Global Solar and Water Initiative

Nigeria Visit Report – 6th to 19th April.

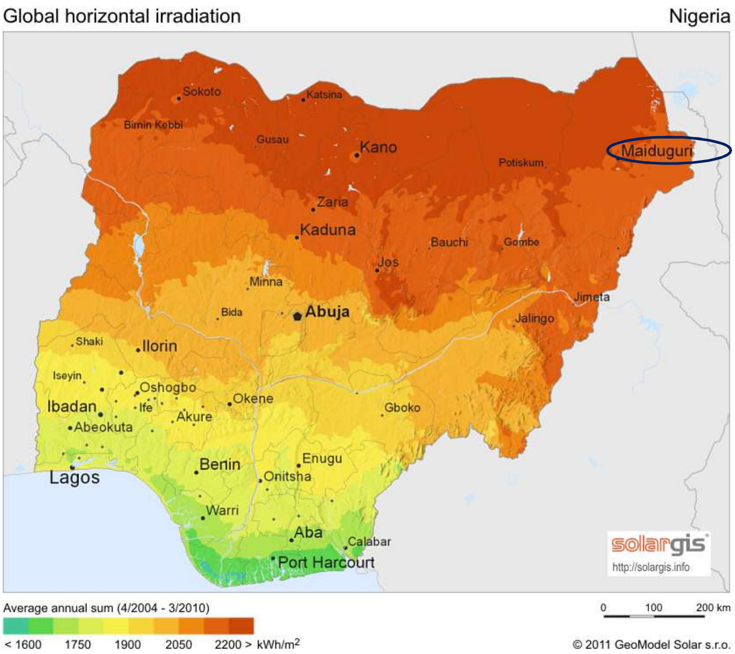
CONTENTS:

1 - OBJECTIVES OF THE TRIP AND AREA VISITED.

As part of the Global Solar & Water Initiative (see ***Annex A 'Programme Summary'*** for details), a 2-week visit to North-Eastern Nigeria was carried out with the following objectives:

- Raise water stakeholder awareness and technical capacity in design, O&M of solar water projects.
- Visits schemes in the field to assess work practices.
- Evaluate private sector price range and product quality in order to perform price comparisons.
- Produce recommendations and support implementation of steps to ensure quality use of solar pumping solutions.

Figure 1: Average annual Solar Irradiation – 1994-2010 and area visited (circled)



Due to ongoing attacks and security threats, 5 out of 6 days of field visits had to be carried out within the boundaries of Maiduguri town. Out of 60 boreholes for which information could be gathered at office level, 14 were selected for on site assessment for reasons of different layouts and different organizations managing the selected schemes.

Additionally, WASH Committee members from 11 different water points were interviewed in order to understand better problems faced and management models put in place.

Besides, a 3-day technical workshop organized counting with the participation of 29 engineers from 14 organizations (NGOs, UN, ICRC, State Ministry of Water and RUWASA) was carried out in Maiduguri.

Humanitarian Response Plan, 2019-Need Assessment Report and Nigerian WASH Technical Guidelines were discussed with several partners at different meetings.

The details of activities carried out during the visit can be found in ***Annex B 'Visit ToR and Training Agenda'.***

Table 1 – Water points assessed during field visits visit.

