A Comprehensive Study on the Use of Solar Based Drinking Water Supply and Solar Irrigation Pump in Bangladesh

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Prepared by

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Submitted By

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Abstract

This report, based on a field visit and a subsequent study, has been prepared to capture the current scenario of the use of Solar Irrigation Pumps or SIP and Solar Based Drinking Water Supply or Solar DWS in Bangladesh with the goal to give a clear picture and analyze the gaps, if any. The report covers both technical and non-technical features, including but not limited to socio-economic profiling of the study areas, environmental bearings etc. Finally, this report draws conclusions by giving suggestions on how to improve the existing facilities and increase the general acceptance level of solar based solutions.

Introduction

Bangladesh is making great strides as a country. The vision of the Government of Bangladesh is to bring the country to the level of a middle income country by 2024. To put smiles on the faces of the people living in the furthest and quietest of rural areas of the north to the remote and isolated communities of the south, the government has delegated the NGOs and the private sectors to take initiatives and realize opportunities in several fronts. At the forefront of all of these, the use of solar power has emerged as one of the most effective solutions to bring better lives to the people, particularly of the rural areas and the isolated communities. The unprecedented boom in Solar House Systems (SHS) in our country speaks volumes of its potential. The fact that the solar based systems have the advantage of being green energy systems and their relative ease of implementation, should translate to be an unparalleled modern solution from environmental and theoretical points of view. Yet, there remains a lack of general acceptance from the socio-economic standpoint in many other prospective sectors. This is due to the initial cost associated with implementation and its relative infancy as a technology. However, the scenario is slowly changing. Solar based irrigation systems, widely known as Solar Irrigation Pumps (SIP) and Solar Based Drinking Water Supply (Solar DWS) have shown promises in the recent years. This report attempts to capture the current scenario through the findings in two separate case studies to increase the level of acceptance amongst the populace and encourage investors to contribute to the overall growth of such system.

Objectives

The overall objective of this field study is to identify the major challenges in maintaining smooth operation and preserve sustainability of the projects with due recommendations. The specific objectives for this study by conducting two separate case studies on the ongoing SIP and Solar DWS projects in Bangladesh are:

- Identifying the capacities of these projects;
- Assessing the efficiency, effectiveness and lifespan of these projects;
- Investigating on the challenges faced in maintaining these systems and keeping them sustainable;
- Evaluating the environmental and socio-economic benefits;
- Identifying the beneficiary groups and the service providers (i.e. the primary stakeholders);
- Including the findings through informal interviews with the aforementioned people;
- Comparative analyses of existing alternatives with solar powered systems;
- Water samples collection and obtain laboratory results for comparison; and

- Brainstorm and come up with ways to improve/ enhance the existing facilities/ systems;

Methodology

The study team developed sets of checklists for the two case studies (Case Study–1: SIP and Case Study–2: Solar DWS) with opinions and suggestions from a pool of knowledge drawn from internal and external experts as well as agencies. A thorough outline for the field study was drawn before mobilizing the team. The team consisted of Mr. Mowaze Mohsin (Electrical Engineer) and Mr. Md. Alamgir Hossain (Anthropologist) of Center for Environmental and Geographic Information Services (CEGIS). The study team came in contact with external organizations namely – Infrastructure Development Company Limited (IDCOL), Wave Foundation and BRAC Water Sanitation and Hygiene Programme (BRAC WASH) which are the implementing organizations for the projects of interest. The study team has been greatly assisted by Wave Foundation and BRAC WASH by sharing locations and specifications of their ongoing projects and assigning their Field Officers/ Engineers as field guides to conduct the case studies of SIP and Solar DWS respectively. The assigned professionals also played immense roles in sharing related information, the mission and vision of their respective organizations for the ongoing and future plans with the projects of interest. The team carried out several informal interview sessions with the local people, the beneficiaries and the service providers. The implementing organizations also shared their up to date data and records for the ongoing projects which are also shared in this report with their approval.

Field Visit and Findings

Case Study–1: Based on the information shared by IDCOL and Wave Foundation, two suitable locations have been selected for this case study designed for the SIPs operating in Bangladesh. These two locations are Jagannathpur and Doyapur of Kaliganj Upzila in Jhenaidah, Bangladesh. CEGIS Team was mobilized to conduct a field visit. The maps for the two locations are shared in **Annex-I, Map 1.1**.

1.1 General Overview: In Case Study–1, the study team was impressed with the way the SIP projects have bloomed and brought happiness to the farmer groups. The excellent services aside, the impressive fact about the SIP projects is how they have been handled by Wave Foundation, the organization that has been delegated by IDCOL to implement the SIP projects in the districts of Chuadanga, Jhenaidah, Kushtia and Meherpur. Moreover, The SIP projects have been found to be working as a sustainable model. According to Mr. Shamim Ahmed, the Kaliganj Field Officer of Wave Foundation, there are 44 similar SIPs in operation under his organization with an additional 30 SIPs are in the process of being implemented. There are further plans to increase the number of such SIP projects due to the success of the ones already in their operation phase.

1.2 Socio-economic Profile: According to the data collected from the Population and Housing Census 2011, Bangladesh Bureau of Statistics (BBS), 2012, the total number of households in the Kaliganj Upazila is 67,696 with a total population of 282,366. The population in 2018 is projected[1] based on the growth rate specified in the BBS. The sex ratio[2] of Kaliganj Upazila is 100. See **Table 1.1**.

Table: 1.1: Total Population and Sex Ratio of Kaliganj

Total Population		Male	Female	Sex Ratio
BBS 2011	282,366	141,287	141,079	100
Projected Population	310,584	155,406	155,177	100

Source: Population and Housing Census 2011, BBS, 2012, Projected for the study for 2018

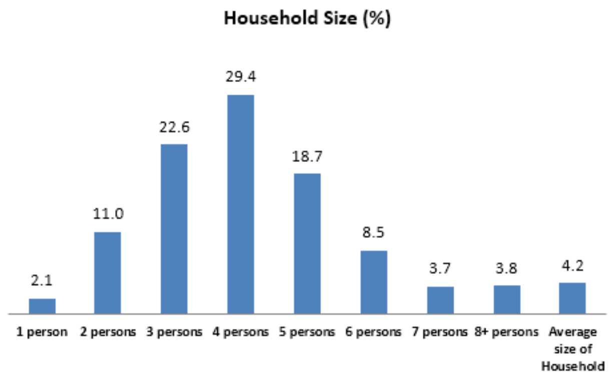
The household sizes by percentage of Kaliganj Upazila is presented in **Figure 1.1**. As seen from this figure, almost 30% of the households consists of four (4) members in Kaliganj Upazila. The average size of household in this area is 4.2.

