Local Government Engineering Department
Government of the People's Republic of Bangladesh

'My Village-MY Town' Technical Assistance Project

Study - 6

Feasibility Study on Water Supply and Sanitation in Arsenic Contaminated Areas

under

Feasibility and Review Study on Rural Water and Sanitation

December 2022

CEGIS
Center for Environmental and Geographic Information Services

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Executive Summery

Introduction

Committed to its election pledges to narrow the urban-rural gaps, the government has undertaken the "My Village My Town" project. The project content reflects the aspiration of a society with shared prosperity and parity. However, numerous challenges exist in executing the project and expanding modern civic services to every village. To find innovative answers to problems that may arise, LGED and DPHE conducted several in-house investigations and sponsored a national workshop in September 2019. These exercises aimed to develop a long-term, realistic plan for establishing civic facilities for a specific village and transforming it into a rural township. This led to a strategy paper adopted by LGED and DPHE that suggests creating 30 guidelines, carrying out 36 feasibility studies, and starting a Pilot Village Investment Project by 2021. Against this backdrop, this technical support project has been designed to create a strong foundation for the election manifesto commitment that resembles the dream of Sonar Bangla as envisioned by the father of the nation Bangabandhu Sheikh Mujibur Rahman.

It's an ambitious, complex, but eagerly anticipated national development program. The government has been making strategic efforts to implement the program, including preparing the time-bound working plan under an Upazila master plan framework. The initiative organizes national workshops to innovate creative working strategies to face the challenges of implementing the program and creating coordinated initiatives among the related organizations.

Initially, the pilot project will begin in 15 villages. The 15 model villages will be developed as a pilot study - starting step toward putting this mammoth plan into action. The pilot program's experience will likely aid the growth of modern civic amenities in other villages around the country gradually. The "My Village-My Town" project was developed in this framework to improve rural households' access to clean drinking water and a good quality sanitation system and raise hygiene awareness. These topics are focused fundamentally on advancing the agenda for national development.

The Centre for Environment & Geographic Information Service (CEGIS) is privileged to provide consultancy services for the ***Rural Water Supply and Sanitation*** part of the 'My Village-My Town' project. Following the project ToR, CEGIS identifies freshwater sources in rural areas and develops a priority assessment framework for emerging water supply and sanitation. From this perspective, understanding the local context and existing rural water supply & sanitation options is vital to this assignment.

The full feasibility study was divided into eight parts. A feasibility study for Surface Water availability in arsenic contaminated areas was designated as "***Study-6***" which covers four villages (Saikchail, Datinakhali, Tipna and Shimulbank) of different parts of the country.

Approach & Methodology

Sixty enumerators were divided into six teams, each having approximately ten members and an assigned supervisor. The questionnaire was developed, and the survey was conducted through mobile Apps and online tools. The enumerators conducted the study using a smartphone app installed with the survey software. The survey data were saved and stored on the designated server. The survey adequately maintained the necessary filtering and analysis.

Social Assessment

Some key findings are presented here to comprehend the proposed study better. The survey includes 51.5% males and 48.5% females. The percentage of married household heads in the survey area was approximately 88% (total number of households 3454). The average income of the people was 16,952 BDT. Moreover, the survey revealed 8.14% of households with disabled members.

WASH Analysis of Arsenic Contaminated Area

Water Supply

Regarding the availability of water supply in the arsenic contaminated area, the survey covered 3454 families. Tube wells are used as their primary source of safe drinking water except Datinakhali village of arsenic contaminated area. The depth of shallow tubewell is 100 ft and deep tubewell is 500-750 ft.The survey indicates that water adequacy (86%), water accessibility and water quality is quite good (70%) in arsenic contaminated area. Approximately 20% bad water quality reason is mostly arsenic (As) and iron (Fe) in most of the villages. For water purification, filtering, sedimentation and boiling are being used in many villages. Pipe water supply system condition is not good in most of the villages.

Sanitation Condition

The analysis also demonstrates the sanitation condition of the study area. Of the 3454 households, 68% HH have access to toilets. Pit latrines are the most common toilet type. VIP latrines are also used in a minimum range. Toilet facilities and toilet condition is not up to mark in the most of the villages. The sanitation condition of Shimulbank is very poor; the coverage rate is only 33%.

Hygiene Condition

In terms of hygiene practice and awareness, the study indicates that the rate of regularly washing hands before taking food is <50% in Shimulbank and other 3 villages the percentage fluctuates between 55-65%. Interviewed during the survey agreed about practicing hand washing after using toilets with soap. Different local NGOs are involved in the public awareness activities conducted in the study area. Around 20% toilets are adjacent to the water supply source in Saikchail & Tipna that may occur contamination of pathogens of defecated water into the water source. Actually, it represents the way of thinking that they perceive about the practicing hygiene quality.

Hydrogeological Assessment

According to hydro-geological research conducted as a component of the study, village Tipna & Datinakhali lie in Zone-N, refer the Groundwater conditions are highly variable and development is highly impaired by the low quality of water affected by the intrusion of brackish and saline water. Again, village Shimulbank lies in Zone-I that covers the plains of Sylhet district, known as the Sylhet Basin. However, the area may be able to sustain ground water development, rainfall on the zone is nearly the highest in the country and recharge potentials are probably high. Next, the village Saikchail lies in Zone-G, includes the southwestern section of Cumilla district and the northern part of Noakhali district. The main aquifer is at depths ranging from 16 to 100 meters below ground surface with an average depth for the zone of 60 meters. This zone should be considered for only deep tubewell development with discharges of up to 56.6 lit/sec (2 cusecs).

Social and environmental impact assessments are also important before any project implementation. Due to the combined effects of climate change, insufficient interventions, and poor drainage systems, arsenic contaminated villages are susceptible to environmental calamities. Accordingly, the Right Intervention selection and proper installation would enable the people to secure safe drinking water collection, which will bring a positive outcome to the study.

Potential Water Sources Identification

Assessment of available potential source of water for the water supply system was carried out. Ground water is found satisfactorily good in quantity and quality for maximum villages described in section 3.1 water availability analysis. Therefore, Ground water is recommended as a water source except for

Datinakhali and Shimulbank village. As Datinakhali village ground water contain high level of salinity, so surface water or rainwater can be used. In Shimulbank, tertiary rocks are encountered at shallow depths and again, the village has also good amount of surface water. So, instead of groundwater, surface water can be a good option for this village.

Demand Analysis

The current demand for general water use per person-day has been assessed based on data from four arsenic contaminated villages. After the completion of the project, a 20-year demand forecast was carried out using a linear regression model for both water supply and sanitation.It is assumed that about 30% increase in water likely to be used due better living condition.

Technology Selection

Design consideration and design criterion, along with option assessment, have been made through field investigations, "Mathematical Modeling," and laboratory tests of water quality before recommending for preferred water supply source. The current water supply situation and sanitation conditions are analyzed, and appropriate interventions are recommended according to their demand priority.

Financial and Economical Assessment

Both financial and economic evaluations are conducted to determine the viability of the proposed intervention to improve access to safe water supply and sanitation in these settlements. A detailed cost-benefit assessment (both financial and economic) is carried out for each village included in this study. An aggregate result is generated as NPV, BCR, and IRR. The project secures a rate of return that is more than 12%, which suggests it is economically viable.

Two government organizations, DPHE and LGED, are responsible for implementing the “My Village My Town’’ project. DPHE is carrying out the project's component dealing with village ***water and sanitation*** systems. The Project Management Unit (PMU) at DPHE carried out the project's sanitation and water supply components. After the handover, the local body (Union Parishad) needs to be strengthened through technical staff provision and training to maintain and repair the water supply and sanitation infrastructures. As it plans, the Union Parishad, or the local community, will ultimately run and maintain the water supply and sanitation system.

The study stands at appropriate innovative activities. People’s engagement in the process could improve the water supply and sanitation coverage in rural areas to satisfy the local living standard, ultimately narrowing the gaps between rural and urban living.

Abbreviation and Acronyms

AIRP	Arsenic Iron Removal Plant
As	Arsenic
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BGS	British Geological Survey
BSTI	Bangladesh Standard Testing Institute
BTM	Bangladesh Transverse Mercator
BUET	Bangladesh University of Engineering and Technology
CBOs	community-based organizations
CF	Conversion Factor
CHELSA	Climatologies at high resolution for the earth's land surface areas
CHF	Conventional Households Filter
CMIP	Coupled Model Inter-comparison Project
DO	Dissolved Oxygen
DOE	Department of the Environment
DPHE	Department of Public Health and Engineering
EBCR	Economic Benefit Cost Ratio
EC	Electric Conductivity
ECR	Environment Conservation Rules
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
FBCR	Financial Benefit Cost Ratio
Fe	Iron
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GCM	Global Circulation Models
GOB	Government Of Bangladesh
GW	Ground Water
HH	Household Head
HRU	Hydrological Response Units
HTW	Hand Tubewells
IRU	Iron Removal Unit
LGED	Local Government Engineering Department
LTAR	Long Term Septage Acceptance Rate
NGOs	non-governmental organizations

PET	Potential Evapotranspiration
PP2041	Perspective Plan 2041
PRECIS	Providing Regional Climate for Impact Studies
PSF	pond sand filters
RO	Reverse Osmosis Plant
RWH	rainwater harvesting systems
RWHS	Rain Water Harvesting System
SODIS	Solar Disinfection
SSF	Slow Sand Filter
SSPs	Shared Socioeconomic Pathways
SW	Surface Water
TDS	Total Dissolved Solid
UNU	United Nations University
VIP	Ventilated Improved Pit Latrine
VSST	Very Shallow Shrouded Tubewell
WASH	Water, Sanitation and Hygiene

1. Introduction

1.1 Background

Through its two implementing agencies, LGED and DPHE, the Government of Bangladesh has launched the "My Village-My Town" project, which aims to bridge the gaps between urban and rural areas by extending urban services to each village. The primary goal of this project is to guide the country's transformation into 'Sonar Bangla,' – a society free of poverty, hunger, and corruption, along with rapid income growth and shared prosperity as envisioned by the father of the nation Bangabandhu Sheikh Mujibur Rahman. The project also aligns with the government-adopted Vision 2041 and the associated Perspective Plan 2041 (PP2041).

"My Village-My Town" project is an ambitious, multifaceted, complex initiative. However, it's implementable. The government is engaged in implementing this program, including preparing a time-bound working plan, the Upazila Master Plan, and organizing national consultations 'to innovate creative working strategies' to face the challenges in implementing the program and creating coordinated initiatives among the related organizations.'

Villages in Bangladesh have distinct characteristics. A fishing community will need a fish landing facility or cold storage, but the other village with small cottage businesses will benefit from enhanced infrastructure with modern technology and equipment. A riverbank village requires embankments to protect lives and properties from flooding, while the other settlements require improvements to their waterway communications. Each village with unique characteristics might deserve specific demands; however, every village should have certain standard amenities like power, digital systems, improved roads, marketplaces, health and education institutes, etc.

DPHE-LGED selected 8 villages in 8 Upazilas of 8 divisions and 7 other from selected areas, of i.e., Haor, Char, Hill, Coast, Barind, Midland beels, and two adjoining economic zones, respectively, for this study project. Beyond this, following principle-based preferences, another 25 villages were selected.

Following its mandate, the Local Government Division implements the planning process, infrastructural development and capacity building & regulation for Local Government Institutions for essential service delivery to the citizens. This broader scope could divide into six components, namely:

1. Rural Road Connectivity
2. Rural Growth Center and Hat Bazars
3. Rural Water Supply and Sanitation
4. Rural Waste Management
5. Community Space and Recreation
6. Upazila Physical Plan/Master Plan.

Among the above mentioned six components, Center for Environmental and Geographic Information Services (CEGIS) has been engaged only in the feasibility and review study of "Rural Water Supply and Sanitation". Accordingly the study will follow one sub study area on the rural water supply-sanitation domain which is as follows:

Study	Description of the Study
1	Survey work regarding identifying and conserving fresh water sources in rural areas established by the Department of Public Health Engineering

Study	Description of the Study
2	Developing a priority assessment framework for water supply and sanitation development
3,4,6 & 7	Feasibility study for water supply options, including surface water availability and sanitation in rural areas, hill districts, arsenic-contaminated areas, disaster-prone, and other problematic areas
5	Technical, socio-economic, and environmental study for water supply and sanitation system in coastal, haor, barind, arsenic-contaminated, flood-prone, plain land, and hill areas
8	Feasibility study about rural activities for cleanliness at the individual and social level to ensure safe sanitation

However, this study will focus on the Feasibility study for water supply options, including surface water availability and sanitation in arsenic contaminated areas.

1.2 The Setting of the Study Area

1.2.1 Study Location Selection Criteria

According to Terms of Reference (ToR), thirty-five (35) villages are selected from 15 different districts (8 districts from 8 divisions and 7 districts of remote regions) to conduct the study focusing on water supply, sanitation, and hygiene. The villages were selected considering nine given criteria. These are Arsenic contaminated areas, barind areas, coastal areas, cyclone-prone areas, beel/char areas, haor, hilly areas, flood-prone areas, and plain land. The list of 35 villages is listed below. The asterisk-marked villages are picked from the piloting umbrella of the “My Village My Town” project, while the rest are for a sample survey. Under the “Rural Water, Supply and Sanitation” component of the “My Village-My Town project,” the study covered the above-referred villages.