Site Details			Technical Design						Comment /Recommendation
No.	Location	BH ID	Existing Power Pump, kW	Solar Power Size, Wp	Daily Water Demand (m3/day)	Daily Output Solar (m^3/day) in average month	Daily Output Generator (m^3/day)	Combined Daily Output (m3/day)	
1	Konduga Boarding Sch Camp	IOM/MBH/KDG/0001	Grundfos SQF2.5-2	950	Unknown	16.9	0.0	16.9	Existing pump is okay though a smaller pump like the SQF 1.2-2 would have been more appropriate for the tested yield. The alternative was to use the SQF 2.5-2 but reduce the PV size to 800W
2	Konduga Boarding Sch Camp	IOM/MBH/KDG/0001	Grundfos SQF2.5-2	950	Unknown	16.9	0.0	16.9	Existing pump is okay though a smaller pump like the SQF 1.2-2 would have been more appropriate for the tested yield. The alternative was to use the SQF 2.5-2 but reduce the PV size to 800W
3	Konduga Boarding Sch Camp	IOM/MBH/KDG/0003	Grundfos SQF2.5-2	1000	Unknown	16.9	0.0	16.9	Existing pump is okay though a smaller pump like the SQF 1.2-2 would have been more appropriate for the tested yield. The alternative was to use the SQF 2.5-2 but reduce the PV size to 800W
4	Konduga-Mandarari HC	IOM/MBH/MHC/0007	Grundfos SQF2.5-2	1000	Unknown	16.9	0.0	16.9	SQ F 2.5-2 is appropriate for the borehole characteristics.900W of solar PV would be more appropriate
5	Maiduguri town	IOM/MBH/MMC/0002	Grundfos SQF2.5-2	800	Unknown	14.6	0.0	14.6	SQ F 2.5-2 is appropriate for the borehole characteristics.900W of solar PV would be more appropriate
6	Maiduguri town	IOM/MBH/FGB/0001	Grundfos SQF2.5-2	1000	Unknown	16.9	0.0	16.9	SQ F 2.5-2 is appropriate for the borehole characteristics.1200W of solar PV would be more appropriate to extract the full potential of the borehole
7	Maiduguri town	IOM/MBH/MMC/0001	Grundfos SQF2.5-2	800	Unknown	14.6	0.0	14.6	Existing pump is okay though a smaller pump like the SQF 1.2-2 would have been more appropriate for the tested yield. Solar PV size is okay.
8	Maiduguri town	IOM/MBH/MNM/0001	Grundfos SQF2.5-2	1000	Unknown	16.9	0.0	16.9	SQ F 2.5-2 is appropriate for the borehole characteristics.900W of solar PV would be more appropriate
9	Maiduguri town	NRC/ L	Grundfos SQF2.5-2	800	Unknown	14.6	0.0	14.6	SQ F 2.5-2 is appropriate for the borehole characteristics. 1000W of solar PV would be more appropriate
10	Maiduguri town	NRC/ N	Grundfos SQF2.5-2	780	Unknown	14.6	0.0	14.6	SQ F 2.5-2 is appropriate for the borehole characteristics. 1000W of solar PV would be more appropriate
11	Maiduguri town	NRC/ 0	Grundfos SQF2.5-2	780	Unknown	14.6	0.0	14.6	SQ F 2.5-2 is appropriate for the borehole characteristics. 1000W of solar PV would be more appropriate
12	Maiduguri town	NRC/ K	Grundfos SQF2.5-2	1000	Unknown	16.9	0.0	16.9	SQ F 2.5-2 is appropriate for the borehole characteristics. Solar PV size is also okay.
13	Maiduguri town	SI/A	Grundfos 9-13	5280	Unknown	94.4	0.0	94.4	Grundfos Simulation gives an SP9-13 3kW (4HP) pump with 9720W PV array. The current PV array is very undersized.
14	Maiduguri town	SI/D	Grundfos SP7-17	4200	Unknown	65.3	0.0	65.3	System is correctly designed. However 3 additional panels would improve output during cloudy periods.

2 - BRIEF HUMANITARIAN AND WASH SECTOR OVERVIEW.