[1] Projection formula used:

$\text{Future} = \text{Present}\,(1+r)^n$

Where Future = Future Population, Present = Present Population,
r = Growth Rate (0.0137, BBS, 2012) and n = Number of Years (7, i.e. 2011 to 2018)

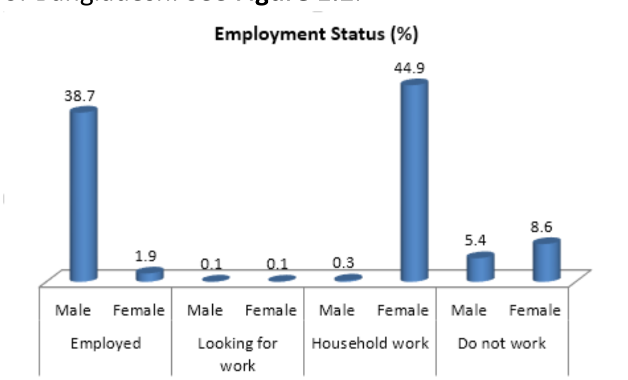
[2] Number of males (M) per 100 females (F) in a population, using the formula: Sex Ratio, SR = M x 100 / F



Source: Population and Housing Census 2011, BBS, 2012

Figure 1.1: Household Size of Kaliganj by Percentage

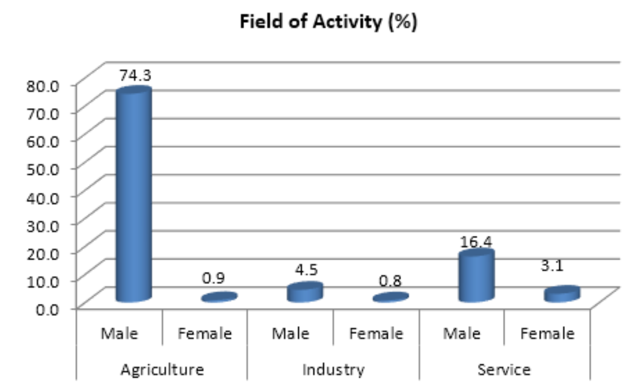
The employment status of Kaliganj reveals that most of male population are employed with outside activities and the majority of the female population are engaged in household works, which reflects the standard socio-economic situation in the rural areas of Bangladesh. See **Figure 1.2**.



Source: Population and Housing Census 2011, BBS, 2012

Figure 1.2: Employment Status of Kaliganj by Percentage

The statistics also reveal that the primary occupation in the Kaliganj Upazila is agriculture as shown **Figure 1.3**. More than 75% of the active workforce is engaged in agricultural activities. It also shows that 99% of this sector is male. The study team made an attempt to confirm this through field observation and conducting informal interviews with the local people during the visit. The local people shared that the scenario is slowly changing as more female workers are getting involved in agricultural activities, a scenario that reflects the positive change from the outdated social perception that women should only be involved in household activities. The study team found notable number of active female workers involved in cultivation activities.



Source: Population and Housing Census 2011, BBS, 2012

Figure 1.3: Field of Activity of Kaliganj by Percentage

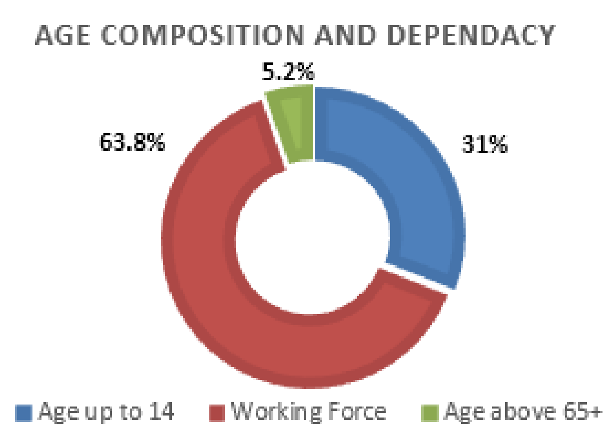
The statistics reveals that the literacy rate of the Kaliganj Upazila is significantly lower than the national average of 61.5%. Only 52% of people are obtaining at least the basic level of education according to the BBS data as shown in **Table 1.2**.

Table: 1.2: Literacy Rate of Kaliganj by Percentage

Literacy Rate (%)			
Both	**Male**	**Female**	**National**
52.0	54.5	49.5	61.5

Source: Population and Housing Census 2011, BBS, 2012

The following **Figure 1.4** shows that more than a third of the population (36.2%) is dependent on the active workforce of Kaliganj Upazila.



Source: Population and Housing Census 2011, BBS, 2012

Figure 1.4: Age Composition and Dependency of Kaliganj by Percentage

1.3 Technical Features: The general technical information collected from Wave Foundation during the field visit is as follow:

- The installed capacity of the solar panels (119 standard panels) is 38,080V DC, 18.5kW which is then inverted to 620V AC to operate a 25HP[3] induction motor.
- The motor is optimized to operate at 3000 rpm[4] under normal conditions. The motor is connected to the vertical shaft of a centrifugal pump.
- The pump head is at 3.05 meters (m) (10 ft.[5]) above ground. The pump depth is at 15.24m (50 ft.). The boring depth varies from 54.86-60.96m (180-200 ft.) from one location to another based on the groundwater depth depending on the aquifers.
- Each SIP is designed and developed with the capacity of irrigating 9.48-9.62 Hectare (Ha) (2,343-2,376 decimal[6]) of land through specially designed underground pipes.
- These pumps are capable of drawing 96 litres of water per second. Under normal operation, they draw around 85-86 litres of water per second on average. The operators of the SIPs also showed the pumps in operation and the above information was verified by the study team.
- The pumps are operated based on water requirements and run from 8AM to 5PM.
- During overcast, the pumps operate at 1500-2100 rpm, usually enough to irrigate the lands. However, they need to be run for longer duration.
- In case of continuous days of overcast with no rainfall, Wave Foundation has guaranteed to provide diesel operated pumps at their own cost.
- The initial lifespan of these projects is expected to be 20 years.

