FY 2013

Feasibility Studies on Joint Crediting Mechanism Projects towards Environmentally Sustainable Cities in Asia

Low Carbon & Safe Water Supply in Rural Area:

CO2 Free Clean Water Supply Project

Final Report

March 2014

Pacific Consultants Co., Ltd.

EXECUTIVE SUMMARY

Surface water has long been the primary source of drinking water for the rural population of Bangladesh. Contamination by pathogens was causing widespread outbreaks of diarrheal diseases across the nation. In the 1970s the Government of Bangladesh began free installation of shallow tubewells which extracts water from the shallow aquifer. As a result, cases of diarrheal diseases were dramatically reduced. However, arsenic contamination was detected in these shallow aquifers in the early 1990s. There are other water quality issues such as salinity, iron and manganese which are also of concern. Significant challenges are faced in providing access to safe drinking water in rural Bangladesh.

Installation of a small water purification plant is an effective way of supplying local residents with safe drinking water. However, large proportion of the rural area remains unreached by the power grid. In such areas, electricity is often generated by a small gasoline or diesel generator.

This study investigates the feasibility of implementing a water supply venture in the rural areas of Bangladesh where safe drinking water is scarce. The assumed business aims to provide the rural population with safe and affordable drinking water with low carbon footprint. This is achieved by using a coagulant developed by Nippon Poly-Glu, and an off-grid power supply system using renewable energy.

Learning from the experiences of a preceding rural water supply venture in Porir-Khir Village in Barguna District, the business model developed as a result of this study will provide up to 7,000L/day of safe drinking water to a target population of 1,700 people per business unit, and achieve a GHG emission reduction of 1.345 t-CO_2 per year.

Demands for the assumed business were identified in the villages close from Porir-Khir Village. It is estimated that there are business opportunities in 1-2 villages in each union on average in Southern-western Bangladesh. However, several issues need to be addressed before the assumed business can be actualized. This includes the need to review the assumptions which form the basis of the cash flow, securing funding to subsidize installation of the off-grid power supply system, establishment of a SPC to operate the assumed business, and promotional activities targeting residents and authorities in the areas targeted for business deployment.

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Chapter 1. Introduction

1.1. Background

The rural population of Bangladesh has long resorted to surface water such as pond water as a source of drinking water. Such water is usually highly contaminated by pathogens. As a result, the rural population suffered diarrhea and other waterborne illnesses. The situation was vastly improved when shallow tubewell, a technology which draws water from an underground water source using a hand pump, was installed across the nation. However, in 1993, arsenic was detected in the groundwater in Chapai Nawabganj District in north-west Bangladesh. Since then, arsenic was detected in the groundwater across the country, and victims of arsenic poisoning (arsenicosis) were identified. Access to safe water is once again in need of intervention.

Since the discovery of arsenic in the groundwater, technologies to pump water from deeper aquifer, technologies to purify surface water using a sand filter, and rain water harvesting systems have been developed and installed. However, along with their advantages, these technologies have various disadvantages and the issue of arsenic is yet to be solved. In recent years, water quality issues such as salinity, iron and manganese have also been identified. Furthermore, due to the limited income of the large part of the rural population, the need to develop and provide affordable means to obtain safe drinking water is extremely high.

Installation of a small-scale water purification plant would be an ideal way to provide the rural population with affordable and safe drinking water. In order to operate a water purification plant, electricity is required. However, the electrification rate in rural Bangladesh is low. In the electrified area, power supply is unreliable with long and frequent load shedding. Shops and businesses in the rural area often use diesel or gasoline powered generators.

1.2. Study Purpose

The purpose of this study is to investigate the feasibility of a rural water supply business, which supplies the rural population with safe and "CO2-Free Clean Water" - drinking water that has a low carbon foot print - at an affordable price, by combining a water purification technology and an off-grid power supply system developed by Japanese firms.

The assumed business will employ renewable energy to supply the power required to run the water purification plant thereby reducing the emission of greenhouse gas (GHG). It is hoped that the project will be registered under the Joint Crediting Mechanism (JCM) upon successful commencement of the business.

Chapter 2. Rural Water Supply and Electrification

2.1. Development Plan

In 2010, the Government of Bangladesh laid down its' long term development plan envisaging the eradication of poverty by 2021 in the "Outline Perspective Plan of Bangladesh 2010-2021". The long-term plan is accompanied by the "Sixth Five Year Plan (2011-2015)" which provides a breakdown of the government's plan towards achieving its vision.

With regards to water supply, the government has set a target for all urban population to access safe water, and for 96.5% of the rural population to access safe water by 2015. As for the power sector, the government aims to enlarge the country's generation capacity to 15,457MW and 20,000MW by 2015 and 2021 respectively, to increase the electrification rate to 68% by 2015, to increase the share of renewable energy to 5%, and to expand the supply of primary and secondary energy to the poor through targeted pricing policies and other measures.

2.2. Administrative Bodies

Water supply in Bangladesh is governed by the Local Government Division (LGD). Water supply in the urban cities of Dhaka, Chittagong, Khulna and Rajshahi are provided by Water and Sewerage Authorities (WASAs) situated in each city. In rural areas, services related to water supply are provided mainly by the Department of Public Health and Engineering (DPHE). The Local Government Engineering Department (LGED) installs water points in markets. Upazilas and unions may also support or implement installation of water supply facilities. Rural water supply projects are on some occasions implemented by the DPHE and NGOs under the oversight of the Water and Sanitation (WatSan) Committees set up in upazilas and unions. Coordination at the national level is carried out by the National Forum for Water Supply and Sanitation (NFWSS) established within the LGD.

