	Arua	1,600
Kyempango C	Rwamwanja	Congolese[1]	Kamwenge	1,800
Maaji	Maaji	Sudanese	Adjumani	1,100
Nyumanzi E & F	Nyumanzi	Sudanese	Adjumani	7,000
Odubu 2	Rhino Camp	Sudanese[1]	Arua	1,500
Rwamwanja School	Rwamwanja	Congolese[1]	Kamwenge	2,300

Design and performance of solar pumping systems in refugee settings

Technical considerations

A summary of the technical design specifications of the solar water pumping systems that have been constructed by Water Mission in refugee settings is provided in Box 1. Care was taken to ensure the technical performance, design life, and ease of operation and maintenance met expectations of refugees in the service area in order to increase likelihood of utilisation and willingness to contribute to ongoing costs.

Box 1. Technical specifications of solar water pumping systems constructed by water mission in refugee settings in Uganda

The 10 solar water pumping systems that have been constructed to-date can be characterized as follows:

- **Water sources –** Boreholes with average safe yield of 10 m^3/hr (min 3; max 30)
- **Water quality –** All groundwater sources below Sphere guideline value for turbidity (5 NTU), erosion chlorination step included to add disinfectant residual during collection, transport, and storage
- **System demand –** Average design population of 2,610 people per scheme (min 1,100; max 7,000) with basic water needs of 15 L per person per day, average demand of 39 m^3/day (min 17; max 105)
- **Pumps –** Various models of Grundfos SP, SQ, and SQF pumps with average design pumping rate of 8 m^3/hr (min 5; max 10)
- **Power –** Average nominal solar array size of 2.7 kW (min 0.9; max 4.2); all systems installed with AC genset backup power systems for use when sunlight is limited (e.g. evening and rainy season)
- **Water storage –** Average storage volume 21 m^3 (min 10; max 30)
- **Distribution –** Average 4 public tap stands per scheme (min 2; max 5)
- **Estimated equipment lifespan –** 10+ years for solar pump and gensets, 20+ years for water sources and all other treatment and distribution equipment
- **Availability of spare parts –** Available through local reliable supply chains at an average distance from closest town of 93 km (min 64; max 120)

An example site plan for the solar water pumping system installed at Ayilo 1 is provided in Figure 1.