1.4 Agricultural Information: The field study identified that the irrigated lands under the SIPs are mainly used for the cultivation of Aman and Boro – two main paddies of Bangladesh. The secondary crops in these areas are wheat *(gom)* and sugarcane *(ankh)*. The study team also found chili (*kutcha morich*), basella alba (*pnuishak*), tomatoes, eggplants (*begun*), cucumbers (*shohsa*) and bitter melon (*karola*) being grown in small scale under the SIP project.

1.5 Operation and Maintenance: The SIP projects are based on a lease system. The implementing organization identifies potential areas where their projects can be implemented. After that, they obtain permission from the land owners who lease part of their lands (approximately 242.8 m^2 or 6 decimals of area) to develop solar infrastructures which include the panels and a housing with submersible pump, motor, panel boards, inverters and controllers installed in it through lease agreements. The lease terms are set for 20 years (which is the expected lifespan of a project) and are subject to renewal through fresh agreement once the lease period is over. The lessee gets BDT 6,000 per year for their land. The lessee is then integrated with the process by being given the task of everyday operation and general maintenance of the SIPs. They are given training before handing over the responsibilities of general maintenance and operation. For this, a lump sum amount of BDT 1,500 per month is given to the lessee. The lessee also holds the right to enjoy 15% of the total yields from the farmers benefitted from the SIP installed on their (lessee) land. The farmers pay approximated BDT 2.25 per m^2 per season to the implementing organization.

1.6 Environmental Advantage: SIP systems have almost no environmental bearings. The only drawback the study team has identified is that the land under the panels do not see adequate sunlight to make them usable for normal cultivations. But the overall environmental benefit in comparison to diesel operated pumps and grid connected irrigation pumps far outweighs the small portion of land being compromised for implementing these systems (the ratio of the land used for SIP installation and the total irrigated land by SIP is almost 1:400). Besides,

[3] 1 HP (Horsepower) = 746 Watts
[4] rmp = revolutions per minute; the rotation speed of the motor;
[5] 1 ft. = 0.3048 meters
[6] 1 decimal = 40.4686 square meters = 0.0040468 hectare (Ha)

suggestion of potential vegetation is recommended at the end of this report to enhance productivity. This green technology is seen as the most environmentally sustainable technology and the fact that Bangladesh is trying to embrace it is very encouraging.

1.7 A Story of Success: The beaming faces of the farmers, the lessees and the officials from implementing agencies gave away a story of success. Amongst the secret recipes behind the success of the SIPs, the most important one was the understanding the problems and issues the farmers of the areas had been tackling before the solar based systems were implemented. The second most important one was integrating the beneficiaries into the management and maintenance processes. To elaborate more on this, IDCOL identified how to include the beneficiaries, in this case, the farmer groups and the land owners to form a three-way mutual understanding by sharing the priorities, defining the key objectives, and setting and meeting the targets. Meanwhile, Wave Foundation, the organization which has been designated to implement the projects and provide supports to the beneficiaries by IDCOL, have been playing a vital role in building mutual trust through showing keen interest towards the betterment of the beneficiaries, and at the same time shouldering the responsibilities that they had promised. Some of these are shared below:

- Maintaining excellent rapport with the farmer groups and the SIP land owners (the lessee);
- Providing timely technical maintenance and repair works. During the visit, the study team found that one of the connections had failed due to short circuit in one of the panels and was replaced within 24 hours of the fault occurrence. It was verified by both the lessee and the farmers present at that time;
- Knowledge sharing on how to improve the amount of yields per crop cycle by holding informative workshops;
- Guaranteed to provide diesel operated pumps at their own cost during overcast; however, till date, since the start of their operation, they have not required to operate the diesel operated pumps;
- By making the lessee the service provider and the operator at the same time, the system bridged the gap between the farmers and the service they seek;
- As the service provider (lessee) is also financially benefitted from the total yield (15%), their mutual interest of high yield is aligned with the farmers; this in return, made the service providers more keen to provide better service to the farmers for the best of interest of both parties;

1.8 Comparison with Alternatives: The following **Table 1.3** gives a quick overview of a monetary comparison between SIPs and its market competitors.

Table 1.3: Cost Comparison: SIP vs. Diesel Operated Pumps vs. Grid Connected Pumps

System	Cost/m^2 per season (BDT)
SIP	2.25-2.30 (irrigation)
	1.50-1.60 (15% yield)
SIP Total	**3.75-3.90**
Diesel Operated	1.75-2.00 (Fuel Cost)*
	0.95-1.00 (Pump Hire)
Diesel Total	**2.70-3.00**
Grid Connected	1.75-1.85 (Govt. subsidized)

*Source: CEGIS Field Investigation, 2019. *the variables are litres of fuel required and local market price of fuel per litre.*

However, the above table does not tell the whole story. Informal discussion with the benefitted farmers of the project revealed that they have had gone through hardships in the past which have been alleviated after they came under the umbrella of SIPs. The findings are shared below:

- In the past, the farmers, who relied on hired diesel operated pumps, had to wait in long queue to get water. Sometimes it would take days to get the water. Sometimes the long wait affected the saplings that require timely irrigation. The result would be a considerable amount of loss in the final yield.
- Sometimes the diesel operated pumps went out of service and that drastically impacted the yield at the end of the crop cycle. Sometimes the pumps

remained out of service for 4-5 days as they had to be sent to the marketplace for repairs. The final result is loss in the final yield.

- Then there is the outage in grid power. Natural disasters and other grid related failures that sometimes need 2-3 days to be resolved, long enough to cause major irrigation hamper during crucial moments of a crop's lifecycle. The result is poor yield.

The maximum downtime identified during the study can be seen at a glance in the **Table 1.4** below for a quick overview.