The power sector in Bangladesh is governed by the Power Division of the Ministry of Power, Energy and Mineral Resources (MoPEMR). A large part of electricity in Bangladesh is generated by the Bangladesh Power Development Board (BPDB), BPDB's subsidiary companies, and some Independent Power Producers (IPPs). Generation activities are overseen by the Power Division. The power is transmitted by the Power Grid Company of Bangladesh (PGCB), and distributed by different organizations in urban and rural areas. In Urban areas, the BPDB, Dhaka Electric Supply Company Limited (DESCO), Dhaka Power Distribution Company (DPDC), and West Zone Power Distribution Company (WZPDC) supplies electricity to its users. In rural areas however, the Palli Bidyut Samity (PBS) set up in each area distributes electricity to its members. Rural electrification is planned and coordinated by the Rural Electrification Board (REB). Licensing and approval of pricing is governed by the Bangladesh Energy Regulatory Commission (BERC).

2.3. Current Status of Rural Water Supply

The most widely used water supply technology in rural Bangladesh is the shallow tubewell. Other available technologies include deep tubewell, dug well, rain water harvesting system, Pond Sand Filter (PSF) and arsenic removal filter. Piped water supply is still uncommon in rural Bangladesh.

Shallow tubewell was widely popularized in the 1970s when the DPHE installed them free-of-charge for the low income rural population. The relatively low price of the technology attracted the rural population to install shallow tubewell in their own premises, helping further popularization of the technology. Popularization of shallow tubewell contributed to significant reduction of diarrheal disease. However, it is becoming difficult to promote the use of shallow tubewell because of the existence of arsenic in shallow aquifer.

The DPHE recommends the use of deep tubewells to replace shallow tubewells. However, deep tubewell is expensive and most rural households cannot afford to install it on their own. The DPHE has so far been installing deep tubewells as a communal facility in public places such as schools. The rural population who are now used to the convenience of accessing water through a shallow tubewell installed in its own premises are experiencing great difficulties in getting used to traveling to a public water point which may be of some distance from the house.

Dug wells, rain water harvesting systems and PSFs are also introduced as a public facility due to its high cost. In addition to the inconvenience of having have to travel to obtain water, difficulty in maintaining the facilities and contamination by pathogens are casting shadows over popularization of these technologies. As for arsenic removal filters, although the unit cost of a filter is not unreasonable, the sum quickly builds up as it needs to be replaced frequently. Furthermore, it is difficult to judge the correct timing of replacement, leaving the danger of consuming contaminated water.

2.4. Current Status of Rural Electrification

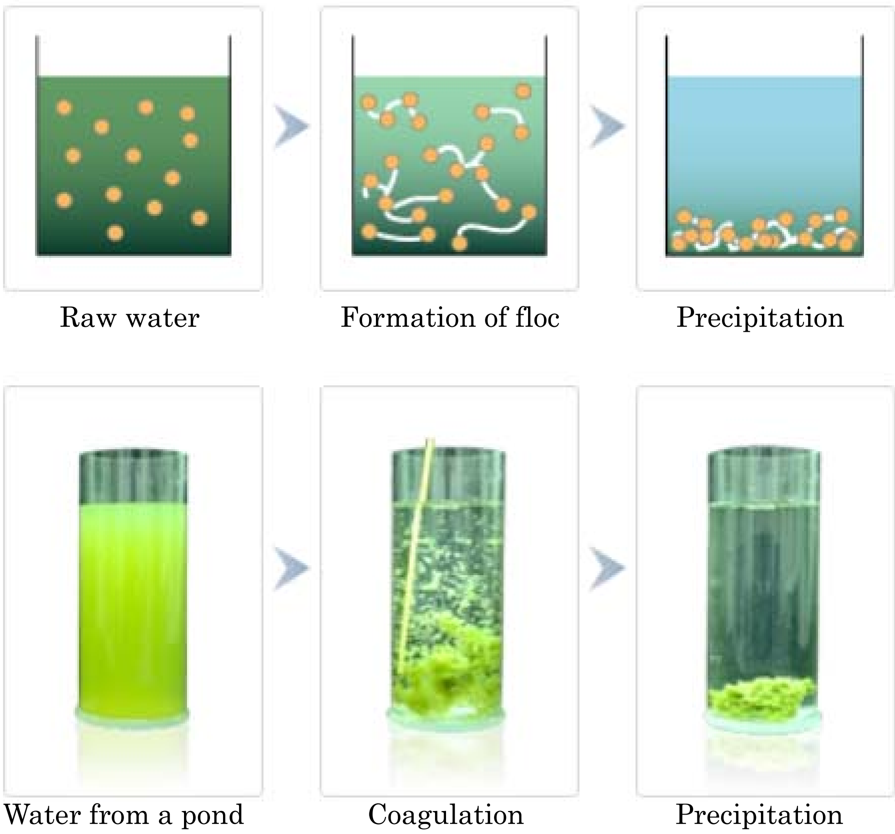
The electrification rate across Bangladesh is 47%. The rate is significantly lower in the rural area at 33% compared to 82% in the urban area. By 2013, 70 PBSs were set up across the nation supplying electricity to 50,129 villages and 8.38 million households. In the past year, 0.49 million households were connected to the grid. The government has set a target to achieve complete electrification of the nation by 2021. However, it is estimated that it will take over 30 years at the current rate of progress.