Study Area				Coastal										
				South-West	South-Central	South-East	Cyclone Prone	Barind	Beel/Char	Haor	Hill District	Plain Land	Flood Prone	As Contamination
Dictrict	**Upazila**	**Union**	**Village**											
Cumilla	Manoharganj	Bipulasar	**Shekchail** *											
Khulna	Dumuria	Kharnia	**Tipna** *											
			Gonali											
Satkhira	Shyamnagar	Labsa	Jabakhali											
			Kalbari											
			Banbibitala											
			Chunar											
			Datinakhali *											
Sunamganj	Dakkhin Sunamganj (Shantiganj)	Shimulbank	Lalukhali											
			Shimulbank *											
Naogaon	Niamatpur	Hajinagar	**Khordachompa** *											
			Patail											
Chattogram	Mirsarai	Ichhakhali	**Charsharat** *											
Rajshahi	Bagmara	Sonadanga	**Sonadanga** *											
Gaibandha	Fulchhari	Gazaria	Ziadanga											
		Fulchhari	**Fulchari** *											
			Parul											
			Baje Fulchchari											
Barishal	Hijla	Memania	**Induria** *											
			Baduri											
Sylhet	Gowainghat	Rustampur	**Bagaiya** *											
		Bhushanchhara	**Chota Harina***											
Gopalganj	Muksudpur	Jalirpar	**Beelchanda** *											
			Baniarchar											
			Jolirpar											
Kurigram	Bhurungamari	Pathardubi	**Pathordubi** *											
			Maidam											
		Baladia	Sarkarpara											
			Uttar Baladia											
Narsingdi	Manohardi	Chalakchar	**Hafizpur** *											
			Chengain											
			Chalakchar											
Netrokona	Barhatta	Sahata	**Dakkhin Demura** *											
			Shahata											
			Kadam Deuli											
otal District = 15	**Total Upazila = 15**	**Total Union = 17**	**Total Village = 35**	**5**	**2**	**1**	**9**	**2**	**3**	**3**	**1**	**17**	**8**	**10**
* Selected pilot villages for "My Village My Town" Project.				South-West	South-Central	South-East	Cyclone Prone	Barind	Beel/Char	Haor	Hill District	Plain Land	Flood Prone	As Contamination
				Coastal										

Figure 1.1: Selection of Study Area

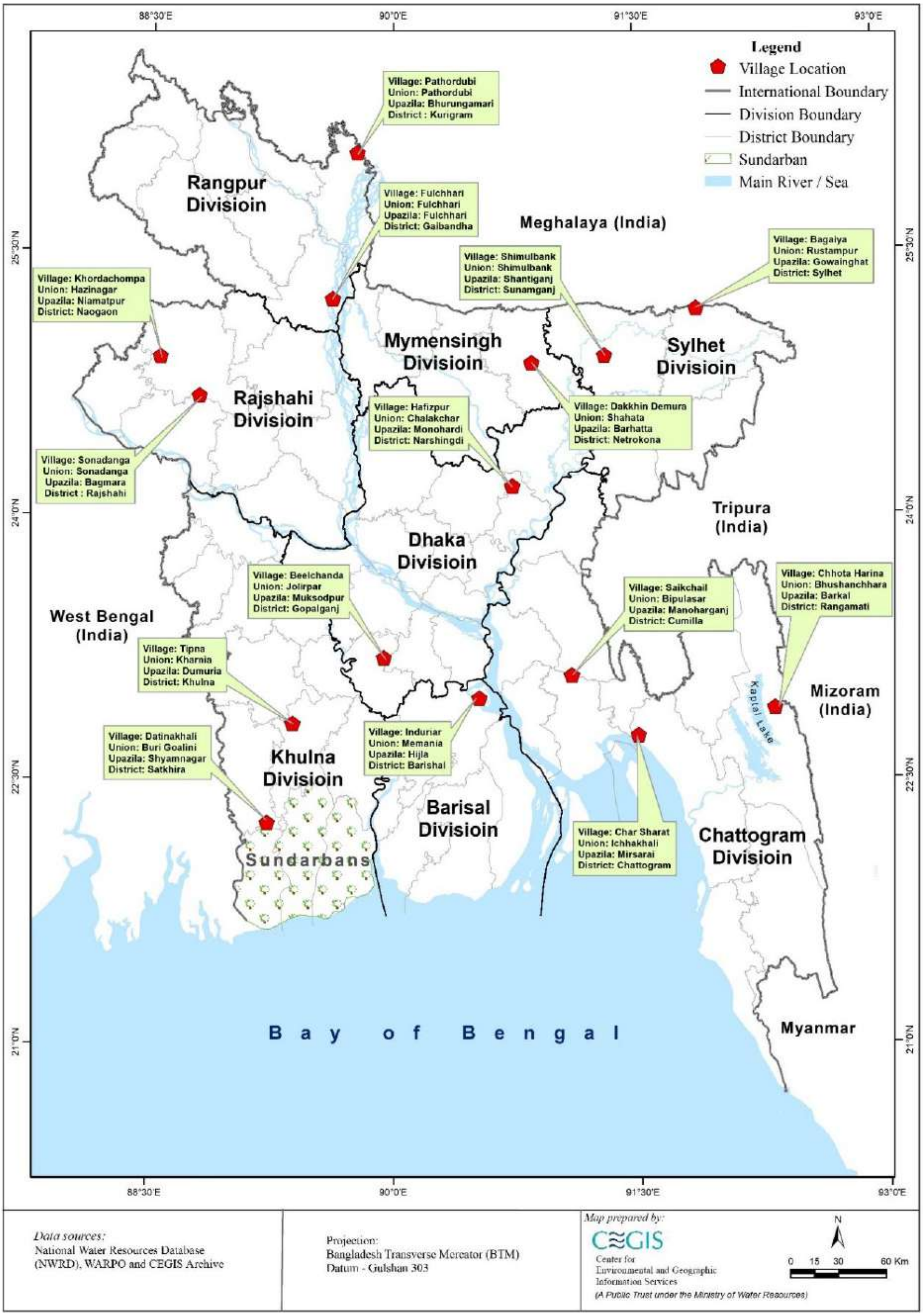


Figure 1.2: Location of Study areas (Villages)

1.2.2 Description of Study Location in Arsenic Contaminated Areas

Out of 15 selected pilot villages, four villages get into the zone of arsenic contamination that are Saikchail, Tipna, Datinakhali and Shimulbank. Although the villages get into the Arsenic (As) contaminated zone of Bangladesh but apart from Arsenic (As), Iron (Fe) is prominent problem in Tipna & Saikchail village of Khulna & Cumilla district respectively.

Out of four villages, the Saikchail village is categorized as having an extremely high risk of exposure to arsenic, whereas the Shimulbank is showing a low risk of exposure to arsenic, according to secondary data sources. The range of arsenic toxicity in the villages under study is shown on the following map. The name of these four villages located in the arsenic contaminated area in Study 6 is tabulated below.

Table 1.1: Name of the four villages located in arsenic contaminated area

SL	District	Upazila	Union	Villages
1	Cumilla	Monoharganj	Bipulasar	Saikchail
2	Satkhira	Shyamnagar	Buri Goalini	Datinakhali
3	Khulna	Dumuria	Kharnia	Tipna
4	Sunamganj	Shantiganj	Shimulbank	Shimulbank

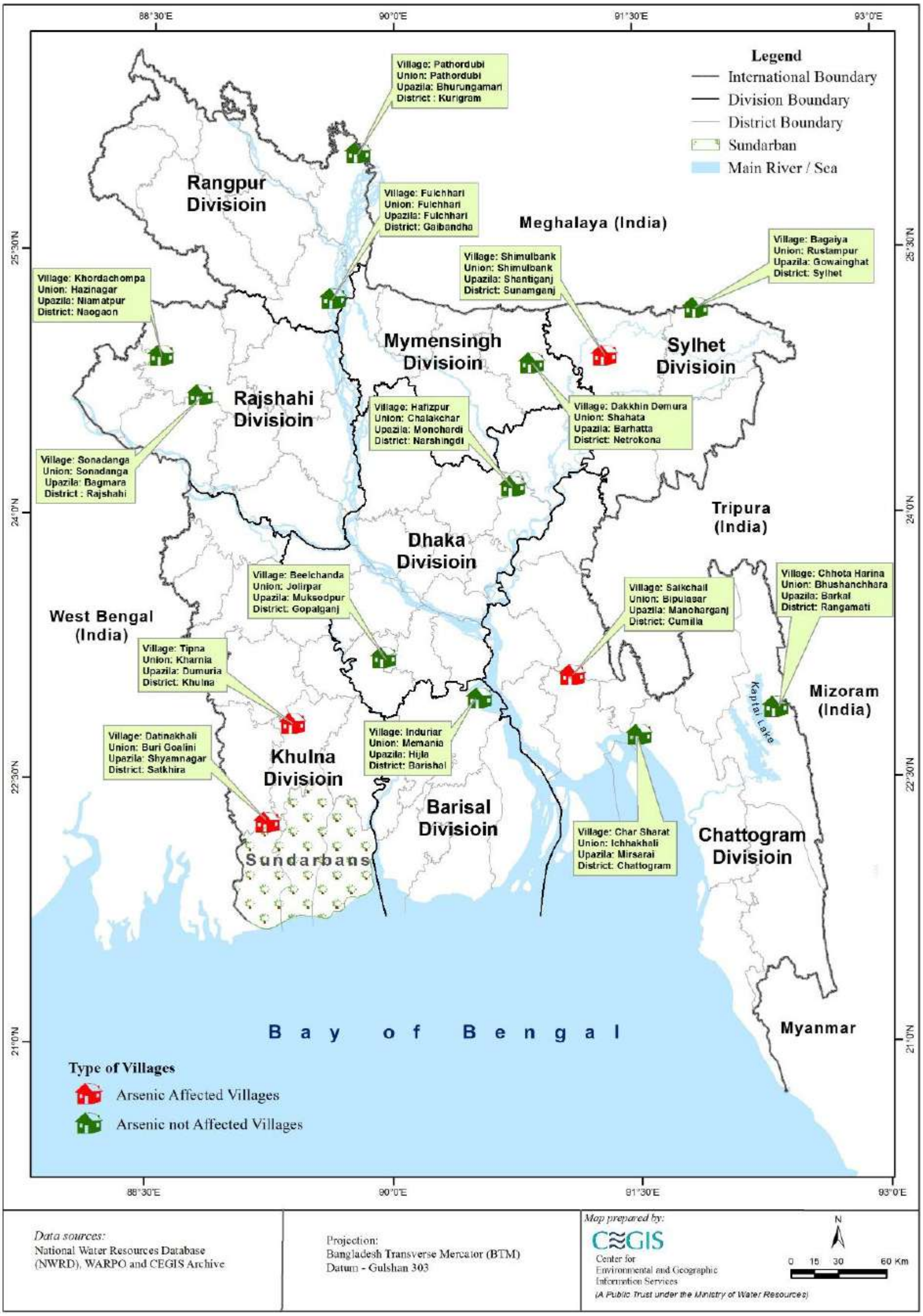


Figure 1.3: Location of Arsenic affected pilot villages

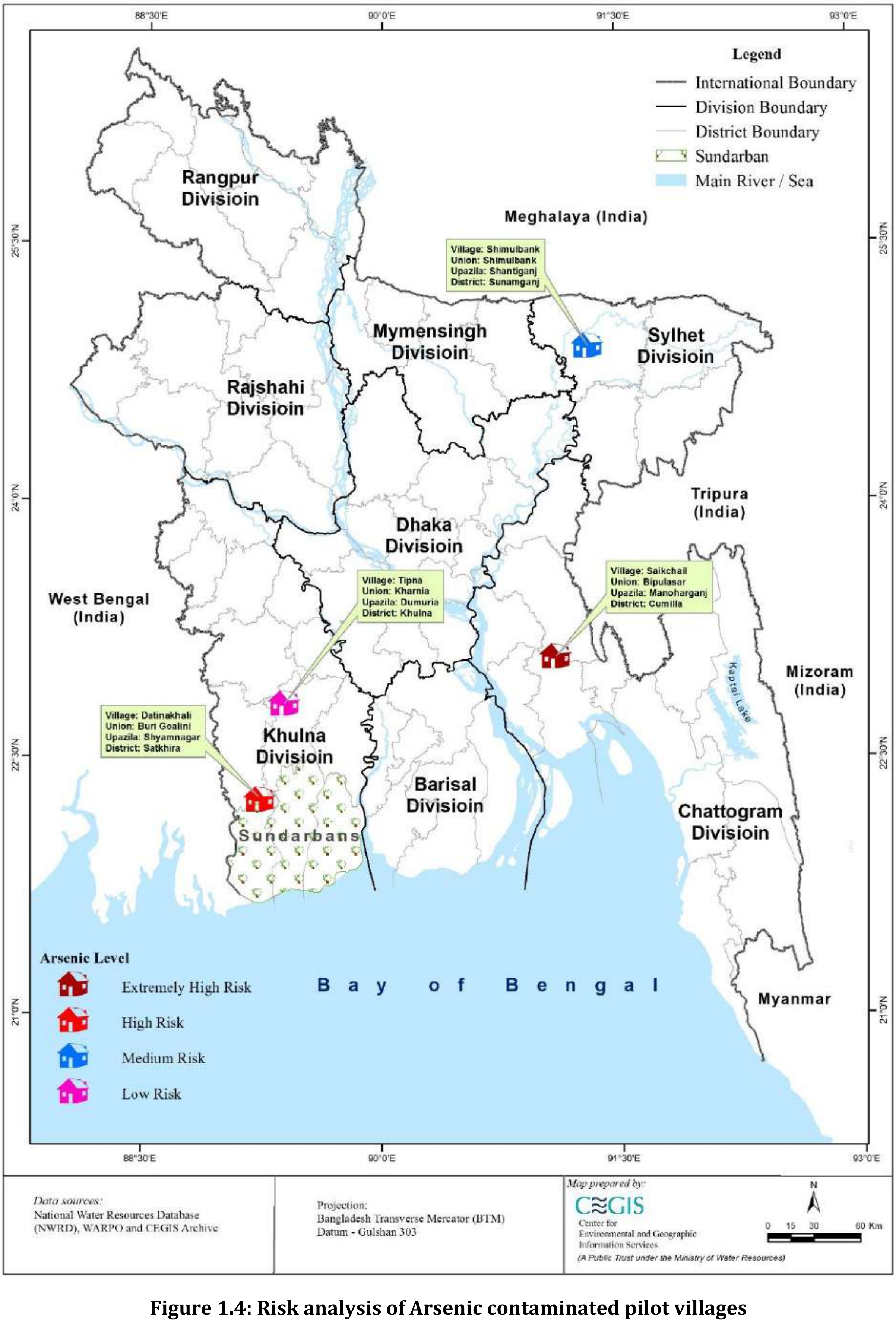


Figure 1.4: Risk analysis of Arsenic contaminated pilot villages

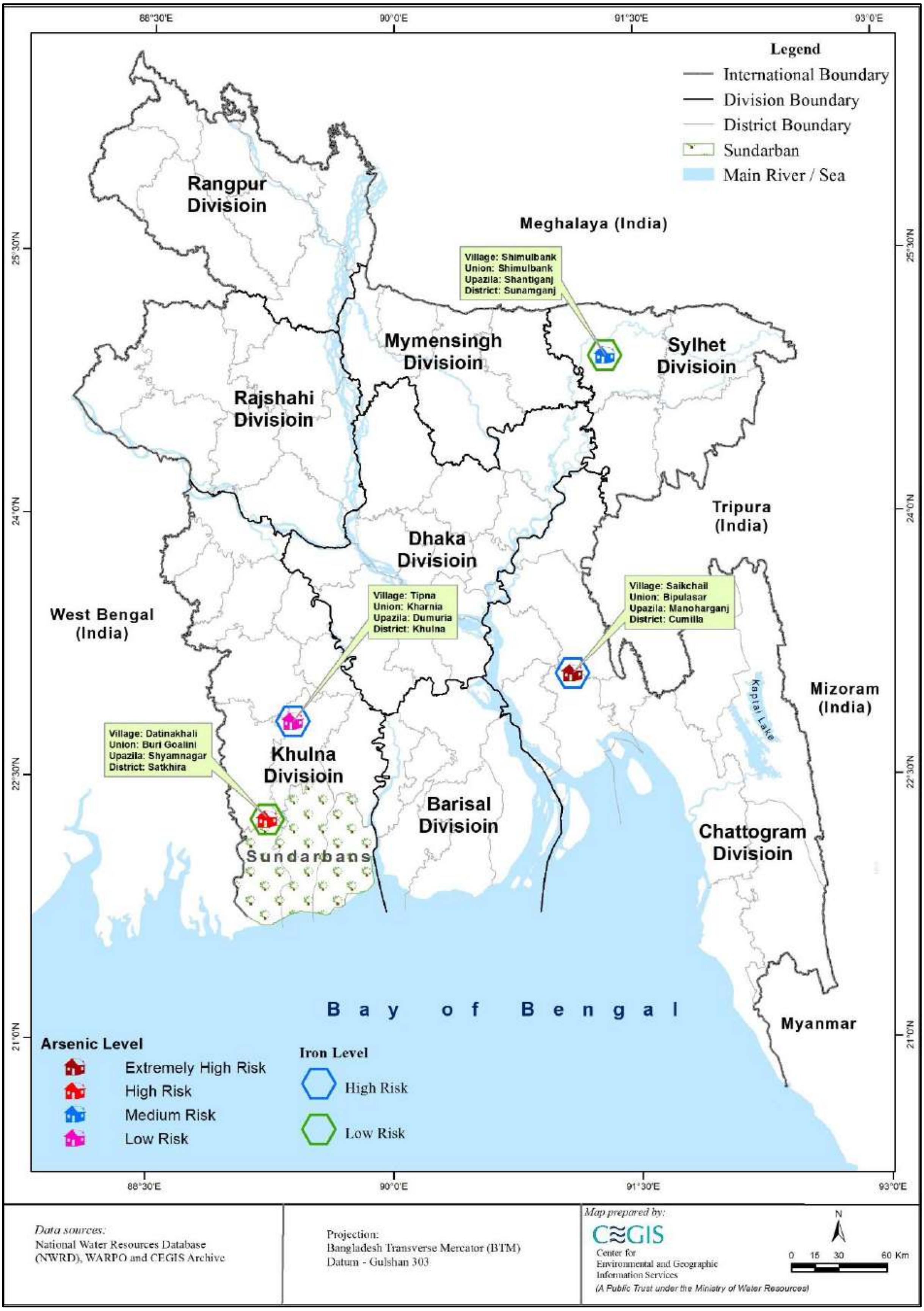


Figure 1.5: Risk analysis of Iron (Fe) in Arsenic contaminated pilot villages.