Table 1.4: Downtime Comparison: SIP vs. Diesel Operated Pumps vs. Grid Connected Pumps

System	Maximum Continuous Downtime
SIP	24 Hours
Diesel Operated	96-120 Hours
Grid Connected	48-72 Hours

Source: CEGIS Field Investigation, 2019

On the other hand, the benefits of using SIPs have been very impressive. The informal discussion revealed that:

- The availability of the right amount of water at the right moment yielded enough crops (ranging from 1250-1500Kg more yield per Ha per season; Source: field interview with the farmers) to earn back a significant part (from BDT 1.90 up to BDT 2.25 per m^2) of the money spent on irrigation.
- The farmers are happy to share the 15% yield with the service provider because they feel that the service provider genuinely care for them.
- The monetary value of the 15% average yield (1.50-1.60 BDT/m^2 per season; Source: field interview with the farmers and taking the increase of production due to SIP irrigation into account) is actually lower than the amount spent on diesel or grid operated systems.
- Additionally, the diesel and grid operated systems have hidden expenditures associated with them. Such as, labor cost/value for setting up irrigation system for both and transportation of fuel for diesel operated systems.
- The savings are used by the farmers to buy seeds, fertilizers, farming tools, etc.
- In comparison to when the farmers had to pay before the crop yield for the irrigation services from the alternatives, now they can pay after harvesting.
- Some of the farmers who were initially against the SIP are now requesting for the same service after witnessing how fellow farmers are being benefitted.
- The farmers do not have to go to multiple places because now the lessee is the operator and the serviceman at the same time and are stationed close-by. There is no formal time consuming procedure as the farmers get access to the service very easily.
- The farmers who have their own land, but could not manage to irrigate on time, were working as labours for other farmers instead. However, SIP made it possible for the lands of these farmers to be under irrigation on time and thus these farmers started cultivating in their own lands.
- At the same time, this allowed other labours the opportunity to work for the farmers who were hiring the aforesaid farmers. In other words, SIP opened new work opportunities for day-to-day labours.
- The underground based water-pipe for irrigation means that there is more land for cultivation as the land used for drainage in the past is now cultivable.
- The farmers were also happy with the water pressure in comparison to diesel operated pumps. The service operator (lessee) claimed that the water pressure is maintained with air outlet at several intervals that ejects any air pockets created within the pipes which would otherwise drop the water pressure inside the pipe.
- Some farmers who were reluctant to get this service and decided not to be part of the system are the ones who are now requesting that the service be enhanced.

However, there are some limitations that have put caps on the SIPs. The service providers (lessee) the field study team got to talk with shared them openly. These are discussed below:

- The SIPs only operate for two main crop cycles of the area. 120 days for Boro season and 90-120 days for Aman season. The rest of the year, which is more than a third of it, the SIP remains inactive.
- Solar panel cleaning is the most arduous and difficult part in maintaining the solar system. The service providers suggested that if they were provided with a solar powered small motor to run a water hose to clean the solar panels, the panels output could be much higher. Some sites are near brick fields and other industries and visible layer of ashes, dust particles, other chemicals such as Sulphur etc. could be seen on the panels during the field visit.
- From their field experience, the service providers believe that the irrigation land can be easily increased up to 13.35 Ha (3300 decimals), which translates to a net 39% increase of land coverage, increasing the ratio of land used for SIP system and total irrigated land by SIP from 1:400 to 1:550, with the same system in place without increasing the output. They also revealed that the demand to get their service is now huge, which echoed the statement shared by the farmers during the interviews;

Case Study–2: CEGIS team visited the Solar DWS facility which is covering Darunmallik, Kalinagar and Harinkhola villages in Paikgachha Upazila of Khulna as this has been taken as the subject of interest for being a suitable site for this Case Study–2 through information collected from BRAC WASH. The map is attached as **Annex-I, Map 1.2**.

2.1 General Overview: Lack of fresh drinking water in the coastal areas is one of the common problems around the world. The problem is more acute for poor communities living in the coastal regions. Needless to say, the fresh drinking water situation in Bangladesh is alarming, more prominently in the coastal regions. But there have been some solutions. The field study team found that a considerable number of people of the villages of Darunmallik, Kalinagar and Harinkhola in Paikgaccha are using underground water for drinking and cooking supplied by the Solar DWS.

2.2 Socio-economic Profile: The people of the villagers are mainly engaged in agriculture (33%, BBS 2012) and fishing. Besides, women are engaged in cow dung collection, which is the primary fuel for the households, bringing up chicken and ducks and allowing the domestic animals to pasture on their watch outside their regular household activities. Demographic data have been collected from secondary sources. According to the BBS Census–2011, the literacy rate of the study area is 68%, surprisingly which is higher than the national literacy rate (61.5%) despite of being in such a remote location which has poor communication system and yet to see grid connection.

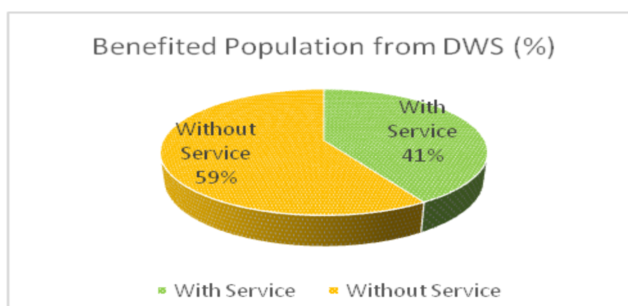
The following **Table 2.1** illustrates that there are a total of 798 households in the study area where 3,392 people are currently residing, of which, 1,741 are males and 1,651 are females.

Table 2.1: Total Population and Household by Mouza

Mouza	Household	Population	Male	Female
Darunmallik	242	1,041	536	505
Kalinagar	216	929	464	465
Harinkhola	340	1,422	741	681
Total	**798**	**3,392**	**1,741**	**1,651**

Source: BRAC WASH Program, 2011

In the current situation, there are 1,405 people who are using Solar DWS facility which is 41% of the total population. In the **Figure 2.1** below the 41% benefited population is comprised of 51% males and 49% females.

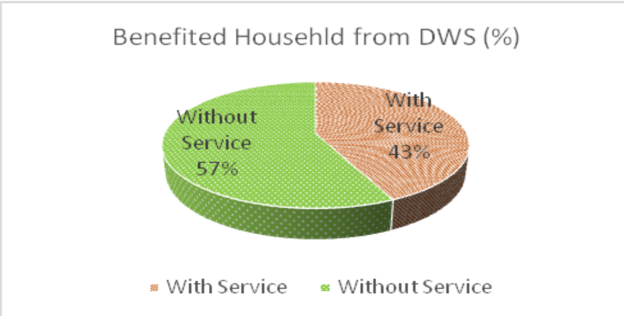


Source: BRAC WASH Programme, 2015.