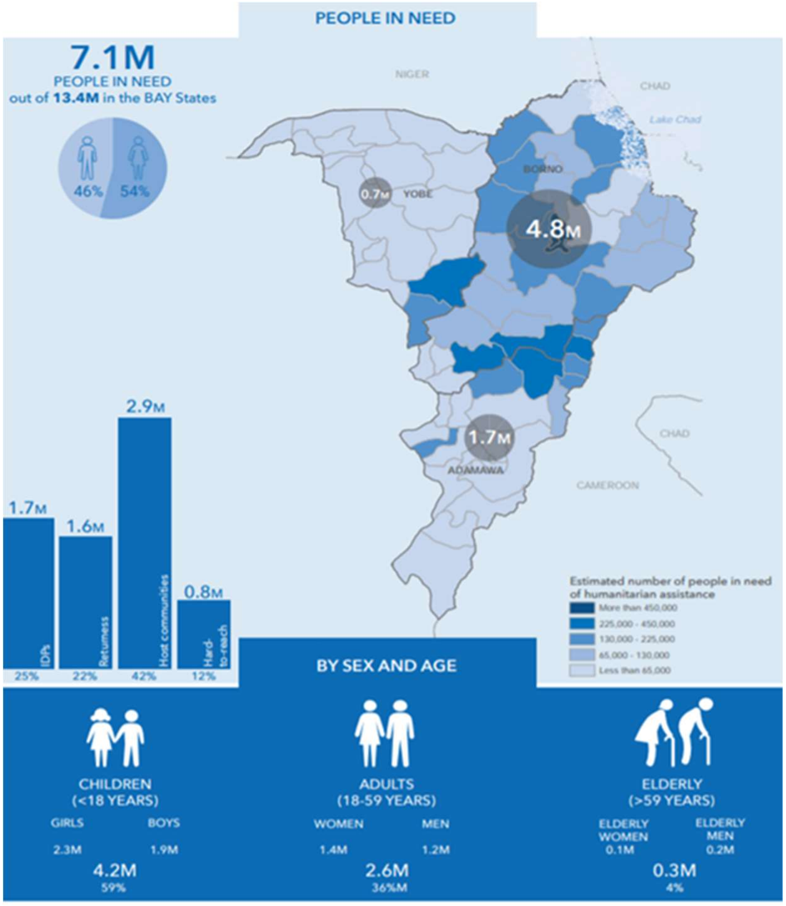
Across the three affected states of Borno, Adamawa and Yobe (BAY), 7.1 million people are estimated to be in need of humanitarian assistance in 2019 out of the total population of 13.4 million, with continuous displacement movements as a result of attacks and military operations.

Over eighty per cent of internally displaced people are in Borno State, the epicenter of the crisis, and over sixty percent are living in host communities, making it harder to access them with assistance and putting additional pressure on the already stretched resources of these communities. One in four of the internally displaced people are under five, and 80 per cent are women and children.

However, some 1.6 million people have returned home since August 2015, indicating that conditions in some locations have improved.[1]

Humanitarian organizations are not able to meet all needs in the north-east; more than 800,000 people in Borno State are estimated to be in areas inaccessible to humanitarian organizations, either because of conflict or impassible roads during rainy season.

Durable solutions are needed to address the risks and vulnerabilities of those most affected by the crisis, especially internally displaced people and refugees, and to reduce humanitarian needs.



Specifically for WASH, people in need of services: is estimated at 3.5 million (1.1M IDPs, 0.9M returnees, 0.7M host community and 0.8M hard to reach)[2].

In addition to the ongoing conflict which has created mass displacement and the need for water, sanitation and hygiene (WASH) facilities in camps and camp-like settings, WASH needs in Nigeria's north-east are compounding the malnutrition situation, and contributing to the spread of epidemics such as cholera or hepatitis E.

WASH assessments identify a vicious cycle, in which unsafe water, inadequate hygiene and poor sanitation have resulted in vulnerable individuals becoming acutely malnourished after suffering repeatedly from diarrheal diseases.

WASH partners are encouraged to strengthen the humanitarian-development nexus, especially in transitional areas, in order to lay the foundation for recovery and development.

[1] Humanitarian Needs Overview – 2019

[2] Humanitarian Response Plan - 2018

3 – ECONOMIC ANALYSIS SOLAR vs DIESEL GENERATOR.

Prices of pumps, generators, solar panels and other components were gathered and analyzed during the visits to private sector companies and quotations from IOM and implementing NGOs.