Saikchail Village

Saikchail village is located in Bipulshar Union of Monoharganj Upazila of Cumilla District. This village is one of the 15 pilot villages of the "My Village My Town" project. In the Rural Water Supply and Sanitation component of the "My Village My Town" project this village is selected based on Arsenic contamination criterion. According to BBS, the total area of the village is about 365 hectares and about 8929 people in 1652 households live in this village.

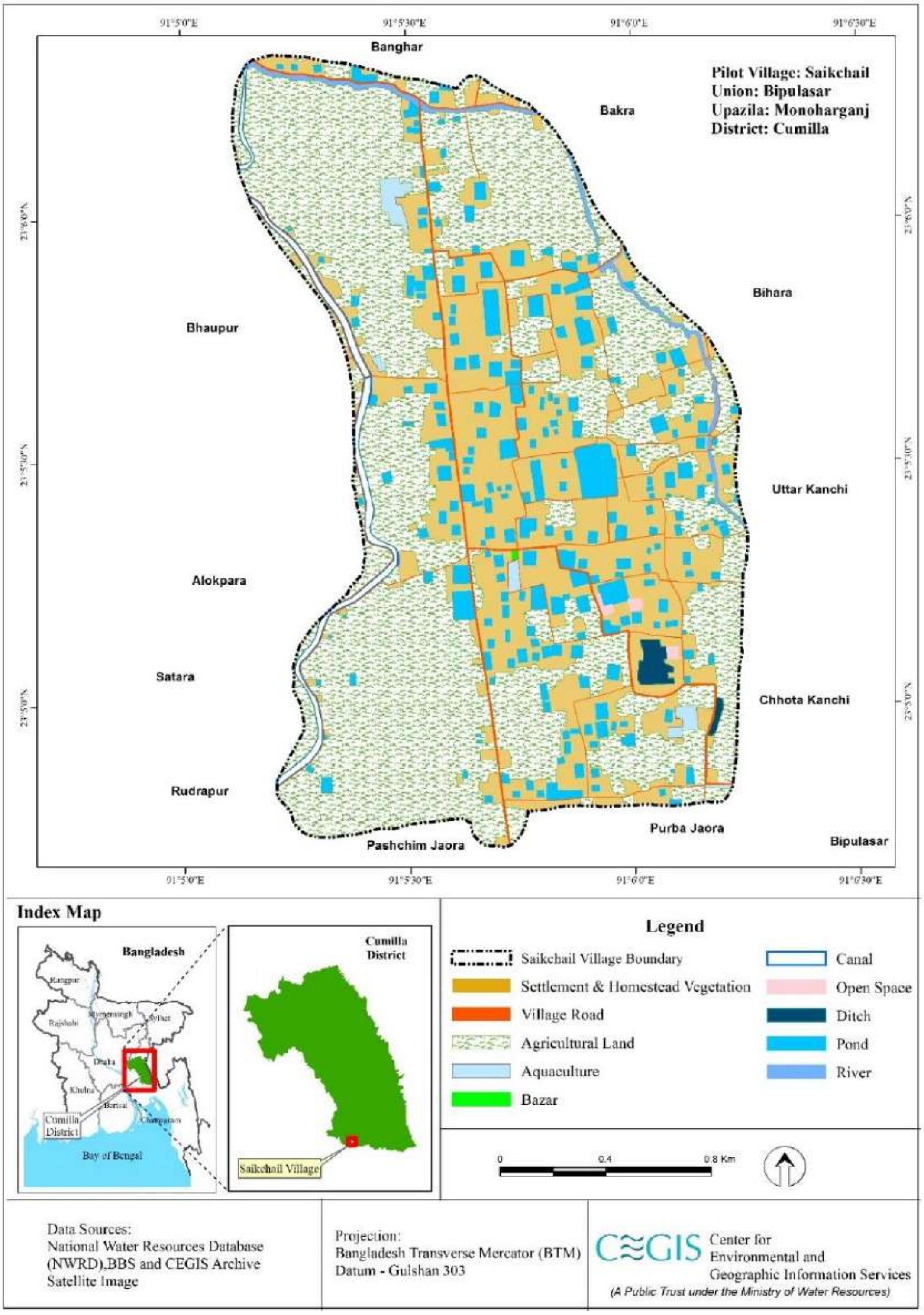


Figure 1.6: Saikchail Village Location

Tipna Village

Tipna village is located in Kharnia Union of Dumuria Upazila of Khulna District. This village is one of the 15 pilot villages of the "My Village My Town" project. In Rural Water Supply and Sanitation component of the "My Village My Town" project this village is selected based on Arsenic contamination and cyclone prone criteria. According to BBS, the total area of the village is about 236 hectares and about 3270 people in 772 households live in this village.

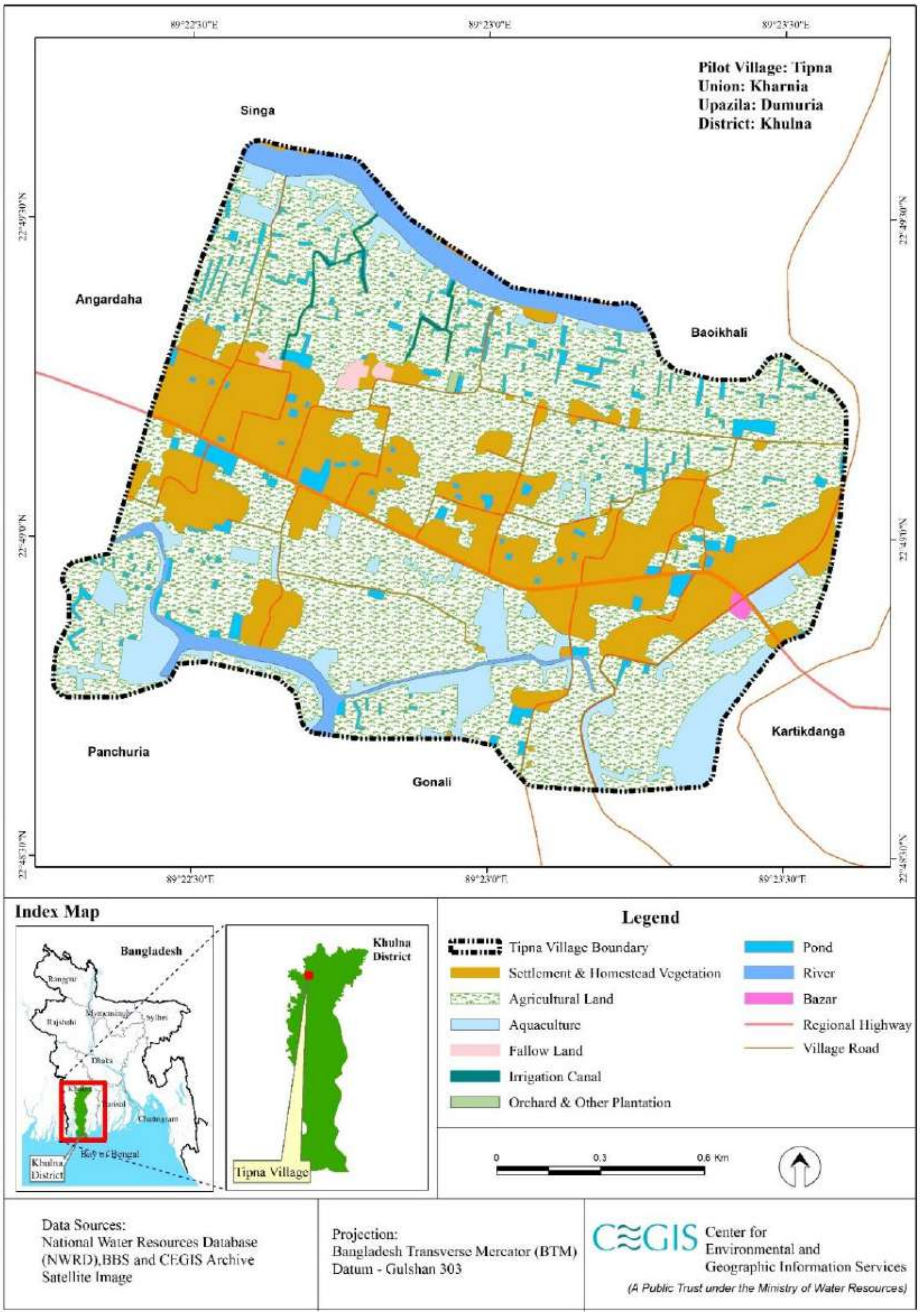


Figure 1.7: Tipna Village Location

Datinkhali Village

Datinkhali village is located in Buri Goalini Union of Shyamnagar Upazila of Satkhira District. This village is one of the 15 pilot villages of the "My Village My Town" project. In Rural Water Supply and Sanitation component of the "My Village My Town" project this village is selected based on south-west coastal, arsenic contamination and cyclone prone criteria. According to BBS, the total area of the village is about 164 hectares and about 2256 people in 568 households live in this village.

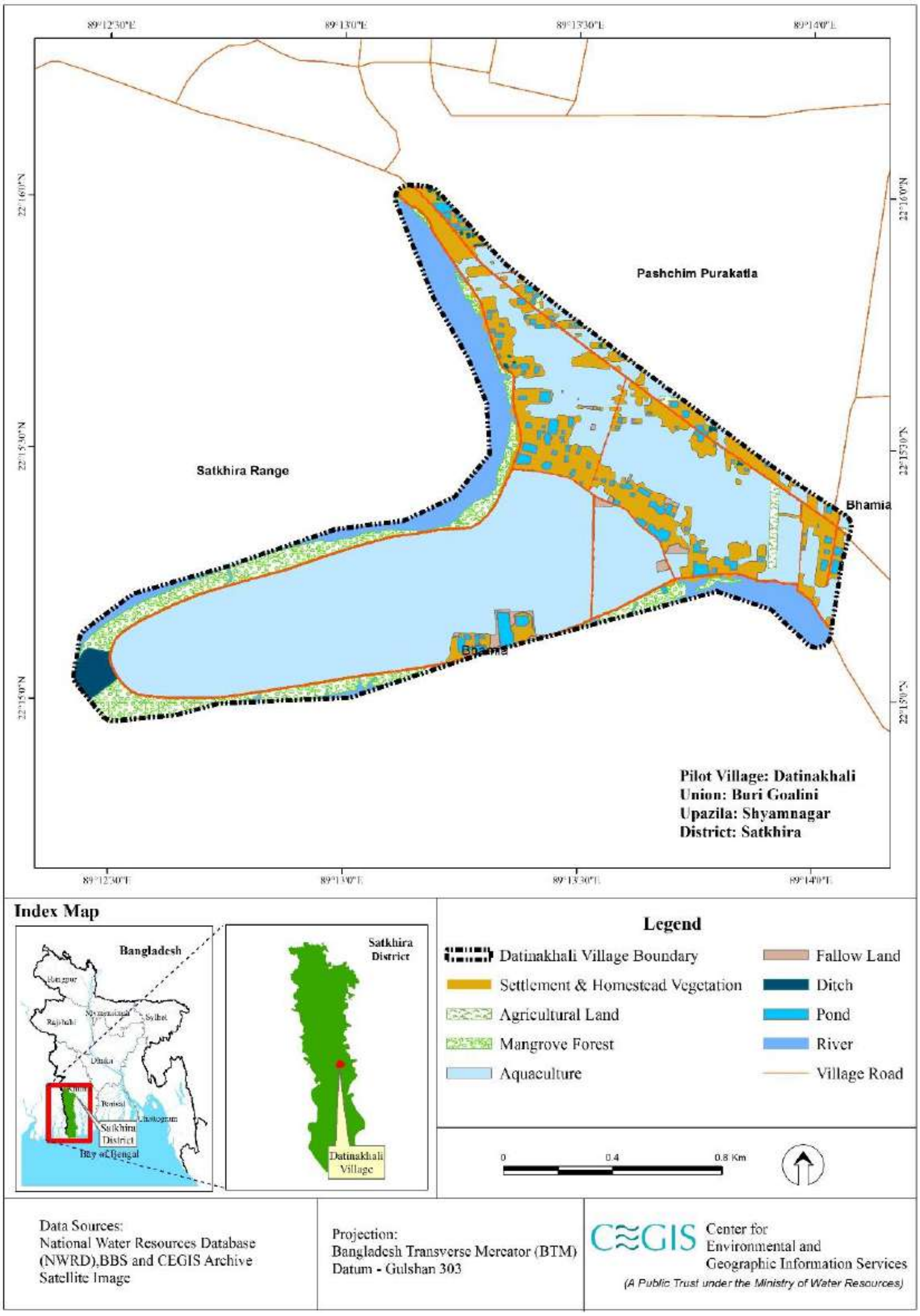


Figure 1.8: Datinakhali Village Location

Shimulbank Village

Shimulbank village is located in Shimulbank Union of Dakkhin Sunamganj (Shantiganj) Upazila of Sunamganj District. This village is one of the 15 pilot villages of the "My Village My Town" project. In Rural Water Supply and Sanitation component of the "My Village My Town" project this village is selected based on haor area and arsenic contamination criteria. According to BBS, the total area of the village is about 218 hectares and about 2629 peoples in 462 households live in this village.