Figure 2.1: Benefited population from Solar DWS

Similarly, the total benefited household is 43% in the study area. The following **Figure 2.2** shows the

Benefited households based on BRAC WASH data, 2015.



Source: BRAC WASH Programme, 2015

Figure 2.2: Benefited household from Solar DWS

2.3 Health and Sanitation: The safe water and hygiene scenario have improved significantly since the implementation of the BRAC WASH project. The use of safe water has been improved from 58% in 2011 to 100% in 2015 while the use of hygiene latrine has been improved from 64% in 2011 to 97% in 2015 (Source: Data from BRAC WASH, 2015).

2.4 Technical Features: The Solar DWS which came into operation in April 2015 has several key technical features. These information have been shared by the officials of BRAC WASH who were also present during the field visit as guide to the study team. These features are discussed below:

- The Solar DWS uses 2 solar panels with combined capacity of 1.49kW. The panels are mounted on top of a water tank.
- The solar power is inverted to AC power to operate a two HP motor which is connected to a submersible pump.
- The pump has a total head of 18.3m (60 ft.). It is capable of lifting 4,000 litres of water an hour to the elevated water tank at 12.2m (40 ft.) height.
- The water tank has a capacity of storing 13,000 litres of water.
- This stored water is discharged through a network of 12.1 km (39,672 ft.) of water-pipe, stretching three km in length with 81 tap connections.
- The lifespan of this project is initially expected to be 20 years.

2.5 Management and Maintenance: There is a water management committee that holds a meeting every month to address any issues and complains from the users. Initially the villagers paid BDT 300 per household to establish a fund for regular maintenance. Currently, the water subscription fee is BDT 20 per month. This subscription amount goes to make payment for maintenance and repair works.

2.6 Alternatives and Comparison: The villagers have also access to rainwater capturing and Pond Sand Filters (PSF) developed in sweet water ponds. There is no access to desalination plants because the nearest plant is more than 35km away from Paikgachha. The differences are given in the **Table 2.2** below.

Table 2.2: Alternative Analyses

Source	Distance	Initial Expense (BDT)	Monthly Expense (BDT)	Time Involved	Availability
Solar DWS	100m	300/ Household	20/ Household	5-20 mins	30-40 mins/day
Rain-water	0m	500-1000/ water drum	N/A	N/A	Seasonal (Rainy day)
PSF	2.5 km	5000/ community	0	2-3 hours	24/7 365 days
Desali-nation	>35km	N/A	N/A	N/A	N/A

Source: CEGIS Field Study, 2019

The PSFs, which are developed based on location and availability of freshwater ponds, are built by BRAC WASH by raising funds from the local community. Initially, a BDT 5000 fund is raised from the local community to build the PSF. Upon completion, the PSF is handed over to the community who also maintains the facility. However, PSF is not an option for the study area because the closest freshwater pond is 2-3 km away from the communities of interest. Before the establishment of the Solar DWS, the women of the study area travelled 2-3 km on foot one-way to fetch water.

2.7 Benefits of the Solar DWS: The installation of the Solar DWS by BRAC WASH, under the funding of the government of the Netherlands has seen more ups than downs. The people of the area, covering three villages, used to collect drinking water from sweet water ponds and PSF which are located at considerably far places. As a result, people of these villages, primarily the women group were spending as long as 2-3 hours a day just to fetch water from these facilities.

However, after installing the Solar DWS, the people, particularly the women of the area are getting additional time to spend on productive household activities.

2.8 Purpose versus Practice: The original purpose of the Solar DWS is to supply drinking water for regular drinking purposes, cooking and small household works such as cleaning utensils and such. However, the field study team found that the people have been using it for bathing, washing their domestic animals, supplying water to their ponds etc. Additionally, it has been observed that the water tap is kept open even when there was no supply. It means the taps are kept open all the time. As a result, the water flow reduces in distant locations, which can be tied to complain from several users living in farther areas that they are unable to get the water that they have been paying for. There have been allegations from the users that the influential people are abusing the water supply and also hoarding water in large tanks.

Although, the water management committee has been trying to address these issues and complains but general users brought to light that the committee has been unable to mitigate let alone solve the ongoing issues.

2.9 General Concerns: Some people have shown their unwillingness to take the services from Solar DWS because they have preconceived mindset that the pipeline water is usually dirty. Moreover, the women-group have this belief that the pipeline water creates gastric problem. Besides, local people have been scared ever since arsenic has been found, although, they are using the tube-well that shares the same groundwater source.

The complain/ suggestions from the local people are listed below:

- The authority wanted to raise the rate to BDT 30 per month because of lack of funding for maintenance works. However, not only the people rejected the suggestion, some of them actually decided not to take water from the Solar DWS;
- The influential people are abusing the water supply;
- The beneficiaries are irregular to pay monthly subscription fee;
- The water supply has been irregular;
- The people leaving far from the source do not get the water pressure that they are paying for;
- The local people want monthly cleaning of water pipeline;

2.10 Arsenic Solution: BRAC WASH has found that the groundwater contains arsenic in it. The measured level was 0.062 mg/L[7] (Source: BRAC WASH Laboratory Test – See **Annex-II, Lab Results 1.1**) which is slightly higher than 0.05 mg/L – the level set by the Department of Environment (DoE) of the Government of Bangladesh. BRAC WASH has found a solution to bring the arsenic contamination below the standard level by implementing a filtering process. The field study team found that the filter has already been constructed adjacent to the Solar DWS water tank. The filter will store rainwater, filter it through several levels of gravels, sands and other filtering materials by stages and then will get mixed with the groundwater through a 36.6m (120 ft.) boring to bring the contamination level below the set level. The field study team has been advised that the filter will start operating as soon as it starts accumulating more rainwater.

2.11 Laboratory Test for Comparisons: The field study team took samples from the Solar DWS and nearby groundwater source (hand-operated mechanical tube-well) to compare several readings. The CEGIS Laboratory has been used to obtain the test results. The laboratory test results are shared in **Annex-II, Lab Results 1.2**.

As expected, the salinity of the Solar DWS sample (Sample 2, Annex-II: Lab Results 1.2) is found to be 1.24 ppt[8], much lower than the nearby separate source of groundwater sample (Sample 1, Annex-II:

[7] mg/L = milligram per litre

[8] ppt = parts per thousand or 10^{-3}

Lab Results 1.2) at 2.14 ppt. For comparison purpose, the average freshwater salinity is 0.5 ppt or lower. The results are also found in favour of the Solar DWS sample as it has lower turbidity and lower concentrations of total dissolved solid (TDS), Nitrate (NO_3) and Iron (Fe) compared to the nearby groundwater sample.