A Present-Worth Life Cycle Cost analysis (see ***Annex C 'Technical Briefing – Cost Analysis'*** for details in methodology) was performed in order to compare diesel generator stand-alone systems with equivalent solar stand-alone systems. Results can be found in table 2 below, showing that in all cases there is a considerable cost reduction over the life time of equipment (average of -63%, ranging from -53% to -72%) when solar solutions are used.

Table 2 – Life Cycle Cost Analysis: Solar vs equivalent Generator systems.

Site Details			Water Output			Economic/Life Cycle Analysis					
						Generator stand alone		Equivalent Solar stand alone system		Solar vs Diesel Comparison	
No.	Location	BHID	Daily Output Solar (m^3/day) in month with least output	Daily Output Generator (m^3/day)	Combined Daily Output (m3/day)	Initial cost (USD)	Cost over Life Cycle (USD)	Initial cost (USD)	Cost over Life Cycle (USD)	Reduction of expenses	Break-even point
1	Konduga Boarding Sch Camp	IOM/MBH/KDG/0001	16.9	0.0	16.9	$7,509	$52,205	$7,883	$19,158	-63%	2 months
2	Konduga Boarding Sch Camp	IOM/MBH/KDG/0001	16.9	0.0	16.9	$7,681	$52,377	$8,055	$19,330	-63%	2 months
3	Konduga Boarding Sch Camp	IOM/MBH/KDG/0003	16.9	0.0	16.9	$7,509	$52,205	$7,964	$19,238	-63%	2 months
4	Konduga-Mandarari HC	IOM/MBH/MHC/0007	16.9	0.0	16.9	$7,466	$52,162	$7,921	$19,195	-63%	2 months
5	Maiduguri town	IOM/MBH/MMC/0002	14.6	0.0	14.6	$7,638	$52,334	$7,770	$19,044	-64%	2 months
6	Maiduguri town	IOM/MBH/FGB/0001	16.9	0.0	16.9	$7,531	$52,227	$7,986	$19,260	-63%	2 months
7	Maiduguri town	IOM/MBH/MMC/0001	14.6	0.0	14.6	$7,488	$52,184	$7,620	$18,894	-64%	2 months
8	Maiduguri town	IOM/MBH/MNM/0001	16.9	0.0	16.9	$7,617	$52,313	$8,072	$19,346	-63%	2 months
9	Maiduguri town	NRC/ L	14.6	0.0	14.6	$7,595	$52,291	$7,727	$19,001	-64%	2 months
10	Maiduguri town	NRC/ N	14.6	0.0	14.6	$7,595	$52,291	$7,695	$18,969	-64%	2 months
11	Maiduguri town	NRC/ 0	14.6	0.0	14.6	$7,595	$52,291	$7,620	$18,895	-64%	2 months
12	Maiduguri town	NRC/ K	16.9	0.0	16.9	$7,595	$52,291	$7,955	$19,229	-63%	2 months
13	Maiduguri town	SI/A	94.4	0.0	94.4	$12,533	$106,667	$18,777	$30,051	-72%	8 months
14	Maiduguri town	SI/D	65.3	0.0	65.3	$6,900	$58,121	$16,282	$27,556	-53%	2.6 years
		Totals:	351.0	0.0	351.0	$110,250	$791,960	$129,326	$287,166	-63%	4.5 months

It needs to be said that 12 of the 14 boreholes analyzed tapped water from the first aquifer (the shallowest of the 3 aquifers present), and therefore they are the smallest systems to be seen in the area. While these represent an extremely cost-effective solution (return on investment of 2 months when compared with equivalent diesel solutions), it is likely that systems in the deeper aquifers will have longer return on investment periods (but also typically higher net costs saved over lifetime). Unfortunately, no enough data were made available at the time of the visit to make such analysis.

For the 14 boreholes analyzed, an extra total capital investment of 19,000USD to use solar solutions instead of stand-alone generator systems, will lead to an overall cost reduction over time of 505,000 USD; or said in another way, for every 1 extra USD invested to apply solar solutions, 26.5 USD would be saved, making it the most cost effective analysis seen to date from 11 countries visited.