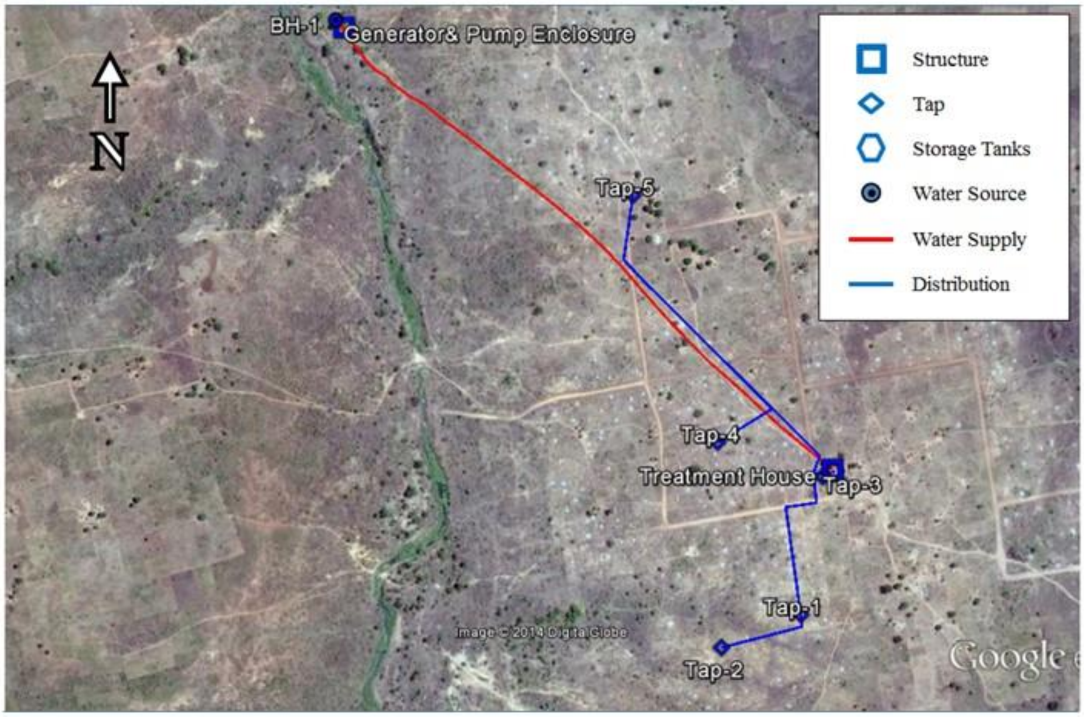

Figure 1. Site plan for solar water pumping system at Ayilo 1

At the time this paper was published, the solar water pumping systems had been operational for an average duration of 16 months (min 4; max 31). Over this time period, the systems produced an average of 19 m^3/day (min 8; max 35) of water with consistent turbidity of <5 NTU and chlorine residual at tap stands between 0.2 and 0.5 mg/L. A conservative estimate[2] would suggest that each of these systems have already saved an average of USD 1,800 and likely more than USD 3,500 in fuel costs over their relatively brief lifespans.

Economic and financial considerations

The average capital expenditure on the solar water pumping systems was USD 82,830 (min 41,022; max 127,337) which included equipment, infrastructure, travel, and labour for construction, installation, and capacity building. In addition to pre-construction activities, capital expenditures also included 12 months of post-construction capacity building efforts. Estimated expenditure on operation and minor maintenance was USD 150 per month and on major capital maintenance, including replacement of water source infrastructure and solar pumping and water treatment equipment adjusted for inflation, was USD 98 per month.

In all cases, refugees were mobilised to pay monthly tariffs of UGX 500 to 1,000 (USD 0.15 to 0.30) per household. Making a payment on any type of service is not a natural preference for refugees. However, with continued support and sensitisation on the relevance of user fee payments regardless of the amount, refugees have come to own and appreciate the practice. Although a few water user committees have not yet been able to open savings accounts, most have been able to generate cash reserves. The highest performing committees have been able to save more than UGX 1,000,000 (USD 300). In addition to covering operating costs such as operator salaries and chemicals, the funds collected from user fees have been used for fencing off water points as well as carrying out minor repairs and replacements, such as repairing tapstands.

Institutional and operational considerations

Key stakeholders such as District and Sub-County leadership, refugee desk officers, and representatives from UNHCR and other implementing agencies were engaged as early as possible in order to garner their support for the approach to involving refugees in ongoing service delivery as described in this paper. Such high level coordination serves to harmonise communication between implementing agencies and refugees in the service areas which in turn establishes a cross-cutting foundation of trust.

In all cases, Water Mission supported refugees to form water user committees which were intended to oversee the ongoing operation, maintenance, and administration of the systems under a community-based management structure. Depending on the expanse of the service area, two approaches were employed to select these committees. When the system serviced a single community, a centralized committee was elected to oversee the system components and one or two tap operators were selected to manage each distribution point. These committees typically comprised of representatives from all user groups such as institutions, local leaders, and women, among others. When the system serviced a broad area covering several communities and institutions, tap stand committees were formed such that the neighbourhood surrounding each distribution point took responsibility of overseeing their water point. This decentralization of responsibilities helped to reduce the burden on volunteer water user committees.

Responsibilities for financing, management, and external support were clearly set out and understood for each system. The following structures were used to ensure all responsibilities continue to be upheld:

- **Memorandum of Understanding** – Agreement between Water Mission and the water user committee documenting responsibilities of both parties, active for the duration of initial follow-up and support period and after which may be renewed
- **Safe Water Project Constitution** – Governing document for solar water pumping system developed by the water user committee and detailing project goals, roles and responsibilities, financial structure, and other pertinent arrangements
- **Financial Sustainability Plan** – Document detailing budget and cost recovery strategy
- **Water User Committee Logbooks** – Transparent and accountable record-keeping system for tracking income, expenses, bank statements and promotional activities

Refugees were set-up to manage the day-to-day technical operation and maintenance as well as administration of all solar water pumping systems. System operators were paid a salary from water user funds and tap operators were paid a commission based on volume of water sold at each respective distribution point. Specific skills that were transferred to refugees included:

- **Finance –** budgeting, fee-setting, handling money, keeping accurate financial records, saving funds
- **Operation and maintenance –** operating, repairing, and troubleshooting equipment, monitoring water quality, sourcing replacements
- **Promotion –** encouraging adoption of healthy WASH practices in the service area
- **Leadership –** resolving conflicts, replacing and training management personnel

Water Mission provided upfront and monthly unsolicited "on the job" training and support for a period of 12 months after system installation. After this initial period, responsibility for providing ongoing direct support was usually transferred to an implementing agency with committed long-term presence in the refugee camp, such as UNICEF. Efforts were also made to train respective district WASH officers to maintain and troubleshoot solar pumping systems.

Social considerations

Refugees were consulted and empowered to make decisions at each and every step of safe water service development and delivery, including design and layout of distribution networks, community mobilisation, selection of water user committees, establishment of user fees, operation, maintenance and administration of WASH facilities, and promotion and practice of healthy WASH behaviours. This allowed the end users to express a real demand for the service provided by solar pumping systems many times before the hardware was installed, and helped to foster additional demand in the broader service area. In addition, at least a third of the water user committee members were female local leaders, and opportunities were created for women to adopt the role of system operator. No other cultural taboos or biases towards other technologies that might cause users to reject solar pumping systems have been observed.

Conclusion

Refugees often carry a sense of dependency when they arrive in host countries. This can nurture a tendency to rely on relief agencies to solve problems and a reluctance to participate in development-oriented activities, and becomes exacerbated as handouts in various forms continue to be distributed to refugee populations. Not only does this dependency hinder sustainability of relief interventions, such as water supplies in refugee camps, it has negative implications on the long-term development of future generations as emergencies become protracted and drawn-out over decades.

Water Mission's experience indicates that solar water pumping is a viable development-oriented relief intervention in refugee settings in Uganda, not only due to technical and financial performance, but also its ability to increase demand and to generate ownership and self-reliance among end-user populations. It has been shown that increased service level and reliability of fuel source offered by solar pumping systems leads to increased demand and willingness to pay on the part of refugees. Refugee participation in the implementation, operation and maintenance, and ongoing financial cost recovery of solar water pumping systems has been shown to be both feasible and critical to positive outcomes. Well-delivered capacity building efforts, ongoing technical and administrative support and accountability, and routine intentional engagement and relationship building on behalf of the relief agency can also help refugees embrace development-oriented approaches despite their perceived vulnerabilities.

Unwavering support from key government and UN stakeholders and other implementing partners is vital for the success of the long-term approaches presented in this paper. Refugees respect the authority of these entities and take motivation to participate in development-oriented activities from them. If a unified demand-driven approach is universally adopted by all implementing partners, refugees are more likely to be supportive and have confidence in what is being promoted. The authors strongly encourage host governments and UN actors to encourage refugees to provide financial support towards the operation and maintenance of solar water pumping systems. Regardless of the size of the contribution, the end-users will develop an attachment to the facilities and will want to maintain them.

Acknowledgements

The work described in this paper was funded at large by UNICEF.

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Notes

1. The Ayilo 1, Birra Health Centre, Kyempango C, Odobu 2, and Rwamwanja School sites also serve Ugandan nationals.
2. Assumptions for this calculation include: reported average system duration and production; one litre of fuel can be used to pump three to five m^3 of water; average fuel cost in Kampala, Uganda is 0.99 USD/L (in reality, fuel would cost more for delivery in refugee settings); solar power on hybrid systems used to pump water 80% of time (during periods of sunlight or off-rainy season)

Contact details

About the author: Andrew Armstrong is a professionally licensed environmental engineer and programme manager at Water Mission with particular interests in sustainability, effectiveness, and capacity building. Ritah Nakafeero is a community development officer at Water Mission Uganda where she works to build capacity and provide support for management of rural water supplies.

Andrew Armstrong
1150 Kinzer St, Bldng 1605,
N. Charleston, SC 29405-1484 USA
Tel: (+1) 843-769-7395
Email: aarmstrong@watermission.org
www: http://watermission.org/