Conclusions and Recommendations

Case Study–1: The overall findings of Case Study–1 has been extremely positive. The farmer groups, the SIP land owners (lessee) and the implementing organizations have worked out a working and sustainable system that they expect to run for 20 years at least. The initial results have been more than satisfactory. However, there are ways to increase the potential of these systems.

The following are the recommendations:

- A comprehensive technical study should be carried out to see if the irrigation land coverage can be increased without increasing the capacity of the systems as stated by the service providers. Care should be taken to make sure the SIPs are not overloaded and thereby their expected lifespan is compromised or the mean-time-between-failures is decreased.
- The solar panels need to be cleaned regularly, at least once a week to maintain the desired output.
- The designer of the panel structures should incorporate the provision for climbing to the panel top for cleaning in a safe way. It is recommended to provide this so that accidents from falling from an elevated height can be avoided and panels can be cleaned regularly.
- A 0.25HP motor with a pump connected water hose can be provided to the operators to clean the elevated solar panels with pressurized water spraying. These motors can be easily connected with the existing system with the controller. The system can be made such that this motor cannot be operated at the same time with the main motor, and thereby effectively making sure the operation capacity for the SIP is not compromised. This way, the cleaning and maintenance will be done when the main pump is not operating.
- During the time no irrigation is required, which has been identified to be more than a third of a calendar year, alternative use of the solar power can investigated. For instances, they can be used to charge batteries for battery operated small appliances or even transportations. It is also possible to inject AC power to the grid if proper infrastructures/ technologies are in place. However, for these, measures can be taken to find proper models to verify whether the return of investment is possible. In this regards, conducting thorough financial and economic analyses of the models is recommended.
- Under the panel shades, plants and vegetation that can grow with little sunlight such as turmeric (*holud*), ginger (*ada*), sweet potatoes (*mishti alu*) etc. can be cultured to maximize use of cultivable lands. Further researches and studies can be carried out to identify similar alternatives. At the same time, researches can be conducted to create variants of crops/ vegetables those can be grown with little sunlight.

Case Study–2: The study team have mixed feelings on the findings of Case Study–2. In one hand, the Solar DWS seemed to have goodwill behind it, but in other hand, the system has been struggling to prove itself to be self-sustainable. The following recommendations are made to address the problems:

- Presently, the dire need is to remove the fear of arsenic contamination from the current and prospective users by fast implementation of the filter system in place.
- One of the complains was that the users found dirt in the water supplied by the Solar DWS. Appropriate measures should be taken such as there is no dirt found in the water. Chlorine injection to kill moss grown and filtering the water at least once a month will need to be carried out;
- Another complain is the typical thinking that water drunk from pipeline results in gastric. For

this, awareness building programmes such as community based workshops would go a long way to change the preconceived views.

- The committee should come up with appropriate measures to penalize those who abuse the Solar DWS supplied water. For this, barring them from using the water, charging them with penalty fees, further sanctions for repetitive offenses can be implemented.
- However, first and foremost, the committee must ensure that the water is clean and drinkable. Only, then the number of subscribers will increase and it will start generating funds for future maintenance and repair works.
- Spring operated taps can be used to remove water wastage;
- Water awareness programmes should be carried out to ensure the villagers understand the best way to use water to maximize water usage;
- The authority should take the advantage of the higher literacy rate of the area. School children may be included in the awareness programme to help spread the awareness in their family.

The findings from Case Study–1 show that SIPs can definitely grow as a sustainable solution and at the same time contribute immensely in the overall crop production of the country if implemented in larger scales where there are potentials. Benefits of SIPs are already apparent but further researches need to be carried out to enhance its capacities during the seasons they remain active and identify areas of usage during the seasons they remain inactive.

The findings from Case Study–2 show that Solar DWS is technically feasible but its benefits are not fully realized due to the lack of proper management and a financial model that can keep it sustainable in the long run. For this, the first objective should be making it more reliable followed by conducting public awareness programmes to change the perception of the current and prospective beneficiaries.

With solar technology being largely accepted as an environmentally sustainable technology in the world, as it evolves, the capital cost for each solar based system is expected to go down in the coming days. The fact that Bangladesh is trying to embrace it is very encouraging. It is suggested that workshops on SIP and Solar DWS involving related government bodies, researchers, potential donor agencies, international organizations, NGOs and most importantly the beneficiary groups are carried out more than ever before.