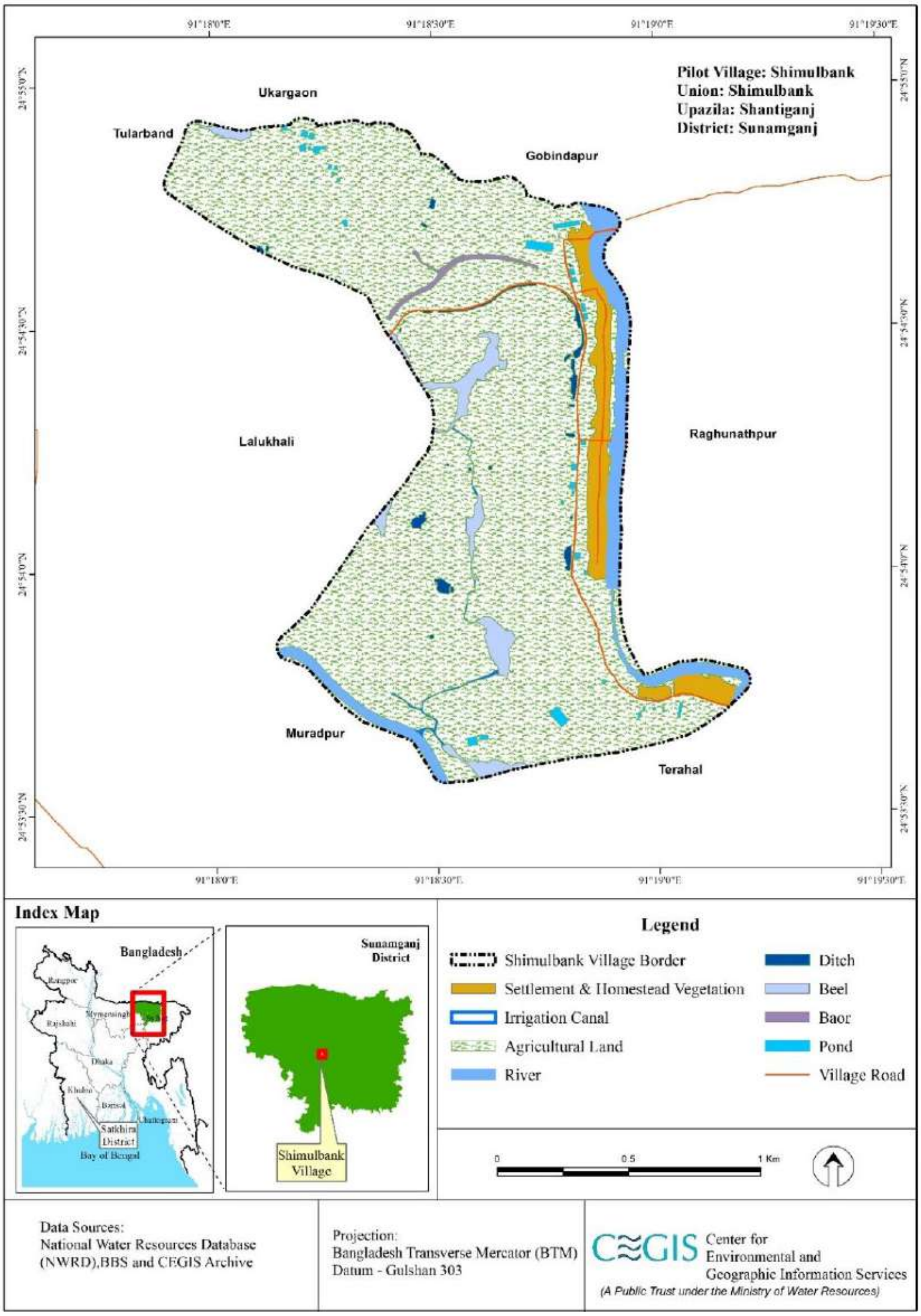


Figure 1.9: Shimulbank Village Location

1.3 The Objectives of the Study

The main objectives of conducting this study are to assess the current status of WASH in context of engineering and socio-economic aspects. However, the objective scope may specify as follows:

Study-06: Feasibility study for water supply options including surface water availability and sanitation in arsenic-contaminated areas. This will include:

- To assess the water supply and sanitation conditions of the selected villages of the country.
- Calculate the water required to meet the demand as per the commitment and goal of the government and international agencies in the water and sanitation sector.
- Identify the suitable options to meet the water demand, overcoming water quality challenges and other geographical issues.
- Quantify the resource required to meet the water demand and detail financial and economic analysis of the proposed interventions.
- Identify the planning area where the existing water supply conditions are most severe and develop a priority intervention area in phases.
- Develop water supply and sanitation technologies for the proposed intervention type.
- Provide detailed engineering designs and drawings for selected villages for a safe piped scheme considering surface and groundwater sources.
- Develop a technical guideline for a small-scale piped water supply scheme for supporting existing DPHE intervention,
- Recommend and suggest Implementation modalities to the water supply and sanitation improvement project.

1.4 Overall Approach

The baseline study follows the systematic steps of approaches and methodology. The primary activities of the study are the collection of water supply, sanitation, and hygiene data from the HHS. The major activities were systematically organized under different methodology steps and diagrammatically presented in Figure 1.10. The methodology is in different subsequent sections described in Appendix I.

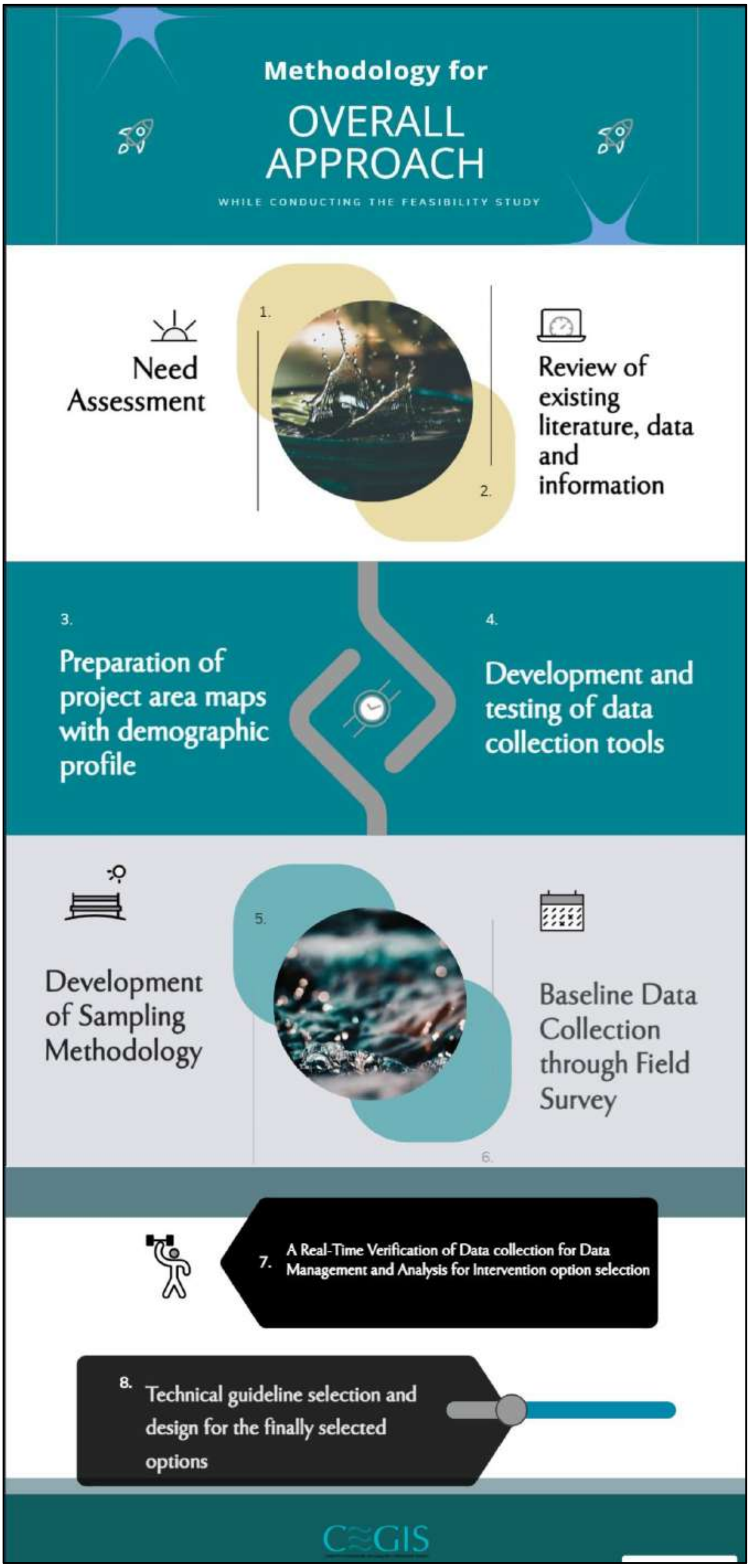


Figure 1.10: Methodology of the Flow diagram used for the study.

2. Existing WASH Status

2.1 WASH Analysis of Arsenic Contaminated Area

The revelation of arsenic in shallow groundwater poses a threat to Bangladesh's groundwater-based water supply. Another major issue affecting fresh water availability is seawater encroachment in coastal aquifers. Surface water, on the other hand, is unsuitable in many parts of the country. Furthermore, vulnerable climatic conditions and the foreseeable impact of climate change are putting additional pressure on the long-term development of safe water resources. By the early 1990s, Bangladesh had almost universal (i.e., 97%) drinking water supply coverage, until the high levels of arsenic in shallow groundwater and saline water in coastal aquifers overshadowed the success. Four villages out of the 15 pilot villages get into the arsenic-contaminated areas, which are Saikchail village under Bipulshar union, Monoharganj upazila & Cumilla district; Tipna village under Kharnia union, Dumuria upazila & Khulna district; Datinakhali village under Labsa union, Shyamnagar upazila & Satkhira district and Shimulbank village under Shimulbank union, Shantiganj upazila & Sunamganj district. Among the four villages, Datinakhali and Shimulbank are also included in coastal zone and haor area respectively.

After dispatching the enumerators to the selected villages, the field monitoring, database preparation, data checking, and database modification began. The survey data is a format for representing findings that can be used to make decisions about intervention by observing the villagers' current situation. The findings of the survey are discussed in a sub-section of **Section 2.1** below.

2.1.1 Water Supply

Bangladesh's water supply system is primarily dependent on groundwater supply. As groundwater is free from pathogens and normally no prior treatment is needed for drinking or other domestic uses. In our report, we consider four villages that are mainly facing arsenic problems. This project surveys ***Saikchail village*** in the Bipulsar union of the Monoharganj upazila of Cumilla district. It is a cyclone prone and arsenic contaminated area where the main source of water supply is a personal tubewell. About 50% of people use their personal tubewell, 27% use their neighbor’s tubewell, 11% use their motorized personal tubewell, 8% use government-supplied tubewells, and other people use different water sources for water consumption, which is shown in **Figure 2.1.** ***Tipna village*** under Khurnia union of Dumuria upazila of Khulna district, which is also cyclone prone and arsenic-contaminated, was surveyed under this project, with the result that 50% of the people use government tubewells as their main water source. ***Shimulbak village***, under Shimulbank union of South Sunamganj upazila of Sunamganj district, has been surveyed for this study. The Sunamganj under the Sylhet Depression is a tectonic basin subsiding at a very fast rate and is bounded by the hills of the frontier strip of Sylhet. It is a haar- and arsenic-contaminated area where nearly 70% of people rely on government tubewells as their primary source of water. The most vastly varied water source has been found in ***Datinakhali village*** of Labsa union under Shyamnagar upazila of Satkhira district, which is in the south-west coastal zone facing cyclone and arsenic problems. People in that village mainly drink water by purchasing it from NGO’s and other sources. Rainwater is also a potential water source for the people living here. Other sources that are detected in the bar chart pasted below are mainly focused on people who drink filtered water from individual ownership, treatment plants, different companies, and so on. They give money for taking water from different private organizations, like 5 BDT per jar. By comparing four villages, it is discovered that, with the exception of Datinakhali, people in the three villages use personal, neighbor's, or government tubewells for water consumption. The highlighted portion (>10% of Table 2.1) shows the available sources from which they obtain their daily drinking water.

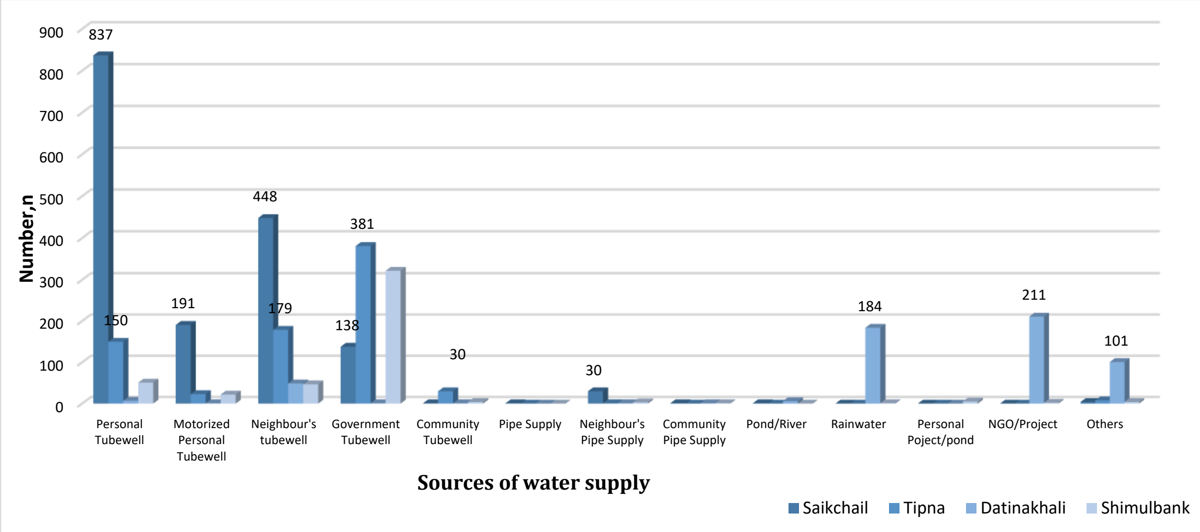


Figure 2.1: Main water sources of Arsenic contaminated villages

Table 2.1: Main water sources of Arsenic contaminated villages

Water Source	Saikchail	Tipna	Datinakhali	Shimulbank
Community Pipe Supply	0%	0%	0%	0%
Community Tubewell	0%	4%	0%	1%
Government Tubewell	8%	49%	0%	70%
Motorized Personal Tubewell	12%	3%	0%	5%
Neighbour's Pipe Supply	2%	0%	0%	1%
Neighbour's tubewell	27%	23%	2%	10%
NGO/Project	0%	0%	0%	0%
Others	0%	1%	62%	1%
Personal Project/pond	0%	0%	0%	1%
Personal Tubewell	51%	19%	1%	11%
Pipe Supply	0%	0%	0%	0%
Pond/River	0%	0%	1%	0%
Rainwater	0%	0%	32%	0%
Grand Total	**100%**	**100%**	**100%**	**100%**

A shallow tubewell is 100 feet deep, while a deep tubewell is 500-750 feet deep. The depth of existing tubewells in four villages is shown in **Figure 2.2**. Mainly, Saikchail is covered with shallow tubewells, and Shimulbank and Tipna are covered with deep tubewells. According to the hazard quotient, carcinogenic risk, and water quality index, deep tubewell water is less contaminated by arsenic and other trace metals than shallow tubewell water. Regular consumption of arsenic-contaminated water may hasten chronic arsenic-related toxicity, putting people's health at risk.