In areas where power grid is yet to arrive, kerosene is widely used as a conventional source of light. However, in recent years, Solar Home System (SHS) have become increasingly popular. SHS consists of solar cell modules of several to dozens of wattage, a lead-acid battery, and a charge controller. Installation of a SHS will enable the owner to use lighting equipments and charge mobile phones.

Chapter 3. Japanese Technologies

3.1. Water Purification Technology

The rural water supply business assumed in this study (here after referred to as “the assumed business”) will utilize the water purification technology developed by Nippon Poly-Glu Co., Ltd. (here after referred to as Nippon Poly-Glu). Nippon Poly-Glu has developed and supply “PG α 21Ca” – a coagulant derived from fermented soybeans – across the world for uses in water purification and supply. PG α 21Ca is particularly effective in removal of particulates and heavy metals in water. PG α 21Ca is added to water and churned for a short period of time to form floc which then assist suspended solids in water to precipitate. Formation and precipitation of floc using PG α 21Ca is fast compared to Poly Aluminum Chloride (PAC) often used in water treatment processes.



Source: Nippon Poly-Glu

Figure 1 Coagulation and Precipitation using PG α 21Ca

Nippon Poly-Glu has been operating a rural water supply business using PGα21Ca in Porir-Khir village (here after referred to as the “Porir-Khir business”) in Barguna District, in southern Bangladesh since 2011. In the Porir-Khir business, purified water called the “Poly-Glu Water” is produced by a simple water purification plant which uses PGα21Ca. The plant consists of a water intake pump, a coagulation tank, a pump to pressure and convey water, polypropylene (PP) filters, a sand filtration system, an ultraviolet sterilizer, and a water tank for temporary storage of purified water (Figure 2).

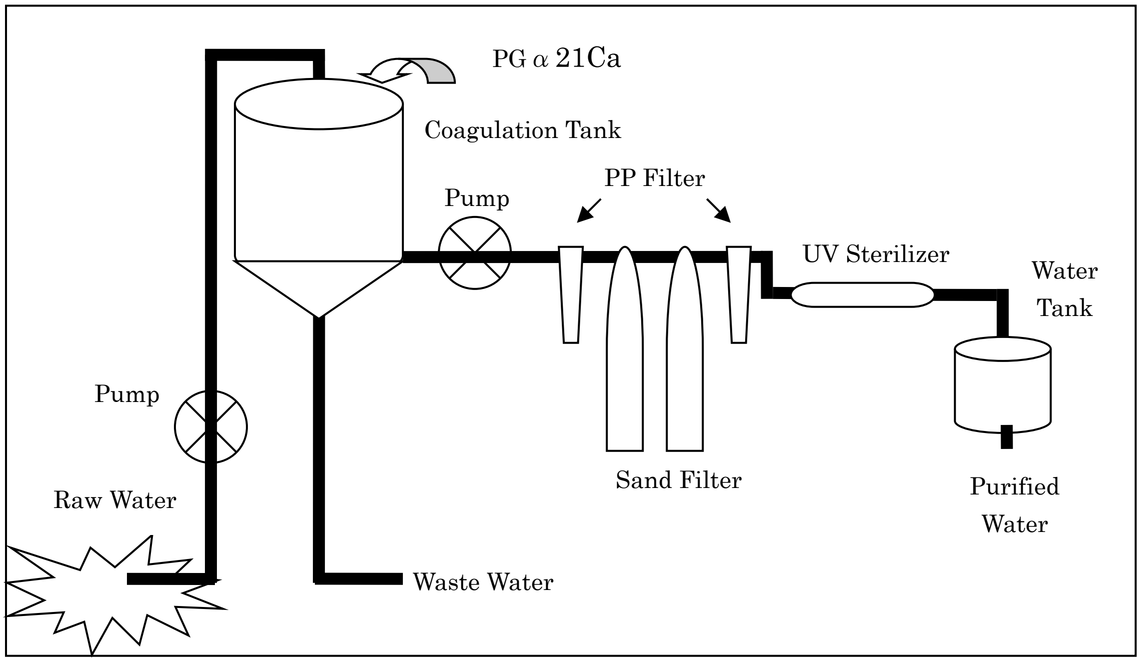
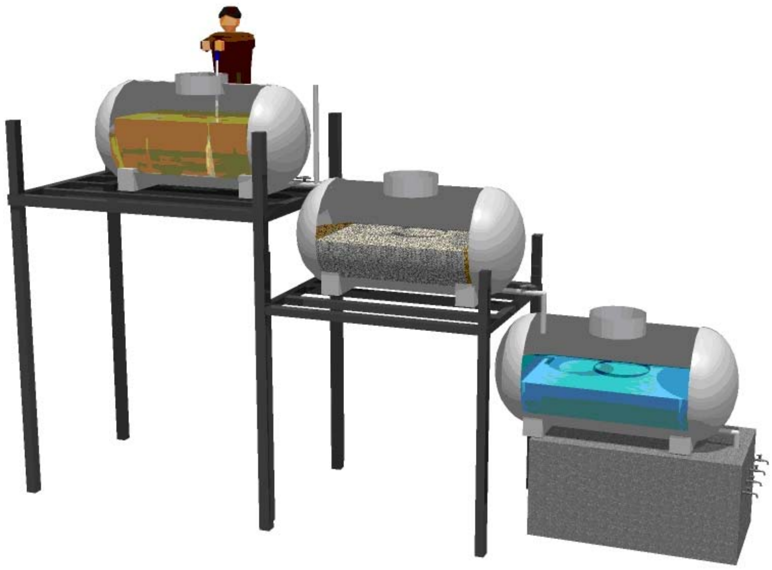


Figure 2 Water Purification Process in Porir-Khir

The assumed business will use an improved model of the water purification plant installed in Porir-Khir village. The PP filter and sand filter will be replaced by a filtration tank using sand, gravel, and coal, and tanks will be produced from locally procured High-Density Polyethylene as opposed to stainless steel made in Japan.