Acknowledgements

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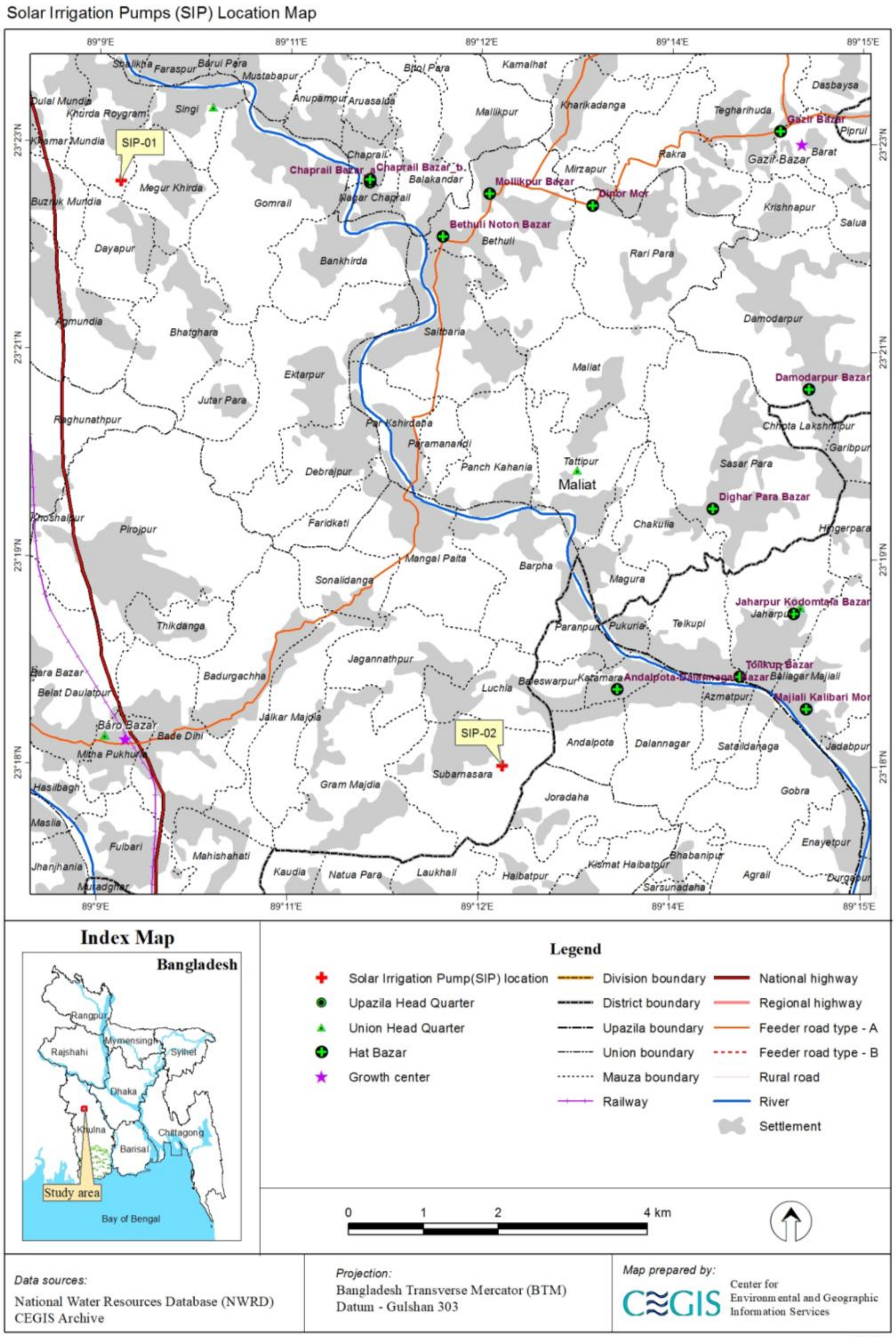
CEGIS would also like to thank all the local people who were very welcoming and open to share their experiences in using the solar based solutions.

Finally, CEGIS would like to convey its gratitude to Bangladesh Water Partnership (BWP) for allowing CEGIS to conduct this comprehensive study.

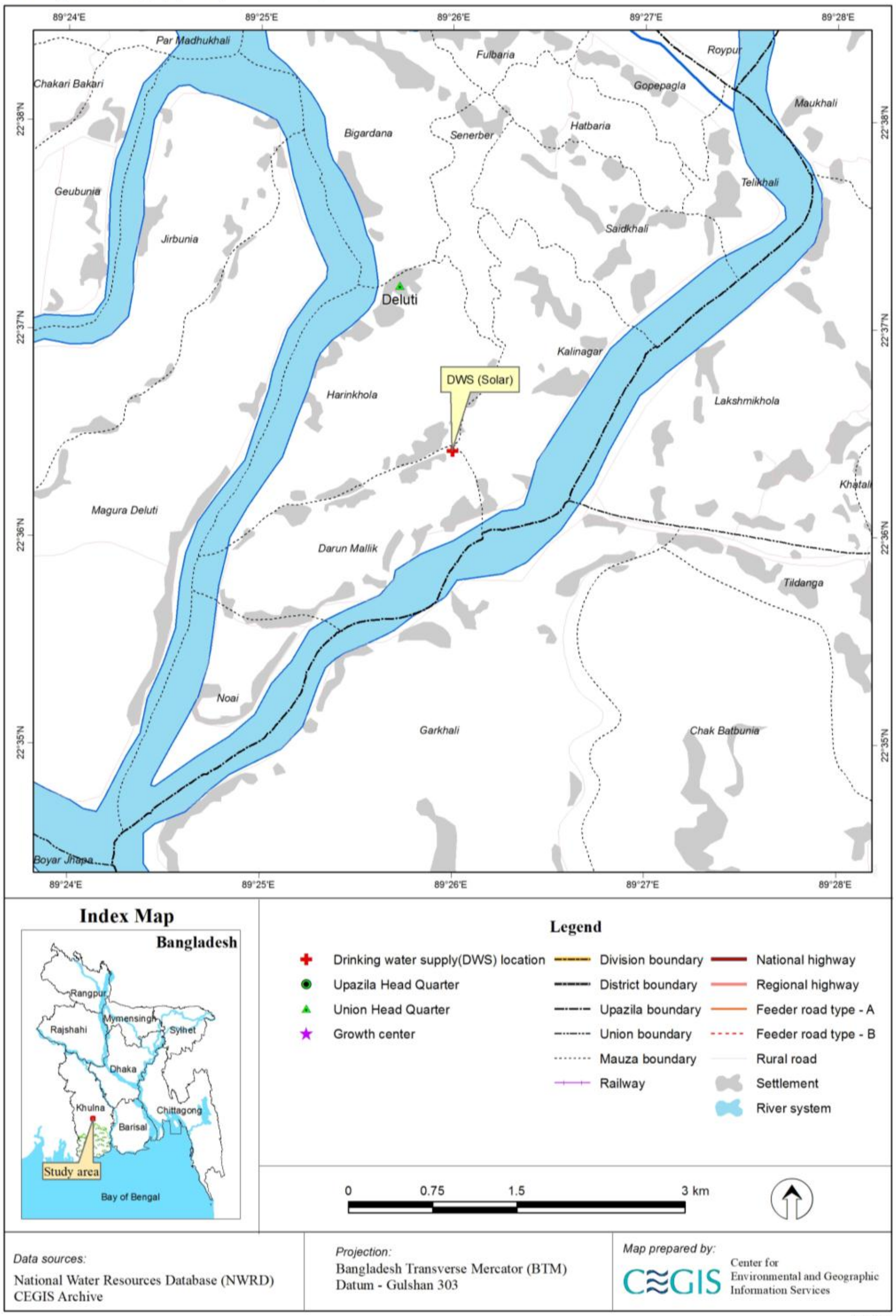
Annexure-I: Location Maps



MAP 1.1: Location Maps of SIP-1 (Doyapur) and SIP-2 (Jagannathpur),

Kaliganj Upazila, Jhenaidah, Bangladesh

Drinking Water Supply (DWS) Location Map



MAP 1.2: Location Maps of Solar DWS (Darun Mallik), Paikgachha Upazila, Khulna, Bangladesh

Annexure-II: Laboratory Test Results

Asia Arsenic Network

Jessore Office

(NGO Registration No.1609)

Environmental Laboratory

Arsenic Center, Jessore-Benapole Road, Krishnobati-Aminnagar, Pulerhat, Jessore. Tel / Fax: +880-0421-68663
Web: http//www.aan-bangladesh.com

AAN / Jes /Lab/Report-76/2017

Date: 30-08-2017

BRAC WASH Programme,
Paikgachha,Khulna.