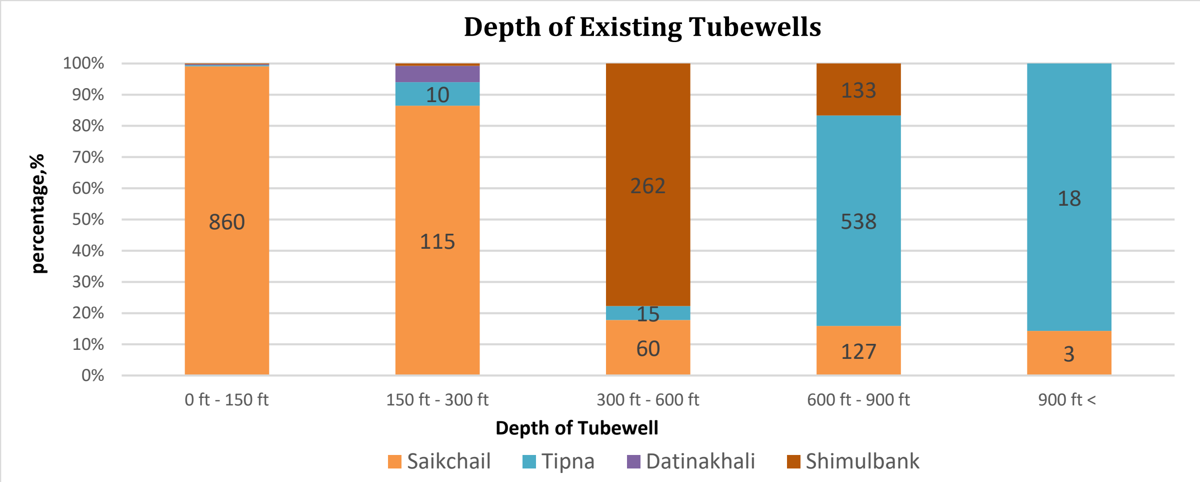


Figure 2.2: Depth of Existing Tubewells

As people collect water from tubewells, it is a matter of concern to notice the availability of water from the sources throughout the year. Above 80% of people in Saikchail, Tipna, and Shimulbank villages get access to water throughout the year, but below 80% of people in Datinakhali village find available water from their adjacent water supply sources, as shown below in **Figure 2.3.**

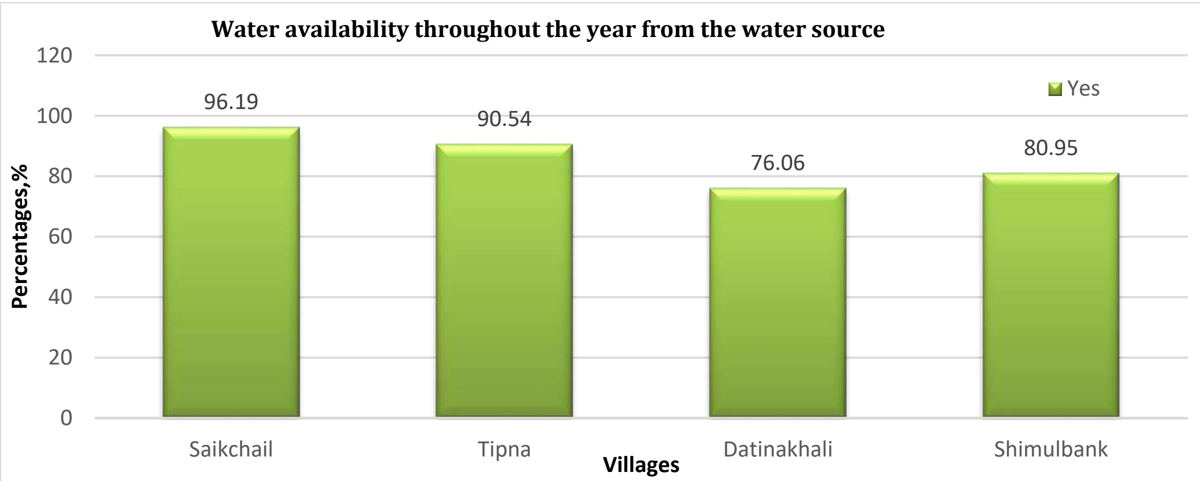


Figure 2.3: Water availability throughout the year from the water source

Bangladesh's climate is divided into four seasons based on meteorological data. The winter months are December, January, and February. The pre-monsoon months are March, April, and May. Monsoon months are June, July, August, and September, with post-monsoon months being October and November. Most water scarcity happens in the pre-monsoon season in all villages, but Datinakhali represents the pre-monsoon and monsoonal periods of water scarcity. The bar chart of the period of water scarcity in four villages is pasted below in **Figure 2.4,** which can give us a conceptual idea of this scenario.

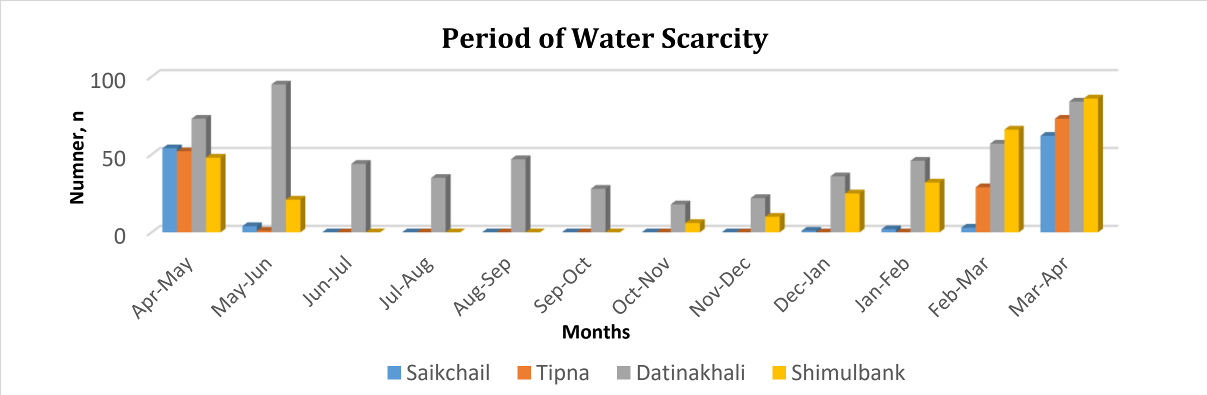


Figure 2.4: Period of Water Scarcity

The causes of water scarcity in the three villages are nearly identical, namely a drop in groundwater levels and the drying up of rivers, ponds, canals, and other surface water sources. However, Datinakhali is experiencing insufficient rainfall and tubewell sinking during cyclones and floods. The overall scenario is represented below in the diagram in **Figure 2.5.**

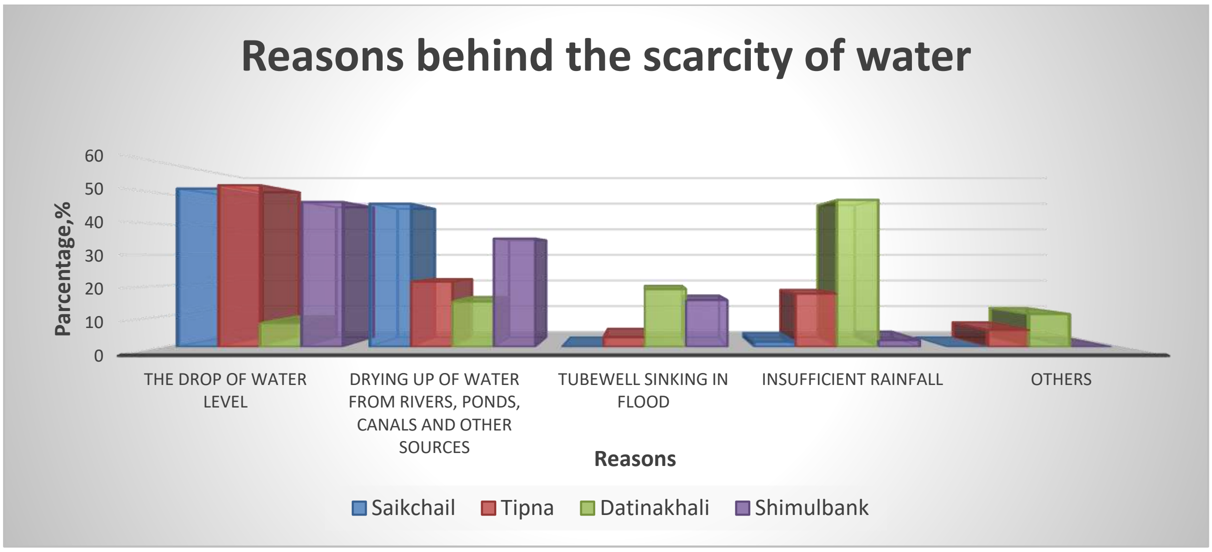


Figure 2.5: Reasons behind the Scarcity of Water of the Villages

In almost all villages, people collect water for household uses from the same alternative sources that are used for drinking water purposes. In Saikchail, people use surface water for household work. It is estimated that Saikchail is deserted with ponds and lakes, and the people who live there use the water for household purposes.Except in Tipna village, the people of Datinakhali and Shimulbank villages mainly use pond water and river/canal water for household works, respectively. The following graph in **Figure 2.6** can give us an idea of this aspect.

Here, **Figure 2.7**, pasted below, represents that the arrangement of piped water supply in those villages is almost nonexistent.

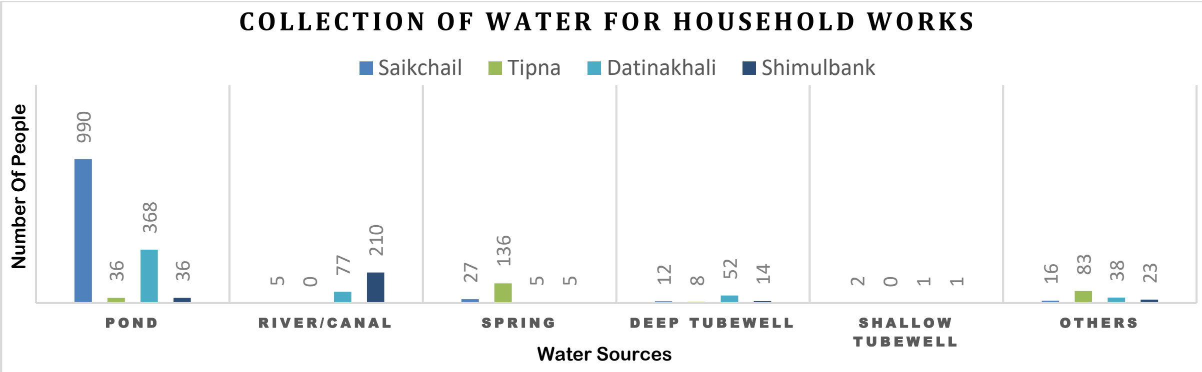


Figure 2.6: Sources of collection of water for household works

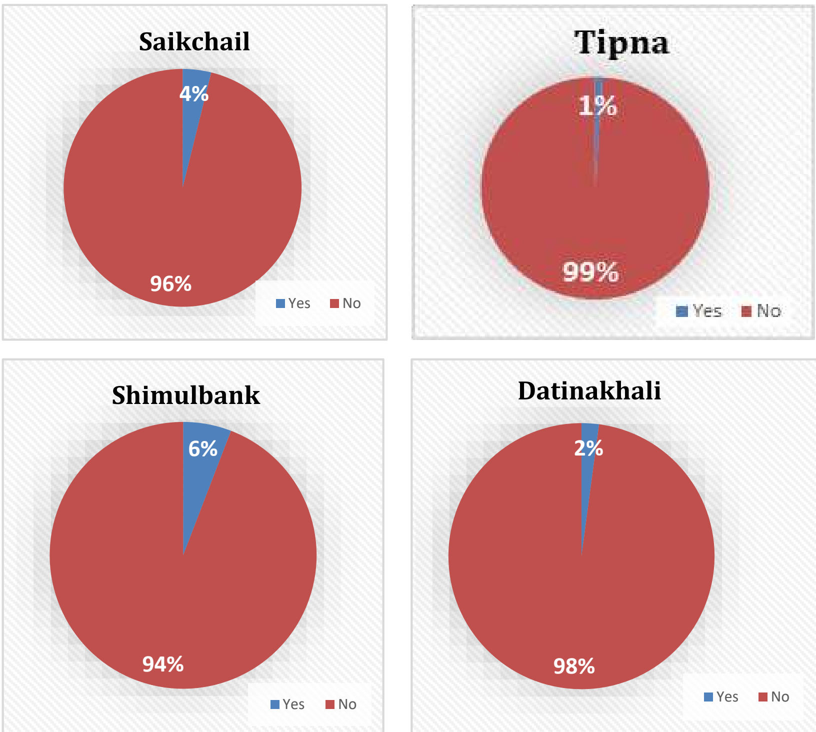


Figure 2.7: Arrangement of Pipe water supply in four villages

The water supply sources of the four villages are not sufficient to meet their demands. So, during the survey, people from those villages placed their recommendations for the development of the water supply system in their villages. The recommendation for development of a water supply system from the villagers of four villages is given below in **Table 2.2**.

Table 2.1: Recommendation for development of water supply system

Village	Elevated installation of tube wells	Region based deep tube wells	Arsenic free tube well	Pipe Water supply	Govt., Non-Govt. Water Supply During Disaster	Others
Saikchail	676	856	1355	890	398	8
Tipna	248	492	384	501	103	48
Datinakhali	207	325	188	500	274	29
Shimulbank	275	244	330	267	143	0

Table 2.2: Water Supply (Tubewell) Coverage

District	Village	Total HH	Total Population	Tubewell	Tubewell per person	Required Tubewell	Tubewell Demand	Demand (%)	Coverage (%)
Cumilla	Saikchail	1652	8929	1028	8.69	892.9	0.00	0	100
Khulna	Tipna	772	3270	173	18.90	327	154.00	47	53
Satkhira	Datinakhali	568	2256	8	282.00	225.6	217.60	96	4
Sunamganj	Shimulbank	462	2629	73	36.01	262.9	189.90	72	28

The water demand and water coverage have been analyzed based on the after-present condition assessment of the arsenic-contaminated area. From the following **Figure 2.8,** it is observed that the water coverage of Saikchail village is very good; the percentage is 100% except for the other three villages, including the lowest water coverage of 4% in Datinakhali.

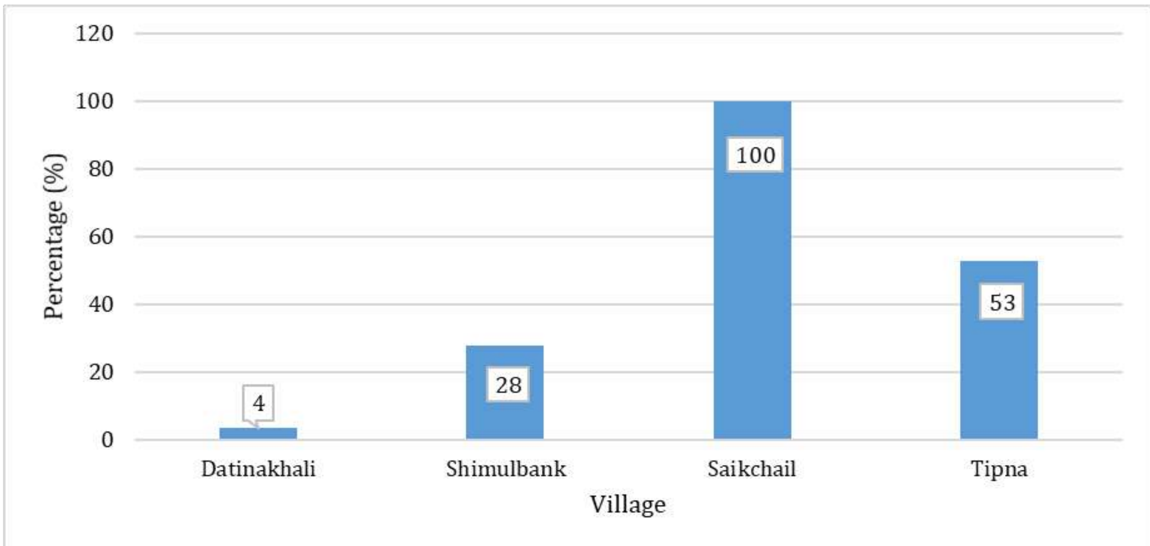


Figure 2.8: Water Supply Coverage of Arsenic contaminated area

2.1.2 Quality of Drinking Water

The term "drinking water quality" refers to the standard quality of water that does not harm the human body or health. Some of the water quality parameters respond to the human senses of sight (turbidity, color), taste (salty, offensive), and smell (odor). The basic requirements for drinking water should be as follows:

1. completely free from pathogenic microorganisms that can cause diseases;
2. contains no element or compound in concentration that can cause an acute or long-term adverse effect on human health;
3. Aesthetically acceptable;
4. no salty taste;
5. contains no compounds that can cause an offensive taste or odor;
6. It does not corrode, scale, discolor, or stain.
7. Acceptable temperature.