Source: Nippon Poly-Glu

Figure 3 Water Purification Plant

3.2. Renewable Energy Technology

Average solar irradiation of Bangladesh is 3.5~4.0 kWh/m²day in coastal regions, 4.5~5.0kWh/m²day in central regions, and 5.5~6.5 kWh/m²day in the northern regions. In Bangladesh, owing to its location close to the equator, relatively stable supply of sun light can be expected, with monthly average solar irradiation reaching 6kWh/m²day in some areas during March and June. Solar irradiation exceeding 4kWh/m²day can be expected even in the rainy season between June and September, and just below 4kWh/m²day in December/January when the irradiation is low. Under such condition, solar power is expected to generate a relatively stable supply of power.

In the assumed business, solar power will be used to supply electricity required for the operation of the water purification plant. It was estimated that the plant will require 3kWh/day of electricity to produce 7,000L of purified water. A solar power system was designed assuming a solar irradiation of 4.0kWh/m². The system designed consists of 16 solar cell modules with rated output of 90W, a solar charge controller, four 12V-255Ah (20hr rate) deep-cycle batteries, an inverter, and a voltage source inverter control (Figure 4)

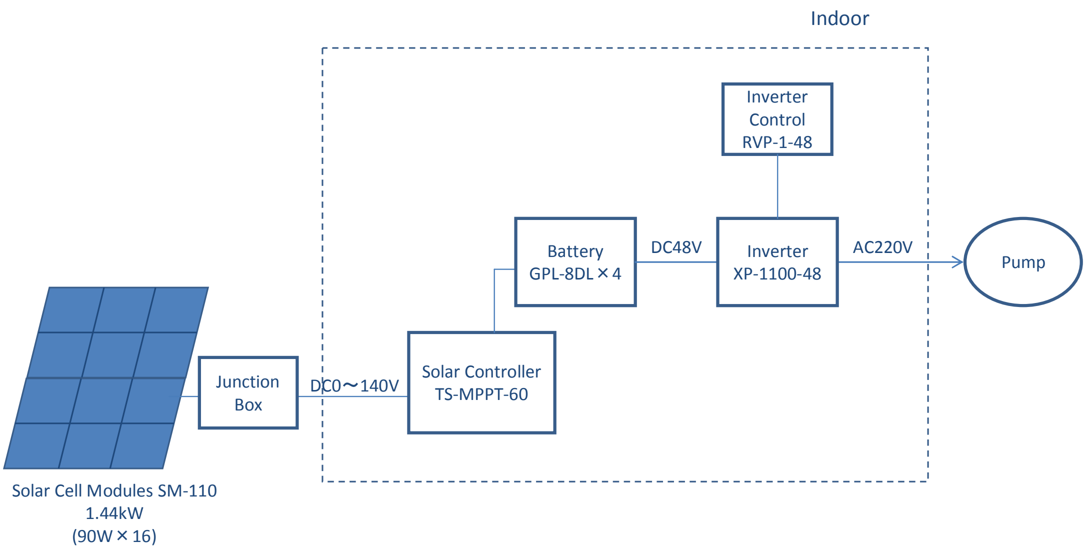


Figure 4 Schematic Diagram of the Off-Grid Power Plant

Chapter 4. Preceding Business

Nippon Poly-Glu supplies Poly-Glu Water to 424 households or 1,700 people – equivalent to 80% of the population – in Porir-Khir village. The volume of sales varies seasonally, with maximum sales reaching 180,000L/month during the dry season. Combined with water provided free of charge, a maximum of 7,000L per day is supplied. Sales is reduced to about a half during the rainy season of June to September, when increased number of residents use rain water.

The Porir-Khir business provides Poly-Glu Water free of charge to approximately 5 households every month. Water is provided free for families which cannot afford the payment due to special circumstances. Water is usually provided free of charge for up to a month, and families for the preferential treatment are chosen by employees who are well acquainted with the circumstances of each households in the village. Poly-Glu Water is also provided free of charge to the school next to the water treatment plant.

The quality of Poly-Glu Water is tested daily using a simple testing kit, and sent for full analysis in the International Centre for Diarrheal Disease Research, Bangladesh (ICDDR, B) every one to two months. There has been no incident of water quality issue in the past. Customers are satisfied with Poly-Glu Water, and comments that their previously chronic symptoms of gastritis, heartburn and diarrhea diseases have improved.

Poly-Glu Water is currently sold at 1 taka for 2L, 2 taka for 5L, 3 taka for 10L, 4 taka for 15L, 5 taka for 20L, 6 taka for 25L, and 8 taka for 30L. At the beginning, there were residents who insisted that they could not pay the price of Poly-Glu Water as their budgets were limited. However, during the visit to the village in September 2013, the residents have suggested that they would buy Poly-Glu Water even if the price was increased by a little, and that the current price is cheap if the positive impacts of the water to health were taken into account.

Poly-Glu Water is delivered to each household on a van rickshaw. The volume of water purchased by a customer on each delivery is recorded by the sales staff. Customers are charged monthly according to the volume purchased. The payment is requested to be made in the first week of the following month. Approximately 60% of the customers meet this deadline, while about 10% may fall behind for up to a month. However, there has not been any case of non-payment.