Finally, and contrary to a still widespread belief, this analysis proofs once more the fact that solar solutions can be cost effective in countries were diesel cost are low (0.7USD/l at the point of use for Maiduguri area).

4 - PRESENTATION OF MAIN FINDINGS.

Given the unreliability of the grid where it exists, the difficulty to properly manage fuel supplies and the remoteness and/or lack of regular access to many sites together with the high and constant solar radiation in the area, solar water supply solutions are critical in the development of new points or conversion of old diesel powered ones if greater cost-efficiency and sustainability want to be achieved.

In contrast with last visit carried out in November 2017, the use of solar pumping solutions is widespread among humanitarian WASH agencies to the point that all of the water schemes from where information could be collected during the visit (60 from 4 different agencies) are using solar technology to supply water.

The table below summarize the main factors specific to the Borno state context that are for and against a quality mainstreaming of solar water pumping solutions.

Factors for solar pumping mainstreaming	***Policy & Institutional***	***Technical***	***Financial***	***Social***	***Environmental***
Positive/ Favorable	Enabling favorable framework Government, UN, NGOs widespread use of solar solutions for water supply	Presence of high quality solar products in Nigerian Market Existence of knowledgeable private sector companies Quick access to spare parts and knowledgeable companies feasible Lack of reliable electricity grid, difficulty to ensure regular fuel supply (insecurity, mismanagement)	Lifecycle costs lower for solar Water cost cheaper to users	Preference of solar to genset by users	Reduction noise and air pollution High solar radiation in Borno State
Challenging/ Need improvement	Lack of guidelines, best practices, lessons learnt	Lack of expertise among stakeholders Low quality products and unsafe layouts used in installations Lack of regular training opportunities in-country Low involvement and training of Water committees in proper operation and management	Low or lack of payment by most users when systems are converted to solar	Low involvement of WASH committees into Maintenance of solar schemes Wrong water-for-free perception when solar provided Risk of theft for water pumps	High winds and dusty environment difficult maintenance of solar systems

While awareness and use of solar pumping solutions is considered a suitable and cost-effective approach, adopted already by most of Water partners in their effort to provide sustainable water supply solutions, technical quality of installations remain a major concern.

The single most important barrier towards a quality solarization of water points in the area visited is the technical expertise of WASH stakeholders involved in the design, implementation, operation and maintenance of solar pumping projects. The humanitarian Response Plan – 2018 echoed this concern by stating that 'capacity of WASH sector stakeholders will be strengthened (…) in more technical topics such as solar power schemes'.

However, short-term training opportunities for field engineers are not available at the country yet, with no place or plan in sight to cover this gap. The large expression of interest by WASH stakeholders and high turnover for the training provided during this visit shows the willingness and need to strengthen technical knowledge, especially bearing in mind that there is already such a strong dependency from solar solutions to supply water in the areas visited.

In terms of **technical problems**[3], a number of issues are strongly limiting the amount of water provided to beneficiaries. The main ones encountered are:

1) Solar panels never cleaned (90% of systems assessed), due to a) unawareness by WASH agency, Water Committee and b) panels difficult to reach due to layout adopted.
2) A mix of solar panel brands and powers used in the solar generator, therefore reducing energy output and decreasing water supplied (>25% of systems assessed).
3) Solar panels of unknown brands without proper manufacturing certifications, subject to high output degradation over short period of time leading to water shortages (>25% of systems assessed).
4) Small capacity of water tanks installed, limiting the pumping capability of solar water schemes (55% of systems assessed).
5) Operator pumping hours not matching the solar day, limiting supply capability of systems installed (20% of systems installed).
6) Solar generator under-dimensioned, limiting energy and water supplied (30% of the systems assessed).

Water output is believed to be reduced for up to 50% and more in most of the systems visited, and as several partners pointed out, 'water available is considerably lower at the tap just 1 year after installation'.