The CEGIS team surveyed the four villages, collected the real perceptions of the villagers, and collected water samples from both the GW and SW in those villages. A water sample is being tested in the environment laboratory at CEGIS. The quality of drinking water tasted in a laboratory is shown below.

From **Table 2.4**, it is noticed that the arsenic presence in the tubewell water is within the limit (50 ppb) as per the guidelines of the WHO for Bangladesh. The presence of iron (Fe) is also undetectable in all collected samples except one, but the presence of iron (Fe) in that sample is within the limit as per the guideline. However, 40% of the TDS (total dissolved solids) and EC (electric conductivity) values of the collected groundwater samples of Tipna village exceeded the limits as per guideline, and 100% of the TDS and EC values exceeded the limits for the surface water samples. Salinity is also present in water samples.

Table 2.3: Laboratory test results of water quality in Tipna village, Khulna

Water Quality Parameter	Concentration Present							Bangladeshi Standard	Analysis Method
	GW					SW			
	DTW (GW_01)	Household STW (GW_02)	DTW (Primary School)	DTW (Village Super Market)	DTW (GW_05)	Pachuria River	Singa River		
Arsenic (AS), ppb	0	0	0	0	25	-	-	50	Arsenic Kit
Iron (Fe), ppm	Undetectable	0.434	Undetectable	Undetectable	Undetectable	-	-	0.3 -1.0	UV-VIS
Fluoride (F^-), ppm	0.1	0.1305	0.1623	Undetectable	Undetectable	-	-	1	UV-VIS
Electrical Conductivity (EC), µS/cm	755	3030	708	713	3100	8230	7600	-	Conductivity
Total Dissolved Solid (TDS), mg/L	377	1520	354	356	1550	4120	3800	1000	Conductivity
Dissolved Oxygen (DO), mg/L	-	-	0.29	-	-	1.8	5.95	6	Electro chemical
Salinity, ppt	0.31	1.55	0.29	0.29	1.59	4.54	4	-	Conductivity
pH	7.52	7.24	7.59	7.71	7.26	7.2	7.67	6.5 - 8.5	Electrometric

From the GW samples tested in the Saikchail village of Cumilla (Table 2.5), the expert team noticed the presence of arsenic (As) in the deep tubewell water sample, which exceeded the limit of Bangladeshi standards. According to testing, the iron (Fe) level is within a tolerable limit, as shown in Table 2.5, but iron is present in almost all tubewells in Saikchail village. The TDS, DO, and turbidity for GW samples from the village are at satisfactory levels. The laboratory report certifies the presence of salinity in the GW and SW samples.

Table 2.4: Laboratory test results of water quality in Saikchail village, Cumilla

Water Quality Parameter	Concentration Present						Bangladeshi Standard	Analysis Method
	GW		SW					
	DTW (GW_02)	DTW (GW_03)	Ramrotnodighi	Dakatia Khal	Thakur Pukur	Rajdighi		
Arsenic (AS), ppb	500	10	-	-	-	-	50	Arsenic Kit
Iron (Fe), ppm	0.0544	Undetectable	-	-	-	-	0.3 -1.0	UV-VIS
Fluoride (F -), ppm	1.4834	0.5720	-	-	-	-	1	UV-VIS
Electrical Conductivity (EC), µS/cm	1100	417	231.7	308	368	274.6	-	Conductivity
Total Dissolved Solid (TDS), mg/L	550	208	115.9	154	164	137.3	1000	Conductivity
Dissolved Oxygen (DO), mg/L	0.37	6.06	3.97	0.94	0.41	0.47	6	Electro chemical
Salinity, ppt	0.49	0.13	0.03	0.07	0.1	0.05	-	Conductivity
pH	7.43	7.74	6.95	7.01	7.55	7.36	6.5 - 8.5	Electrometric
Turbidity (TURB), NTU	-	1.41	-	-	-	-	10	Nephlometric

In Shimulbank, the laboratory test result (Table 2.6) of the samples showed that arsenic (As) presence is very frequent in all ground water samples, with a value of 200 ppb > 50 ppb (Bangladeshi standard). Iron (Fe) is detectable in all samples but remained within the Bangladeshi standard limit, whereas fluoride (F-) exceeded the Bangladeshi standard limit. The TDS, DO, and turbidity for GW samples from the village are at satisfactory levels. The laboratory report certifies the presence of salinity in the GW samples.

Table 2.5: Laboratory test results of water quality in Shimulbank village, Sunamganj.

Water Quality Parameter	Concentration Present				Bangladeshi Standard	Analysis Method
	GW			SW		
	DTW (GW_05)	DTW (GW_06)	DTW (GW_04)	SW_01		
Arsenic (AS), ppb	200	200	200	-	50	Arsenic Kit
Iron (Fe), ppm	0.3766	0.3609	0.6835	-	0.3 -1.0	UV-VIS
Fluoride (F^-), ppm	1.0933	1.6492	1.2267	-	1	UV-VIS
Electrical Conductivity (EC), µS/cm	749	720	738	34.7	-	Conductivity
Total Dissolved Solid (TDS), mg/L	374	360	369	17.4	1000	Conductivity
Dissolved Oxygen (DO), mg/L	0.45	0.45	3.71	4.6	6	Electro chemical
Salinity, ppt	0.31	0.29	0.3	0	-	Conductivity
pH	7.5	7.6	7.54.463	7.7	6.5 - 8.5	Electrometric
Turbidity (TURB), NTU	3.07	1.57	1.41	10.8	10	Nephlometric

According to Bangladeshi standards, arsenic (As) and iron (Fe) are undetectable, and fluoride (F-) is the limit for all collected GW samples from Datinakhali village in **Table 2.7**. The TDS, DO, and turbidity for GW samples from the village are at satisfactory levels. The laboratory report certifies the presence of salinity in the GW samples.

Table 2.6: Laboratory test results of water quality in Datinakhali village, Satkhira.

Water Quality Parameter	Concentration Present		Bangladeshi Standard	Analysis Method
	GW	SW		
	DTW (GW_03)	SW_01		
Arsenic (AS), ppb	0	-	50	Arsenic Kit
Iron (Fe), ppm	Undetectable	-	0.3 -1.0	UV-VIS
Fluoride (F^-), ppm	0.3743	-	1	UV-VIS
Electrical Conductivity (EC), µS/cm	820	24.5	-	Conductivity
Total Dissolved Solid (TDS), mg/L	410	12.2	1000	Conductivity
Dissolved Oxygen (DO), mg/L	6.74	6.91	6	Electro chemical
Salinity, ppt	0.35	14.85	-	Conductivity
pH	6.86	6.67	6.5 - 8.5	Electrometric
Turbidity (TURB), NTU	7.15	102	10	Nephlometric

Again, people from the respected villages give their opinion regarding the water they drink. 70% of the villagers in Saikchail told us that the water quality from the source they collected was good, but when our experts visited the village, they discovered that the water was of poor quality.However, 13% of the people of Saikchail said the water quality is bad, and they mentioned the reasons behind it, mostly the presence of iron, arsenic, turbidity, odor, and bad taste. Approximately 90% of the villagers of other respected villages opined that the water quality is good. The whole scenario is depicted in **Figures 2.9 and 2.10** below.

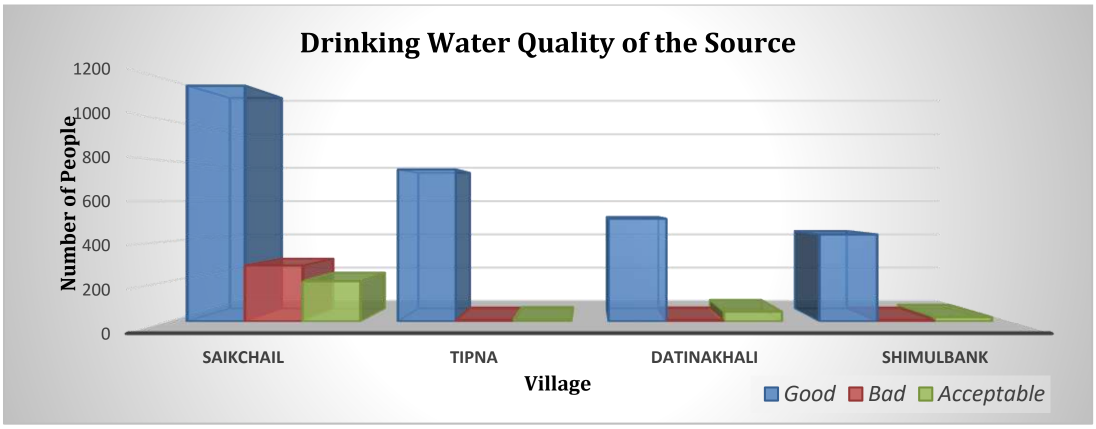


Figure 2.9: Drinking water quality of the source of four villages

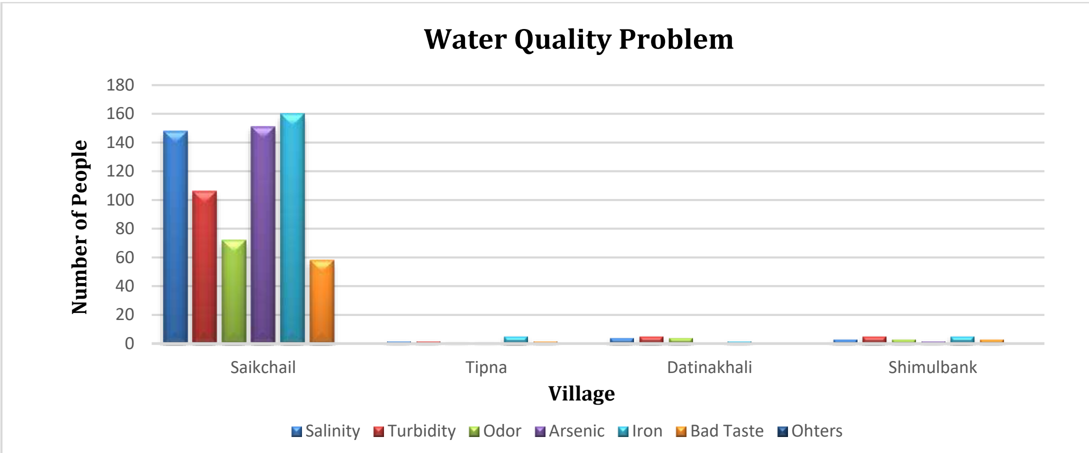


Figure 2.10: Reasons behind the drinking water quality problem of four villages

At the time of surveying, we came to know that only a few people in the villages do purification before drinking water, and the percentage is 10% in all four villages. They mainly use filtering, sedimentation, and boiling as water purification techniques. **Figures 2.11** and **2.12** provide a clear visual representation of this fact, which is pasted below.

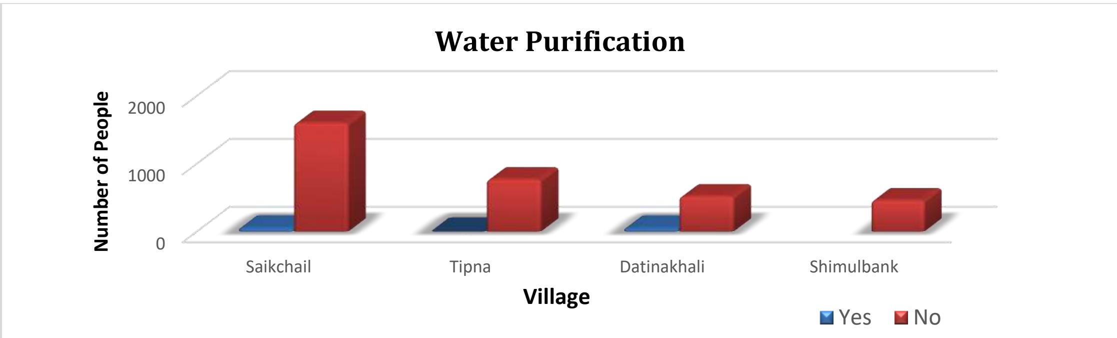


Figure 2.11: Water purification tendency before drinking water of the villagers in four villages

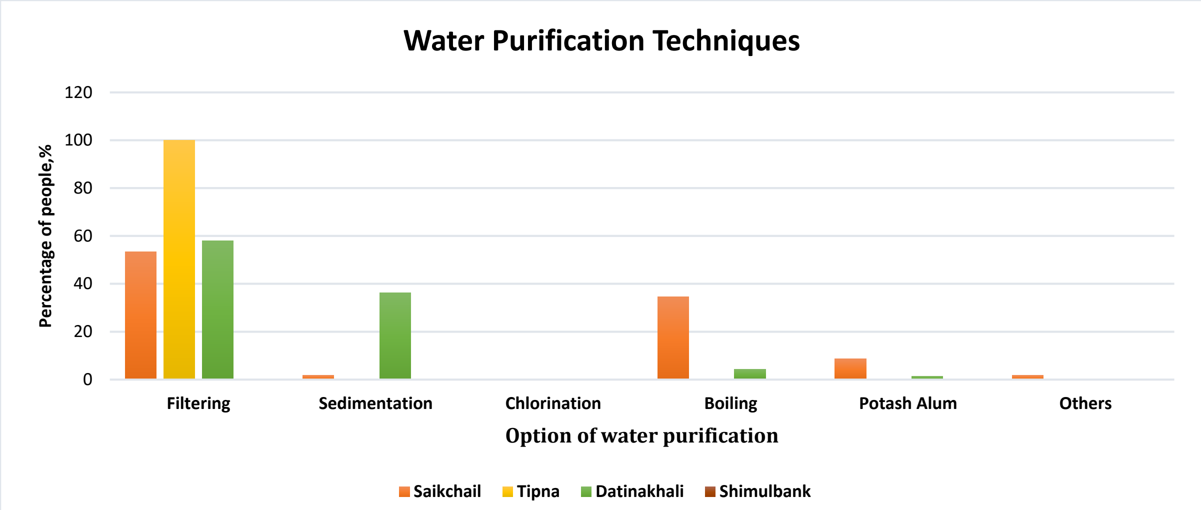


Figure 2.12: Water purification techniques before drinking water in four villages

From **Figure 2.13**, we came to know that the water consumption rate of the house members in a house varied between 10-15 L and >15 L in all villages.