The Porir-Khir business employs a total of six full-time employees and seven part-time employees, including technical staff who operate and manage the water treatment plant, sales staff who deliver the Poly-Glu Water, and Poly-Glu Ladies who collect payments and carry out awareness campaigns. The benefits of Poly-Glu Water are well known in nearby villages, and some customers travel long distance to purchase Poly-Glu Water for special events in their locality. Numerous requests for sales of Poly-Glu Water in other villages have been noted.

Chapter 5. Business Plan

5.1. Business Model

The assumed business targets rural area in Bangladesh where the availability of safe drinking water is insufficient. The business will supply rural residents with safe water produced using water purification technology developed by Nippon Poly-Glu. As large proportion of rural areas are yet to be electrified, and grid power is unstable in areas that are electrified, electricity required for the operation of the water purification plant will be supplied by an off-grid power supply system using solar power (Figure 5).

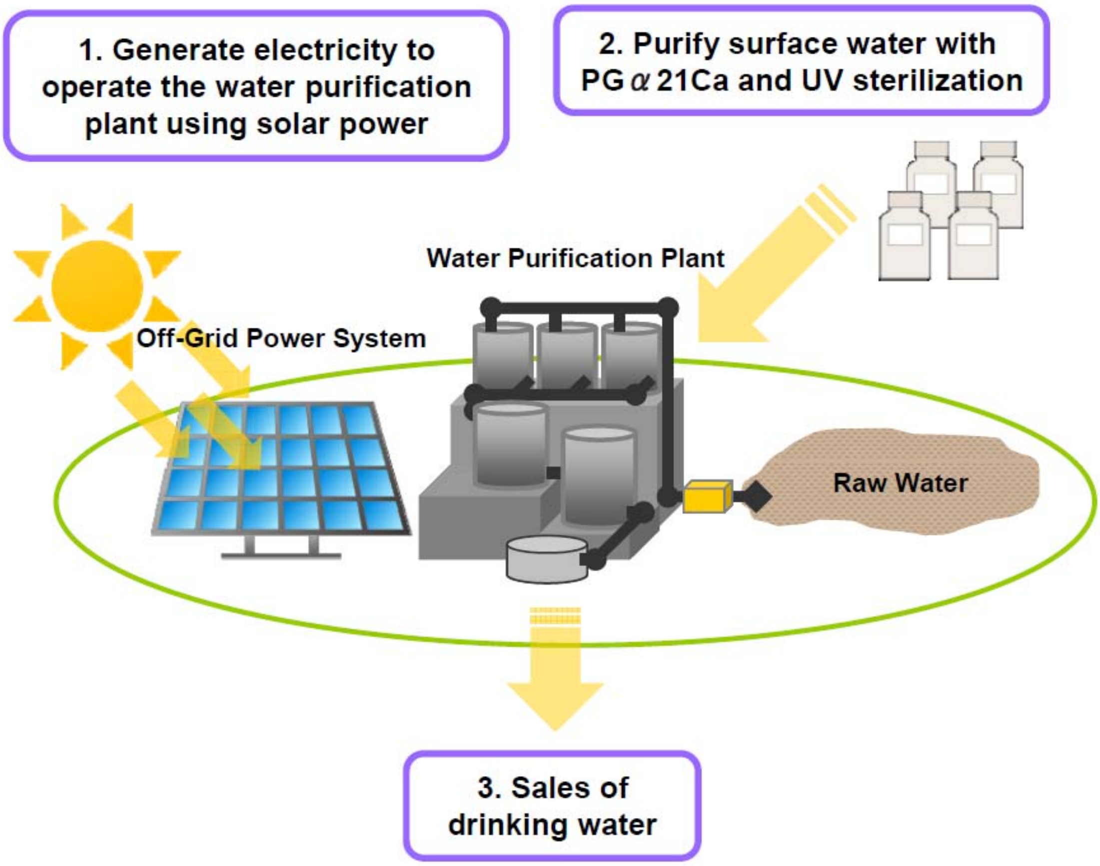


Figure 5 Concept Diagram of the Assumed Business

In the assumed business, the water purification plant will be located in the center of the target population. The cost of the water purification plant will be minimized using locally procured materials. Purified water will be supplied to local residents at the water purification plant, where residents can come and fill their containers, to minimize or eliminate the cost of delivery. The power cost will also be reduced by the installation of an off-grid power supply system using solar power. The power supply system will be introduced through subsidies available under the JCM schemes, to prevent increased burden of initial investment cost on the business.

The unit of the assumed business will be a village. Although the size and setting of villages vary, one business unit is assumed to supply a target population of 400 households or 1,700 residents for the current planning exercise. In accordance with the Porir-Khir business, the water purification plant will use surface water in a nearby pond. Once the business is on track, the sales volume is expected to reach 6,000L per day. The assumed business will operate such business in many villages.

5.2. Business Development Scenario

The assumed business will gradually expand. First, a pilot project will be conducted to scrutinize the profitability of the assumed business at sites close to Porir-Khir Village. The pilot project will be followed by the commercial deployment of the business, beginning from Sadar Upazila in Barguna, gradually expanding across Barguna District, then moving into other districts in Barisal Division, and reaching into the districts in the adjacent Khulna Division. Initially, the assumed business will target sites in the south-west region of Bangladesh which are relatively close to Porir-Khir Village where many people resort to surface water due to the salinity in the groundwater.