The limiting supply of water due to causes listed above is leading to problems of

a) crowds at water point whenever water is available (with crowd management reported as the most important problem by most of Water Committees interviewed),
b) people searching for other water sources or (those who can) paying for water to street vendors,
c) a number of partners planning to drill and install new water schemes to boost production in areas were low performing boreholes are in operation.

To point out as well that the **lack of proper drilling and pumping test reports** for almost all boreholes assessed made impossible to know whether the designs used where the most appropriate ones; additionally, the fact that it is the very same contractor drilling, pump testing and installing the pumping systems (as stated by all partners participating in the training) leave the door open to all kinds of misinformation and misconduct on the side of the contractor.

[3] Almost all water points from where this report is based are small systems (57 out of 60 water schemes with pumps of up to 1.4kW) tapping the shallowest aquifer; therefore, some of the points here raised might not be valid for larger systems.

Other technical issues encountered in a good number of water points are not specific to solar but to general **good practices in water point construction**, well stated in the Nigerian WASH Sector Technical Guidelines but seldom encountered in the schemes visited (eg, lack of fencing, pipe leaking, open access to control box and switches to children, bared cable connection laying in the ground, lack of provision for water chlorination, etc). Especially to note the **absence of water meters** in all but 1 of the schemes visited, which due to the fluctuating nature of solar water supply and the additional problems above mentioned, make very difficult for partners to be accountable to donors and beneficiaries on amount of water supplied.

Besides, while **vandalism is unreported**, theft of pumps is a common problem for which most of partners are adopting measures.

Finally and still on the technical side, there seems to be a high proliferation of drilling in the shallow aquifer, with a large number of very small systems (providing only between 0.8 to 2.5 m3/h, sometimes barely more than a handpump). 2 boreholes drilled in the 2nd –confined- aquifer –average depth of 280m- reported safe yields of 14m3/h and DWL of only 45m. Tapping and equipping such boreholes look like a more cost effective and simple way to provide water, especially in areas that can host large numbers of IDPs or returnees.

Regarding the Nigerian private sector, it is important to point out that, while **low quality products are abundant** in the national market, the highest quality brands of solar panels, invertors and pumps can also be found in Nigeria markets, making quality product knowledge a key point for implementing organizations.

The presence of good quality installations in the field (eg Solidarites International Bolori and Dustman sites) show that **good quality contractors and materials are indeed available and that with proper know-how, WASH partners can get efficient and performant water schemes.** However, an important number of NGOs with not enugh understanding on issues related to sizing of solar arrays, quality of materials or O&M needs are hiring private contractors to design and install solar schemes, which work mostly unchecked in terms of quality of products used, designs proposed, installation made and others. Private sector companies with good experience are found in the Nigerian market mixed with many others with low skills, or driven by an agenda where offering quality installations is not a primary concern.

Solarization of water schemes represent a good business opportunity for the national private sector, which is not being used by other WASH stakeholders as a leverage to encourage private sector to ensure stronger supply chains for spare parts or raise the technical knowledge of the relief community.

In terms of management models, implementing partners (NGOs, IOM, and others) remain available for any repair necessary. While all systems are quite new (1 to 3 years old), it is well known that most of technical problems often come within the first 12 to 24 months of installation; the fact that all systems visited were functional (=water at the tap at the moment of visit), would mean that **partners are doing well to maintain systems working**. **At community level**, the users of all water schemes visited but 1 were getting water for free, with users having direct access to NGOs to act on repairs when necessary. While this can foster better acceptance of IDP presence in the areas where host communities live, it might also pose a future challenge when NGOs retreat their support and paying for water become again necessary, as it was before the emergency.

This dependency on relief agencies have led in a good number of cases to users taking poor care of water points, making little efforts for proper operation and maintenance of the system. The **role played by WASH committees to maintain solar schemes is minimal** in most of the systems visited, with little to no training provided or tools supplied to do so.

Training of these operators on basic maintenance of the system is of paramount importance but it is not provided by all implementing partners. A lack of community knowledge about the technology is also a primary concern.