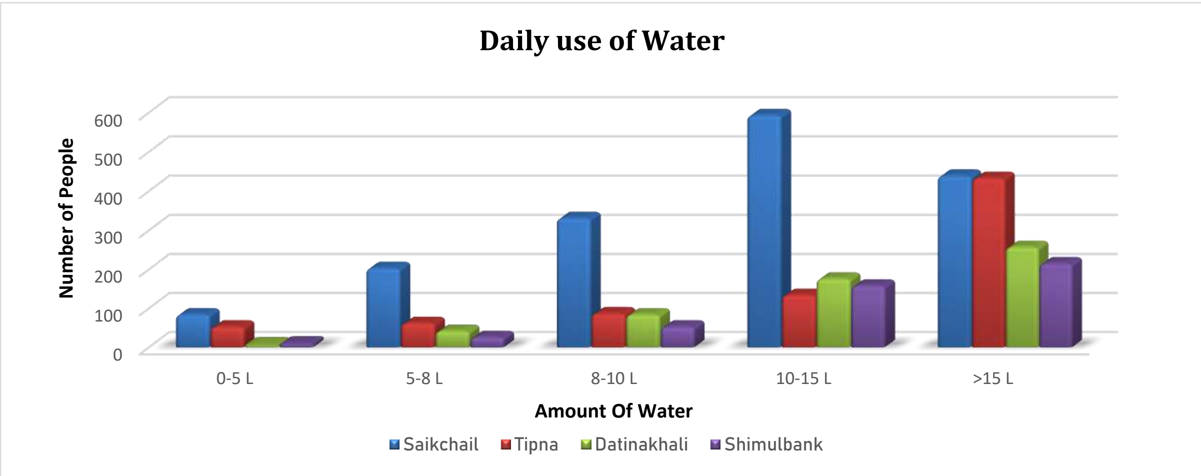


Figure 2.13: Daily consumption of water by members in a house in four villages

2.1.3 Sanitation Condition

The provision of facilities and services for the safe disposal of human urine and feces is referred to as "sanitation." Sanitation differs from hygiene in that it offers people the means to be hygienic. **Figure 2.14** shows that 76% of Tipna and Saikchail residents have toilets in their homes, while 67% of Datinakhali residents and 60% of Shimulbank residents do not.

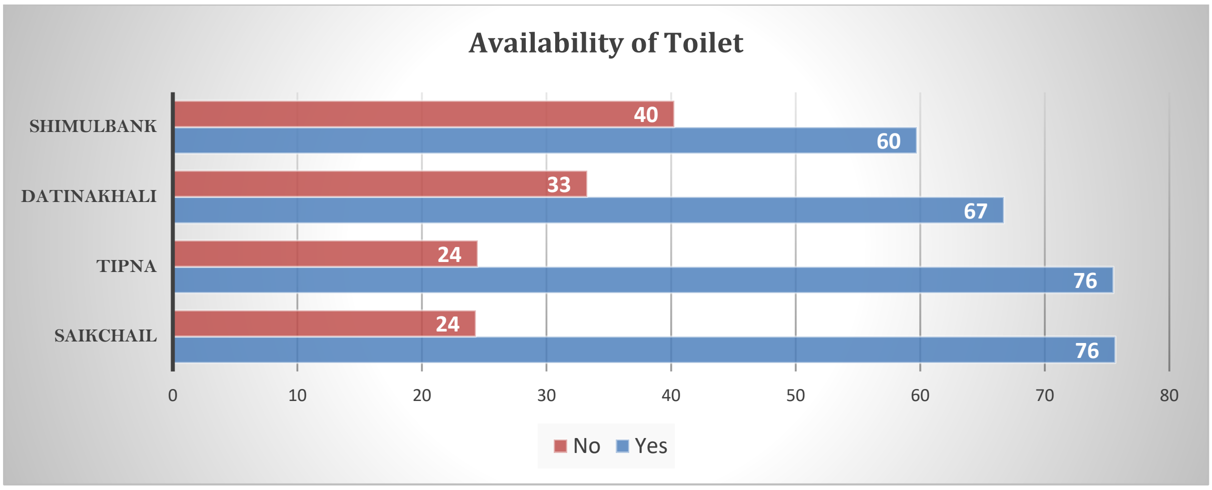


Figure 2.14: Availability of toilets in four villages

As previously stated, 76% of people in Saikchail and Tipna village use toilets, the majority of which are pit latrines. Pit latrines are available in the majority of all villages, but VIP latrines, flash latrines, and septic tank latrines are also available in Saikchail, Tipna, and Shimulbank villages. Table 2.8 and Figure 2.15 are shown below for a depiction of the availability of toilet types in four villages.

Table 2.7: Available types of toilets in four villages

Village	Pit Latrine	Double Pit Latrine	VIP Latrine	Flash Latrine	Septic Tank Latrine	Open Latrine	Others	Not Available
Saikchail	42%	5%	27%	13%	13%	0	0	0
Tipna	58%	4%	6%	14%	18%	0	0	0
Datinakhali	77%	2%	4%	12%	5%	0	0	0
Shimulbank	41%	5%	14%	12%	21%	7%	0	0

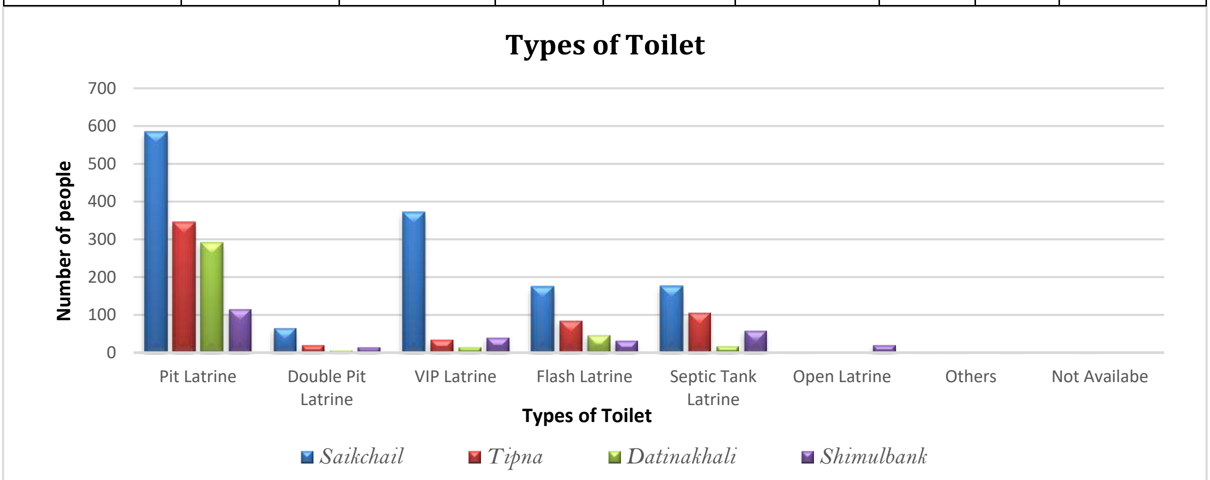


Figure 2.15: Types of available toilets in four villages

The location of toilets is also a big issue in sanitation. **Figure 2.16** shows that among those who have toilets, the majority are located within the boundaries of their homes in the four villages. Again, some of the toilets are outside the house boundary but in their own place. However, outside-the-boundary toilets are almost non-existent in four villages.

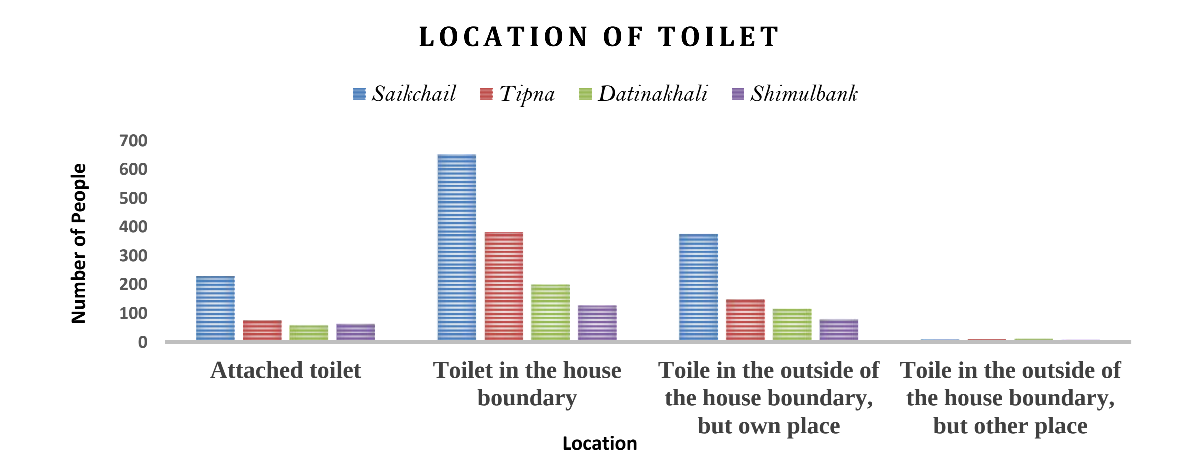


Figure 2.16: Location of toilets

The condition of the toilet is also noticeable for sanitation. Around 40% of the toilets are clean in four villages, but in Saikchail and Tipna, around 50% of the toilets are dirty but usable. Again, around 20% of toilets are dirty and unusable, but people use them in Datinakhali, Shimulbank, and Tipna villages, as shown below in **Figure 2.17.**

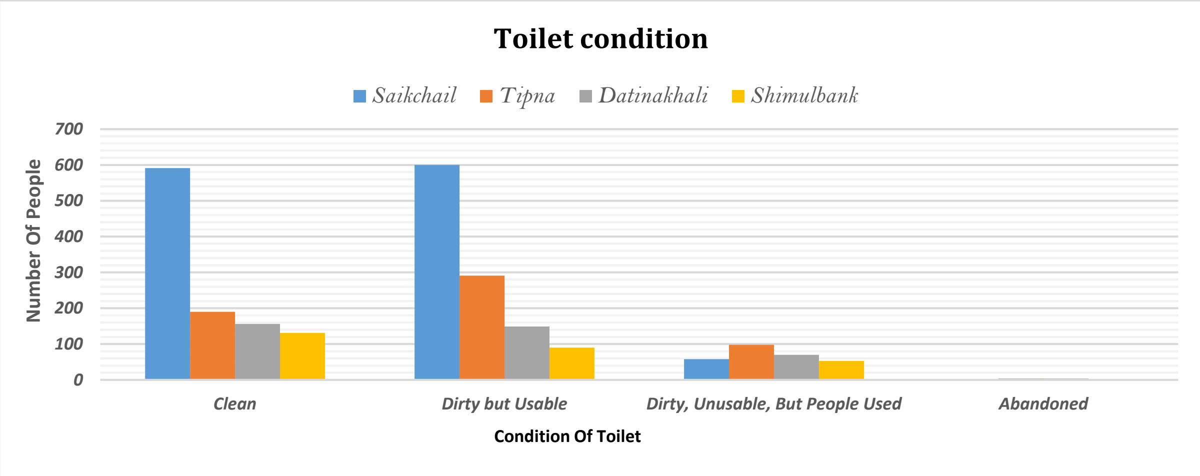


Figure 2.17: Present condition of toilets at the time of surveying in four villages

Table 2.9 and Figure 2.18, shown below, illustrate that around 30% of people in four villages have a handwashing system with soap availability inside the toilets.

Table 2.8: Inside toilet facilities of the four villages

Village	Soap available, %	Toilet tissue available, %	Hand wash system available, %	Tap water available for hand wash, %	Dustbin with lid available, %	Special facilities for the disable, %	Others,%
Saikchail	29	28	22	11	3	0	7
Tipna	29	15	20	10	2	0	25
Datinakhali	21	8	23	3	1	0	44
Shimulbank	32	29	30	6	2	0	1

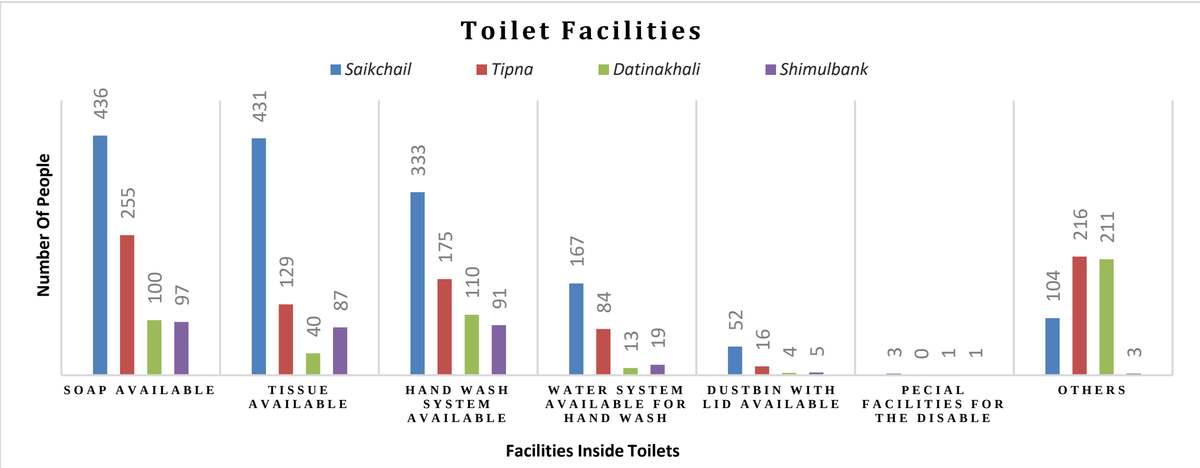


Figure 2.18: Toilets facilities inside the toilets in four villages

Approximately 80% of people in all villages want to improve the state of their latrines. Among them, the people of Saikchail wanted to improve latrines by improving the pan, water supply, flash tank, water tank, and floor or wall. However, in the other three villages, people mainly wanted to improve their latrines' pans and floors or walls. The scenario of latrine improvement is shown below in Figure 2.19.

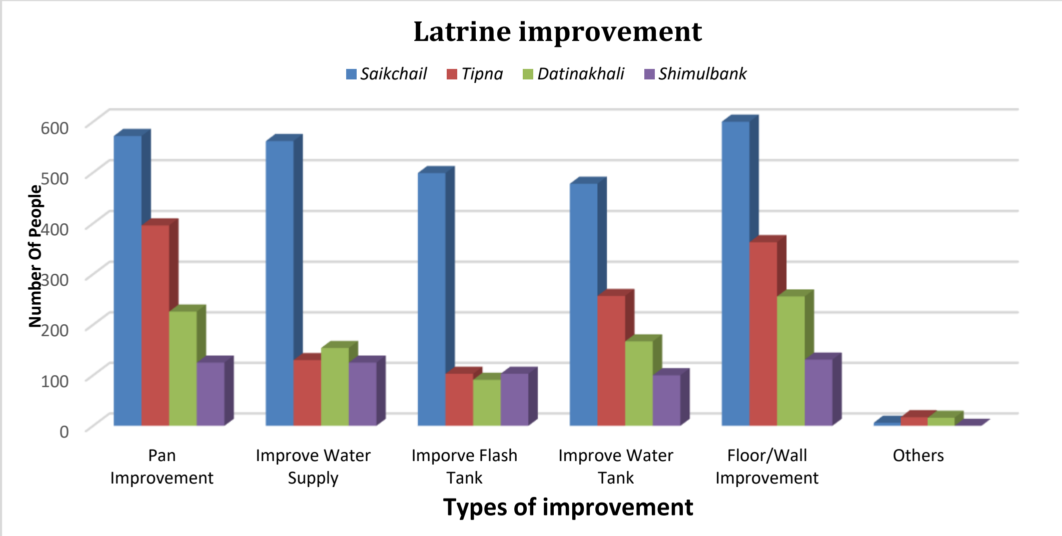


Figure 2.19: Willingness of villagers to improve latrines facilities in four villages

Almost 40% of people in all villages lack access to toilets. **Figure 2.20,** shown below, describes the reasons for not having toilets, which are mainly financial constraints. Again, some villagers attribute the lack of toilets in their homes to a lack of space.