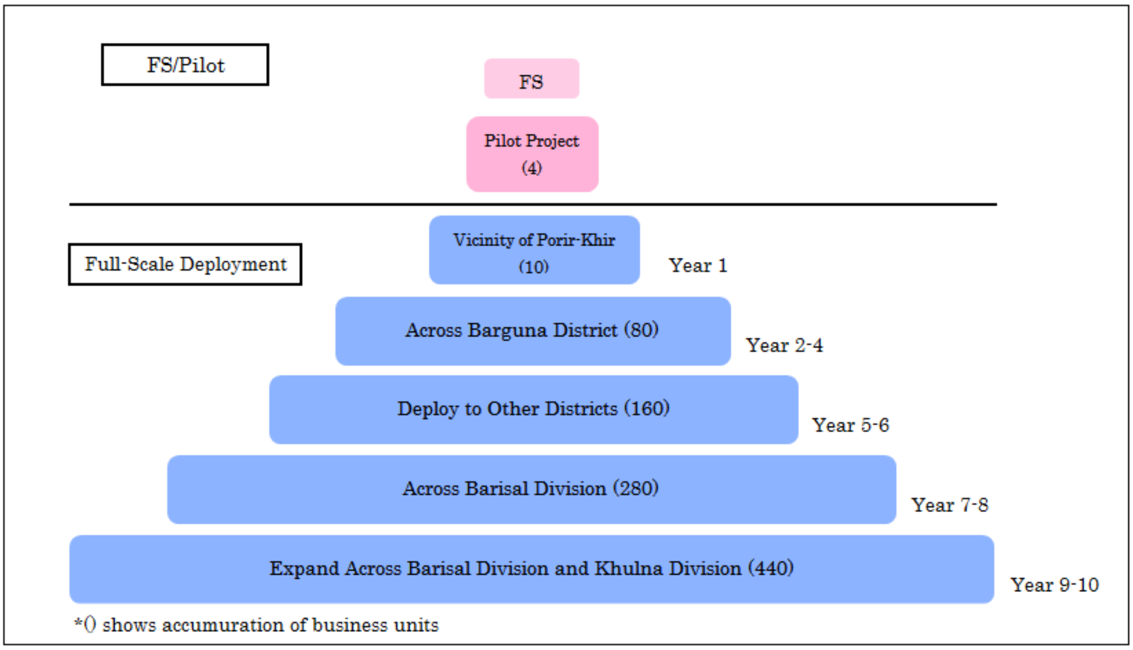
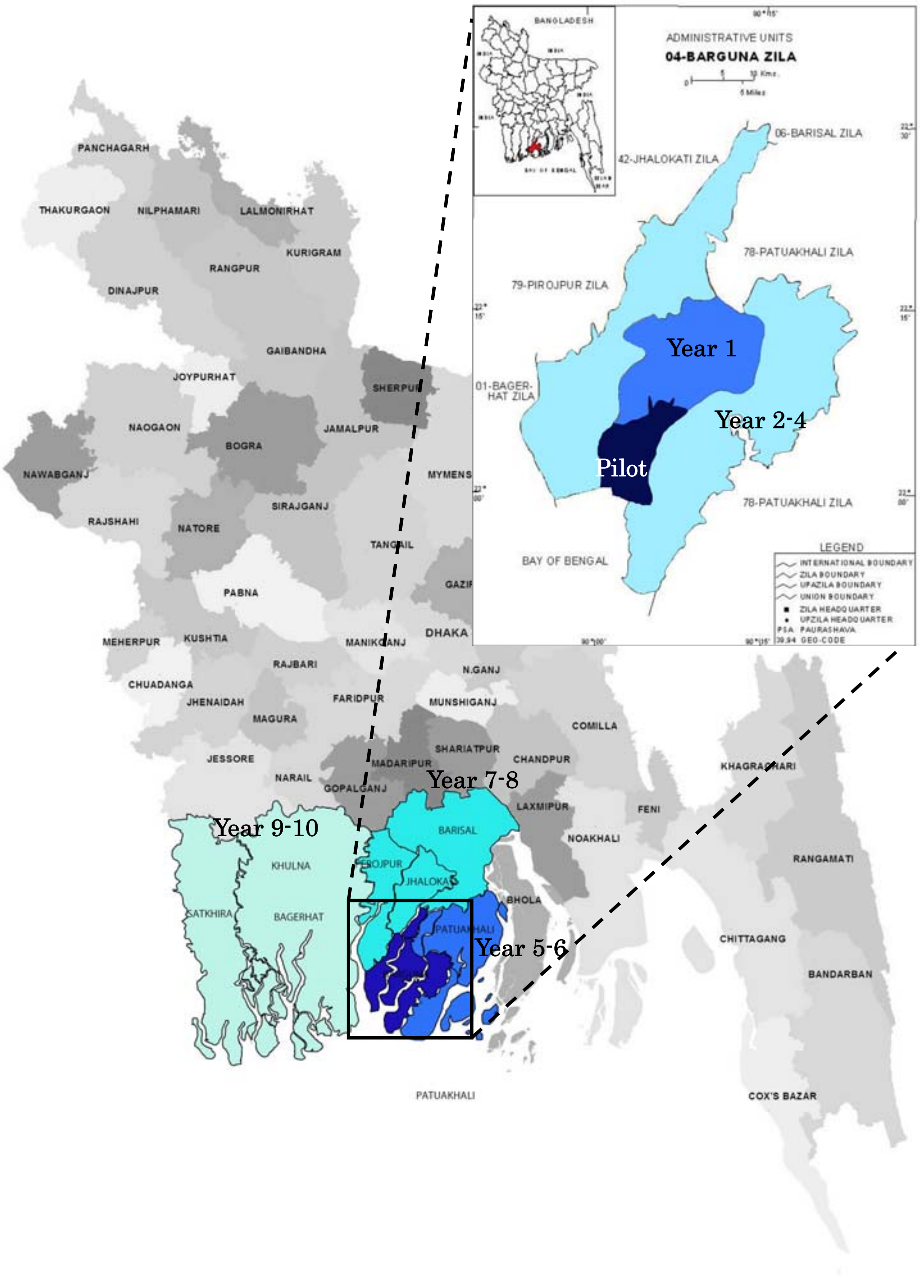