Name: D.H.K. Rural Water Supply Project.
Village: Darunmallik
Union: Deluti
Upazila: Paikgachha
District: Khulna.

General Information:

Customer Id.:145
Water source: Raw Water (STW).
Date of Sampling: 24th August, 2017.
Date of Analysis: 24th to 29th August, 2017.

	Parameter	Unit	Bangladesh drinking water standard	Results (STW)	Method
1	pH		6.50-8.50	7.65	Membrane Electrode
2	TDS	mg/L	1000	1400	Conductivity
3	Arsenic(As)	mg/L	0.05	0.062	HG-AAS
4	Iron(Fe)	mg/L	0.30-1.00	1.42	Flame-AAS
5	Chloride	mg/L	600-1000	700	Mohr's Titration
6	Manganese(Mn)	mg/L	0.10	<0.10	Flame-AAS

Asia Arsenic Network
Date.........
Jessore Office

Md. Abu Shamim Khan
Chemist
Environmental Laboratory
Asia Arsenic Network

(Source: BRAC WASH)

Lab Results 1.1: Laboratory Results of Solar DWS water from Darun Mallik,

Paikgachha Upazilla, Khulna, Bangladesh

(A Public Trust Under The Ministry of Water Resource)

Center for Environmental and Geographic Information Services

House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh. Phone:8821570-72, 8817648-52, 0173000752, Fax:8823128, 855935 Email:cegis@cegisbd.com, Website: www.cegisbd.com

Lab Memo: CEGIS LAB/2019.03.000-1 Date: 20/03/2019

Physical/Chemical/Bacteriological Analysis of Water

Sample ID:UPD001_20190300(1-2)	Sample Receiving date: 07/03/2019
Ref. No.: Nill Date: 07/03/2019	Sample Source: Ground Water
Sent by: Md. Alamgir Hossain	Dist: Khulna Upa: Paikgachha
Care Taker: CEGIS	Union: Raygram Vill: Darunmallik
Sample Collection date: 05/03/2019	Date of Testing: 10/03/2019- 14/03/2019

LABORATORY TEST RESULTS:

SL.#	Name of Sample	Water quality parameters	Bangladesh standard	Concentration Present	Unit	Analysis Method
1	Sample 1	NO3	10	8.623	ppm	UVS
		Fe	0.3- 1.0	0.668	ppm	UVS
		Turbidity	10	3.450	NTU	Nephelometric
		pH	6.5- 8.5	7.460	pH	pH Electrode
		TDS	1000	2420	mg/L	Electrode
		Salinity	-	2.14	ppt	Electrode
2	Sample 2	NO3	10	3.5353	ppm	UVS
		Fe	0.3- 1.0	0.4834	ppm	UVS
		TURBIDITY	10	1.90	NTU	Nephelometric
		pH	6.5- 8.5	7.67	pH	pH Electrode
		TDS	1000	1381	mg/L	Electrode
		Salinity	-	1.24	ppt	Electrode

Remarks: Sample was collected and Supplied by assigned professional.

N.B: UVS-UV 1800 Visible Spectrophotometer

Test performed by: Signature 20.3.19 20.03.19 Name: Rafiqul Islam & Rafiqul Alam Designation: In-Charge of Scientific Equipment & EEE	**Approved by:** Signature 20.03.19 Name: Rafiqul Alam Designation: Laboratory Expert, CEGIS

Lab Results 1.2: Laboratory Results of underground water (Sample-1) and Solar DWS water (Sample-2) collected from Darun Mallik, Paikgachha Upazilla, Khulna, Bangladesh

Annexure-III: Field Photos

Photo 1: Solar Irrigation Pump (SIP) in Doyapur of Kaliganj, Jhenaidah

Photo 2: Supply line of Solar Irrigation Pump (SIP) in Doyapur of Kaliganj, Jhenaidah

Photo 3: Solar Irrigation Pump (SIP) in Jagannathpur of Kaliganj, Jhenaidah

Photo 4: Informal discussion with operator and beneficiaries in Doyapur of Kaliganj, Jhenaidah

Photo 5: Solar Irrigation Pump (SIP) controller, motor and connector panel housing in Doyapur of Kaliganj, Jhenaidah

Photo 6: Inside of the controller, motor and connector panel housing in Doyapur of Kaliganj, Jhenaidah

Photo 7: SIP performance verification through measurement in Doyapur SIP, Kaliganj, Jhenaidah

Photo 8: Informal discussion with operator and beneficiaries in Jagannathpur of Kaliganj, Jhenaidah

Photo 9: Men and women both involved in agricultural activities in SIP served areas, Kaliganj, Jhenaidah

Photo 10: Vegetables being cultivated in SIP served areas, Kaliganj, Jhenaidah

Photo 11: Solar Based Drinking Water Supply (Solar DWS) in Darunmallik of Paikgachha, Khulna

Photo 12: Provision for arsenic contamination reduction in Darunmallik of Paikgachha, Khulna

Photo 13: Key Informant Interview with the Headmaster of Darunmallik Primary School and BRAC WASH

Photo 14: Informal Discussion with local female group in Darunmallik of Paikgachha, Khulna

Photo 15: Rainwater collection using pipes and rooftop in Darunmallik of Paikgachha, Khulna

Photo 16: A woman is using rainwater in Darunmallik of Paikgachha, Khulna

Photo 17: Girls from school using manually operated tube-well in Darunmallik of Paikgachha, Khulna

Photo 18: Water sample collection from Solar DWS in Darunmallik of Paikgachha, Khulna

Note: All photos are captured by CEGIS Field Visit Team with prior permission from the people and their properties involved. All photos are captured between March 03, 2019 and March 06, 2019.