In general, WASH emergency partners face a range of common challenges when using solar pumping solutions for which it would make sense to look at those in a unified, coordinated way. While it is difficult to have engineers with good solar knowledge in all +20 WASH operating organizations all the time, coordination to provide reference material, regular in-country technical support, accessible technical helpline and/or a platform where to share common challenges and agree on best practices as a sector seem lacking.

A final significant finding regarding **finance** is that for the systems surveyed, solar pumps always supply lower life cycle costs than diesel pumps, with average cost reductions of -63% and average break even period of 8 months, implying savings of 26.5 USD for every 1 USD invested to solarize water schemes. While as explained this is mostly valid for small water systems in Maiduguri surroundings, it could be extrapolated to other parts of the country taking into account that diesel costs are higher in remote regions where delivery of diesel is more expensive, however solar cost of water will be consistent among all sites, no matter how remote.

5 – RECOMMENDATIONS AND WAY FORWARD.

Mainstreaming of solar pumping solutions is well underway in the area visited. These are deemed the most appropriate solutions to provide sustainable and cost effective water supply for conflict affected communities, however a stronger focus on technical aspects and capacity building of implementing partners and water state actors will be needed in order to ensure proper functioning and maximization of resources.

The main recommendations from this visit are detailed below.

***For NGOs and implementing organizations*:**

- **DRILLING:** Consider **tapping into deeper more productive aquifers**, to limit the proliferation of small systems and maximize cost-effectiveness and simplicity of O&M of solar schemes, especially in areas serving large populations or with space to host new displaced communities in the future.

- **TENDERING: Separate tenders and contracts for drilling+pump testing and installation of pumping equipment,** in order to ensure better quality job. Ensure reports are provided (drilling, 4-step pumping test, testing and commissioning report) and retain payment till this is done to satisfaction. Ask for software-based solar designs to contractors as part of tender documents. Ensure field monitoring at time of installation (see checklist provided at training).

- **QUALITY COMPONENTS: Ensure certified quality materials** (pumps, inverters/ control box and solar panels) are provided by suppliers. Ask for reputed brands and/ or certification documents during tendering and quotation process (see tips given at training).

- **WASH COMMITTEE PARTICIPATION**: Ensure training and basic tools are provided at WASH Co/ water operators in order to properly operate and basic maintain solar equipment (eg tools for panel cleaning). Ensure communities understand the opportunities and risks associated to solar systems. Install water meters, especially in larger boreholes and train water operator take daily records and monitor water levels regularly.

For coordinating organizations:.

- **SOLAR TECHNICAL GROUP: Create a solar task force** to reinforce inter-agency collaboration, in order to define standards, guidance and best practices for the NE Nigerian context.

- **CAPACITY BUILDING**: Build up internal technical capacity of WASH sector in solar water solutions: tap on expertise available at country level, international private sector companies (eg Grundfos and Lorentz), solar academies in Nigeria or in Kenya (Energy Center at Strathmore University) to organize regular workshops and trainings and raise technical expertise among relevant NGOs and government technical staff.

- **VERY HIGH YIELDING BOREHOLES:** coordinate and articulate assessment for solarization of at least 1 of the 15 hydropwer- high yielding boreholes that supply the town of Maiduguri. Draw learning and define way forward from it.

For Government/ Donors:

- Support **establishment of a solar training center** at University level, as the one existing in Nairobi, that would serve as a reference for regular training of both government, NGO, UN technical staff as well as for private sector actors.
- Support studies/research/evaluations of actions to **capitalize on experience** and further building up evidence on suitability of solar pumping for the given contexts.
- Consider the possibility to support the creation of a **focal solar expert** at country level to support all WASH actors in the quality mainstreaming of solar technologies.

Action points for the Global Solar&Water Initiative team:

- Follow up visit in beginning of 2020. Organization of new solar training with priority to those in waiting list.
- Available for remote technical support at solarquery@iom.int