Figure 6 Deployment Flowchart

The assumed business will be developed by expanding on the experiences of the Porir-Khir business, whilst taking additional measures to improve profitability. The pilot project will scrutinize the effectiveness and issues in implementing such measures and their impact on the cash flow. The pilot project will particularly focus on the installation and maintenance of the revised water purification plant, operation of the off-grid power supply system using renewable energy, sales method and pricing of water, and their impact on the sales revenue. Implementation of the pilot project will be centered on local resources possessed by Nippon Poly-Glu. A Special Purpose Company (SPC) will be established for the commercial deployment of the assumed business. The structure of the SPC will be considered and the preparation for its establishment will be carried out during the pilot project.

The pilot project will be implemented in approximately four sites. Two candidate sites have so far been identified. Sonatola Village and Gonokabor Village in Noltona Union, approximately 30 minutes drive from Porir Khir Village have been identified as potential pilot project sites. Residents of both villages are well acquainted with the work of the Porir-Khir business, and have expressed their wish to have a similar business established in their village. The aim of the pilot project is to establish a highly versatile business model by testing the business in places with different requirements. The effectiveness and limitation of the adopted technologies and measures in the business will be identified during the pilot project.

As briefly mentioned above, necessary preparation for the commercial deployment will also be carried out during the pilot project. Further candidate sites will be identified, and water supply needs, service population and available water sources will be researched. Promotional activities targeting the residents and local officials of the candidate sites will also be implemented. To ensure smooth deployment of the business, outcomes of the Porir-Khir business and pilot projects will be widely advertized. The pilot project is expected to take approximately one to two years.



Source: Made by the study team based on data from LGED and BBS

Figure 7 Geographical Area for the Initial Deployment

As shown in Figure 6 and Figure 7, the commercial deployment of the assumed business will begin from Sadar Upazila in Barguna District where the pilot project will take place. Six sites will be chosen for the first year of the commercial deployment. Sadar Upazila contains ten unions. Combined with the four sites in the pilot project, a total of ten sites will be developed after the first year, achieving the density of one site per union.

From the second year, the business will be deployed assuming that there are one to two suitable sites in every union. Years 2 to 4 will focus on Barguna District, Years 5 and 6 on the adjacent Patuakhali District and Years 7 to 9 on Barisal Division excluding Bhola District. The business will be deployed in Khulna Division in its ninth year. It should be noted however, that this business development plan is of current assumption. Further details will be investigated in the pilot project phase.

5.3. Implementing Structure

The assumed business will be implemented by a SPC to be newly established. At the present stage, it is assumed that Pacific Consultants and InterAct – a related company of Pacific Consultants – will play the central role, assisted by Nippon Poly-Glu and its locally established company, Japan Poly-Glu BD, and D-Water Tech – a local water specialist. Japan Poly-Glu BD currently operates the Porir-Khir business (Figure 8). D-Water Tech assisted the construction and maintenance of the water purification plant and training of staff in the Porir-Khir business. Assistance for installation and maintenance of the off-grid power supply system will be sought from Zephyr Corporation. The implementing structure will be further scrutinized during the pilot project.

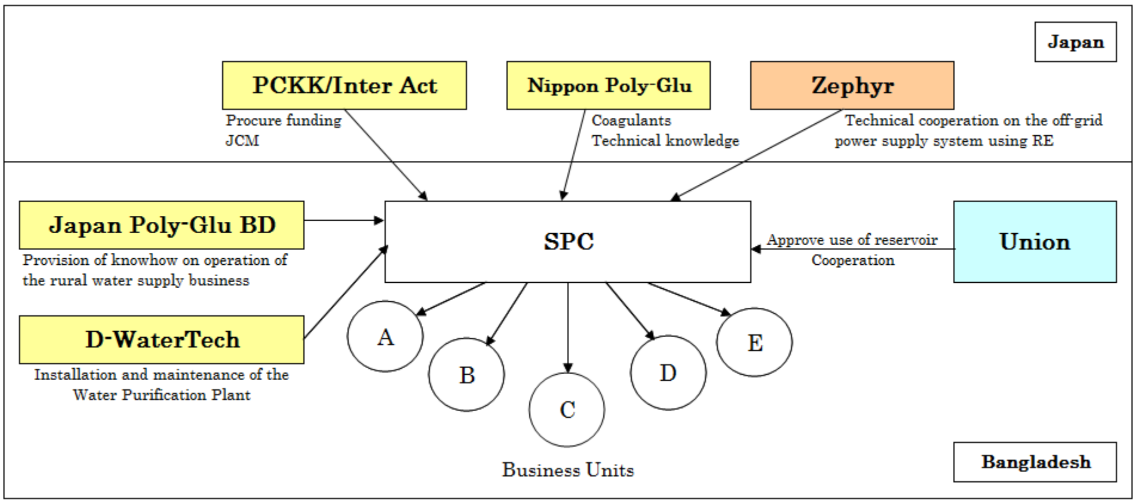


Figure 8 Planned Implementing Structure

5.4. Cash Flow

The cash flow for a unit of the assumed business is studied. Income of the assumed business is derived from the sales of purified water. Based on the performance in the Porir-Khir business, it is assumed that it will take approximately four years for the potential demand for safe drinking water to actualize. The sales volume of drinking water is thus assumed to be 1,500 L/day or 25% of Year 4 sales in the first year, 3,000L/day or 50% of Year 4 sales in the second year, 4,500L/day or 75% of Year 4 sales in the third year, and 6,000L/day in the fourth year. The price of the water is set at 0.4 taka per liter. This is slightly higher than the current price of the Poly-Glu Water. However, it is within the price range affordable by rural population. The sales revenue is expected to be 219,000 taka in the first year, 438,000 taka in the second year, 657,000 taka in the third year, and 876,000 taka from the fourth year onwards. The total revenue for the first ten years of the business unit is estimated as 7,446,000 taka.

The capital investment cost in the first year of the business consists of the water purification system and is expected to be 654,720 taka. The cost for the off-grid power supply system is expected to be subsidized by a fund established by the Ministry of the Environment in Japan for popularization of low carbon technologies. On the sixth year, there will be a cost incurred from replacing the battery for the stand-alone system, amounting to 387,600 taka. The total capital investment cost for the first ten years of the business unit is estimated as 1,042,320 taka.

The operation and maintenance costs include labor, management, coagulant, water quality tests, and maintenance of the facility. The labor cost used in the estimation assumes employment of three staff members. Although the sales volume is small up to the third year of the business, three people will be employed from the initial year so that the staff can be properly trained. There is also the need to secure enough staff to carry out the promotional activities in the first year. The daily operation of the business will be conducted by these three staff members. The management cost of the business, however, is accounted for separately. This includes the cost to employ a manager, under a prerequisite that each manager oversees ten business units. These costs are assumed to be constant over the ten years. The cost of purchasing the coagulant varies in accordance with the amount of water produced. Other management costs include water quality tests to be conducted every one to two months, and maintenance costs for the facility. In addition to these costs, administrative costs for setting up the business, cost for training and promotion will be incurred during the first year. The total operation and management cost of one business unit over the first ten years is estimated to be 5,545,821 taka.

The above-explained cash flow results in a profit of 857,859 taka after ten years. The

Internal Rate of Return (IRR) calculated from the above-mentioned figures is 10.38%. In the first year of the business, due to the large cost incurred by the capital investment, initial administrative fees, training and promotion, and limited sales of water, outgoing expenditure exceeds income. From the second year, the cash flow improves as it is assumed that expenditure is reduced significantly whilst sales revenue increases. From the third year, the annual income exceeds the annual expenditure, resulting in a profit. In the sixth year, the aforementioned replacement of batteries result in a net deficit. However, the income exceeds the expenditure in the seventh year, and the loss accumulated from the first year is cleared in the eight year.

It can thus be said that the assumed business can expect a certain degree of profitability. However, the sensitivity analysis reveals that a slight change in the assumptions will reduce the chance of profitability. The business falls into deficit when the costs are increased by 20%, or when the income is decreased by 20%. Moreover, the above figures assumes 100% subsidy on the cost of the off-grid power supply system. The cash flow will be severed if this assumption is broken. Given such situation, it is thought necessary to scrutinize these assumptions during the pilot project phase, and revise as necessary before launching the commercial deployment of the business.

Chapter 6. GHG Emission Reduction

The amount of GHG emission reduced by the assumed project (referred to as "the project" in this section) is derived by deducting the project emission from the reference emission. The reference emission here refers to the amount of CO_2 emitted when using a gasoline generator to power the water purification plant, whereas the project emission refers to the amount of CO_2 emitted when using the off-grid power supply system using solar power. The amount of electricity consumed by the water purification plant when the power is supplied by the gasoline generator and by the off-grid power supply system is the same. The emission from the gasoline generator is derived by multiplying the amount of electricity consumed by the water purification plant with the emission factor for the gasoline generator. The emission factor of 1.595 kg-CO_2/kWh was derived based on the emission factor of the gasoline and the rated power output of the gasoline generator. The project emission is assumed to be zero, as the off-grid power supply system utilizes renewable energy.

Table 1 GHG Emission Reduction Potential for the Assumed Project

Business Development Phase		No. of New Business Units	Cumulative No. of Business Units	Reduction Amount (t-CO_2/year)
Pilot Project		4	4	2.69
Commercial Deployment	Year 1	6	10	6.72
	Year 2	10	20	14.79
	Year 3	20	40	31.59
	Year 4	40	80	63.86
	Year 5	40	120	100.84
	Year 6	40	160	147.92
	Year 7	60	220	215.16
	Year 8	60	280	282.40
	Year 9	80	360	369.82
	Year 10	80	440	463.96

Under the conditions set above, the amount of GHG emission reduced by each unit of the assumed business is estimated as 0.672 t-CO_2/year for Years 1 and 2, 1.009 t-CO_2/year for Year 3, and 1.345 t-CO_2/year for Year 4 onwards. When assuming that the pilot project is completed in a year, and that the commercial deployment of the business is moved forward as per above-mentioned schedule, the total reduction amount for the first ten years of the commercial deployment phase is estimated as 1,697 t-CO2. Therefore, the average annual emission reduction is calculated as 169.71 t-CO2.