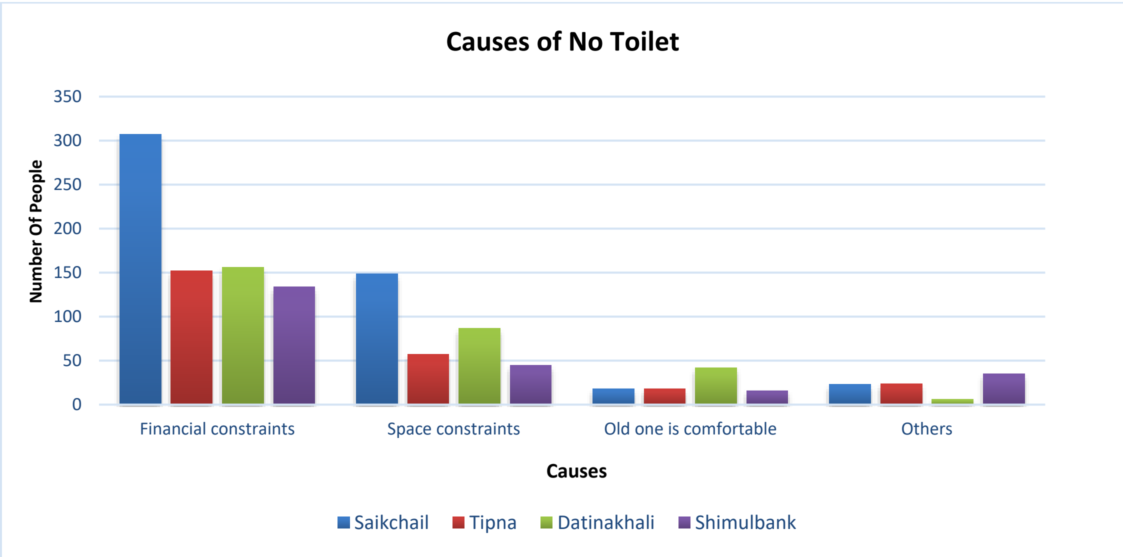


Figure 2.20: Reasons for no toilet

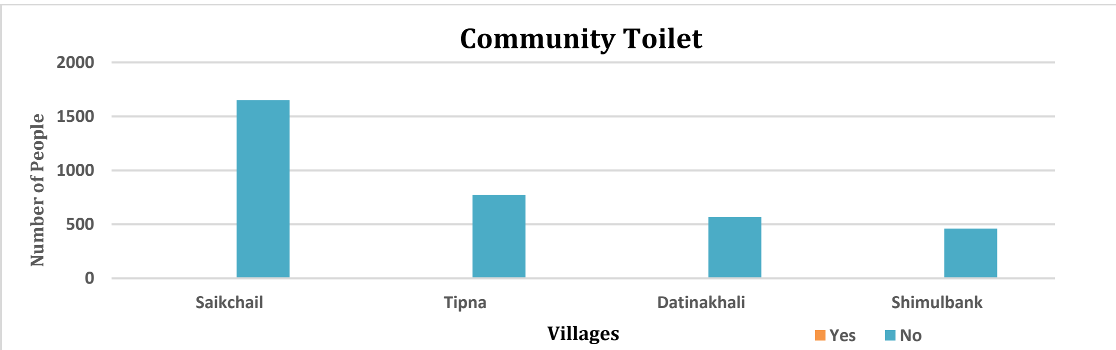


Figure 2.21: Visual representation of toilets in four villages

Toilet of Sheikh Sohrab Ali, Datinakhali

Toilet of Imrul Haque, Shimulbank

Toilet of Mustafizur Rahman, Mulla Para,Tipna

Toilet of Mr. karim, Dakhin Para Saikchail

Figure 2.22: Availability of community toilets in four villages

Sanitation Coverage for Arsenic Contaminated Area

District	Village	HH	Population	Latrine Type	Non-Shared	Shared	Weight (Non-Shared)	Weight (Shared)	Equivalent Toilet	Total Equivalent Toilet	Total Requirement	Demand	Demand (%)	Coverage (%)
Cumilla	Saikchail	1652	8929	Double Pit Latrine	54	11	1	0.5	60	890	1785.8	896	50	50
				Flash Latrine	154	22	0.8	0.4	132					
				Not Available	0	0	0	0	0					
				Open Latrine	2	0	0	0	0					
				Others	1	0	0	0	0					
				Pit Latrine	470	116	0.6	0.3	317					
				Septic Tank Latrine	150	27	0.9	0.45	147					
				VIP Latrine	299	73	0.7	0.35	235					
Khulna	Tipna	772	3270	Double Pit Latrine	17	4	1	0.5	19	371	654	283	43	57
				Flash Latrine	69	17	0.8	0.4	62					
				Not Available	1	0	0	0	0					
				Open Latrine	0	0	0	0	0					
				Others	2	0	0	0	0					
				Pit Latrine	251	95	0.6	0.3	179					
				Septic Tank Latrine	90	17	0.9	0.45	89					

District	Village	HH	Population	Latrine Type	Non-Shared	Shared	Weight (Non-Shared)	Weight (Shared)	Equivalent Toilet	Total Equivalent Toilet	Total Requirement	Demand	Demand (%)	Coverage (%)
				VIP Latrine	28	7	0.7	0.35	22					
Satkhira	Datinakhali	568	2256	Double Pit Latrine	3	4	1	0.5	5	209	451.2	242	54	46
				Flash Latrine	26	21	0.8	0.4	29					
				Not Available	0	0	0	0	0					
				Open Latrine	0	0	0	0	0					
				Others	0	0	0	0	0					
				Pit Latrine	208	84	0.6	0.3	150					
				Septic Tank Latrine	14	4	0.9	0.45	14					
				VIP Latrine	14	1	0.7	0.35	10					
Sunamganj	Shimulbank	462	2629	Double Pit Latrine	13	2	1	0.5	14	171	525.8	355	67	33
				Flash Latrine	28	5	0.8	0.4	24					
				Not Available	0	0	0	0	0					
				Open Latrine	15	6	0	0	0					
				Others	1	0	0	0	0					
				Pit Latrine	89	27	0.6	0.3	62					
				Septic Tank Latrine	43	16	0.9	0.45	46					
				VIP Latrine	31	10	0.7	0.35	25					

The sanitation demand and sanitation coverage have been analyzed based on the present condition of the arsenic-contaminated area. From the following **Figure 2.23**, it can be seen that the sanitation coverage of four villages is different. In Tipna and Saikchail, sanitation coverage is about 57% and 50%, respectively; in Datinakhali, the coverage rate is 46%. The sanitation condition of Shimulbank is very poor; the coverage rate is only 33%.

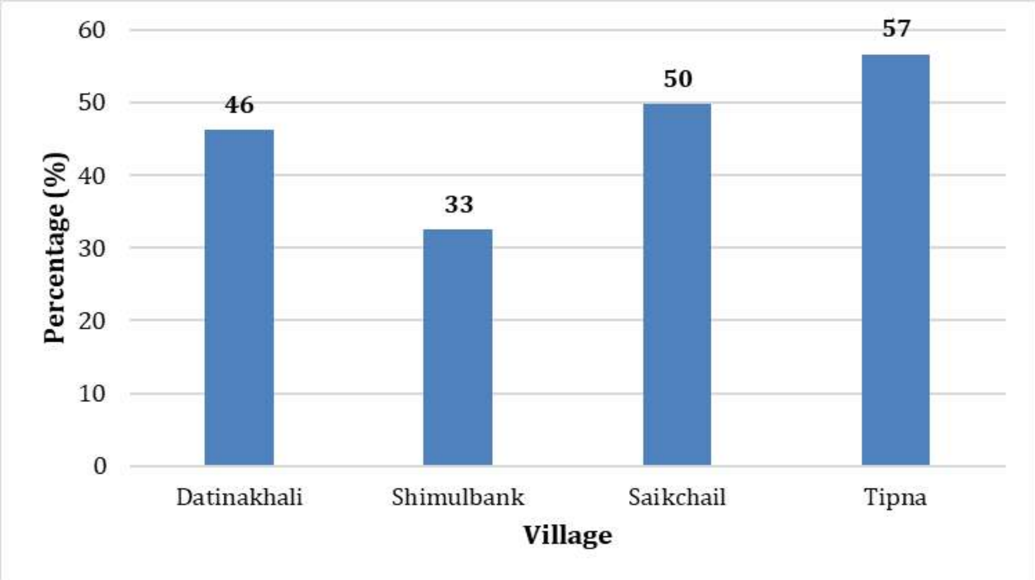


Figure 2.23: Sanitation coverage of Arsenic contaminated area.

2.1.4 Hygiene Condition

Hygiene is a set of practices used to keep one's health in check. "Hygiene refers to behaviors and practices that assist in maintaining health and prevent the spread of infectious diseases," according to the World Health Organization. Personal hygiene is the practice of keeping one's body clean. There are some factors described below that were found after assessing the prevailing condition of the four villages in the subsequential survey.

Figure 2.24 shows that approximately 20% of toilets in Saikchail and Tipna are adjacent to the water supply source, potentially contaminating the water source with pathogens from defecated water. Actually, it represents their way of thinking about the practice of hygiene.

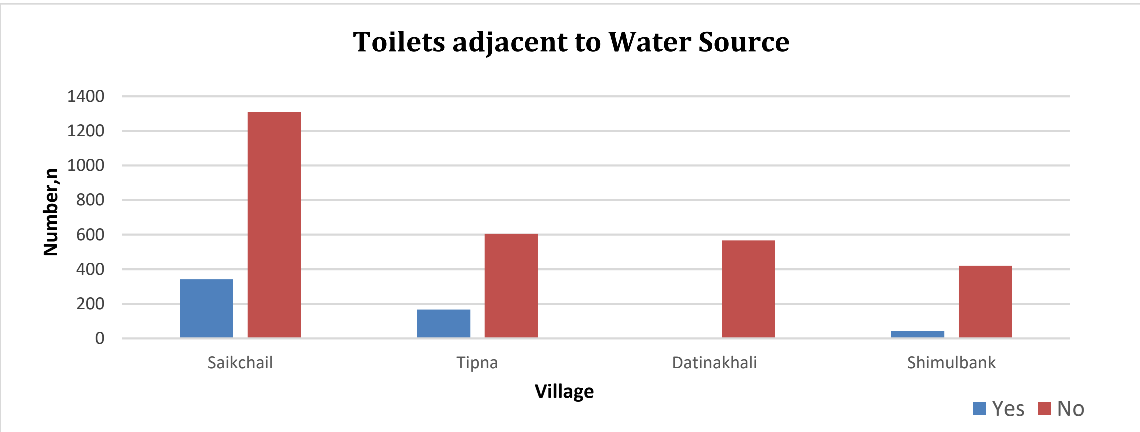


Figure 2.24: Availability of Toilets adjacent to Water Source in four villages

One of the most fundamental hygiene practices is washing one's hands before eating. The rate of regularly washing hands before taking food is 50% in Shimulbank, and in the other 3 villages, the percentage fluctuates between 55 and 65%, as shown below in **Figure 2.25**.

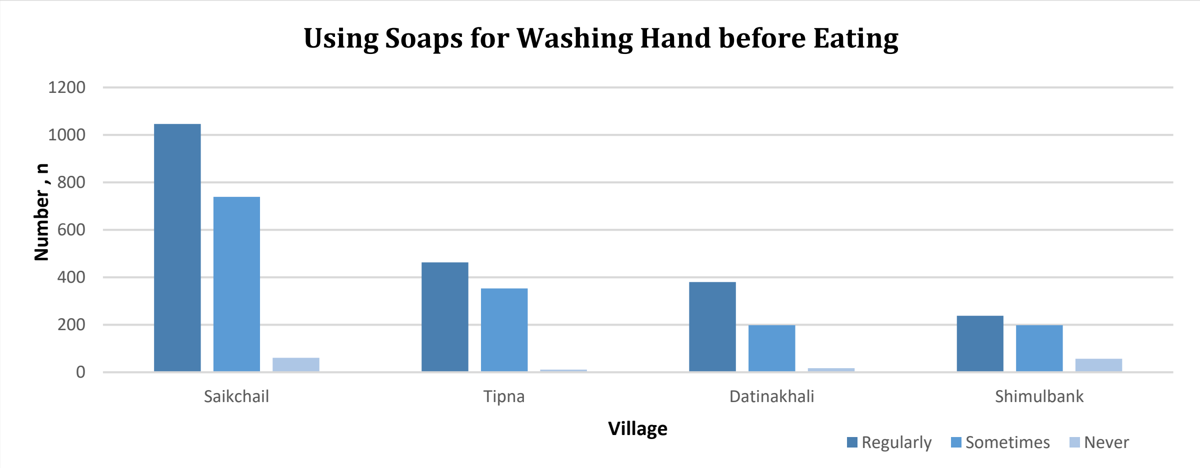


Figure 2.25: The villagers using Soaps for Washing Hand before Eating in four villages

Figure 2.26 gives us the viewpoint that around 80% of people in all villages have the habit of cleaning their hands with soap daily, which represents their minimal knowledge of maintaining hygiene.

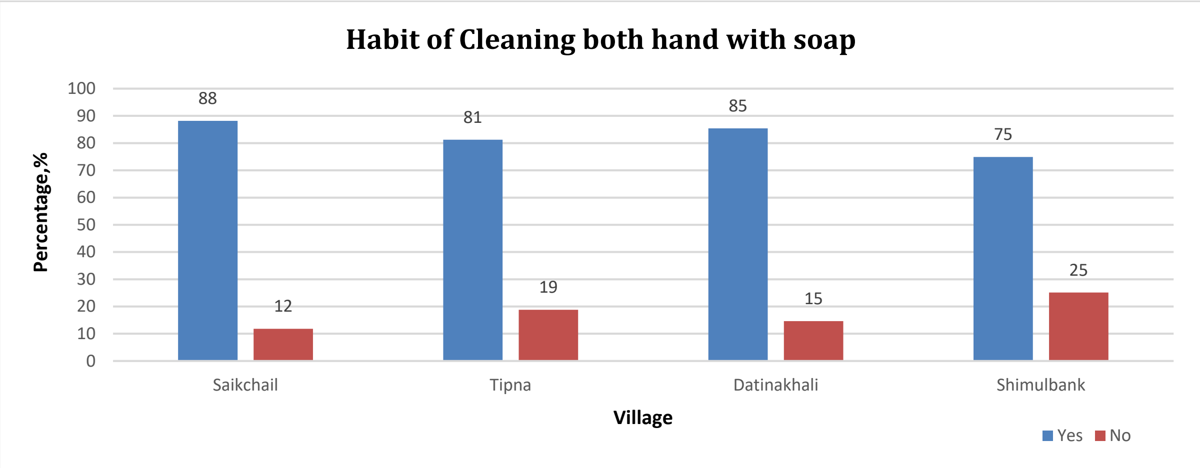


Figure 2.26: Habit of cleaning both hands with soap

The condition of toilet hygiene is not up to par in all villages because they have no scope for washing hands in the cubicle of the toilet. **Figure 2.27** depicts the maximum number of people who wash their hands anywhere other than the toilet. Even so, it is concerning that approximately 5% of Shimulbank residents and 3% of Datinakhali residents do not wash their hands after using the restroom.

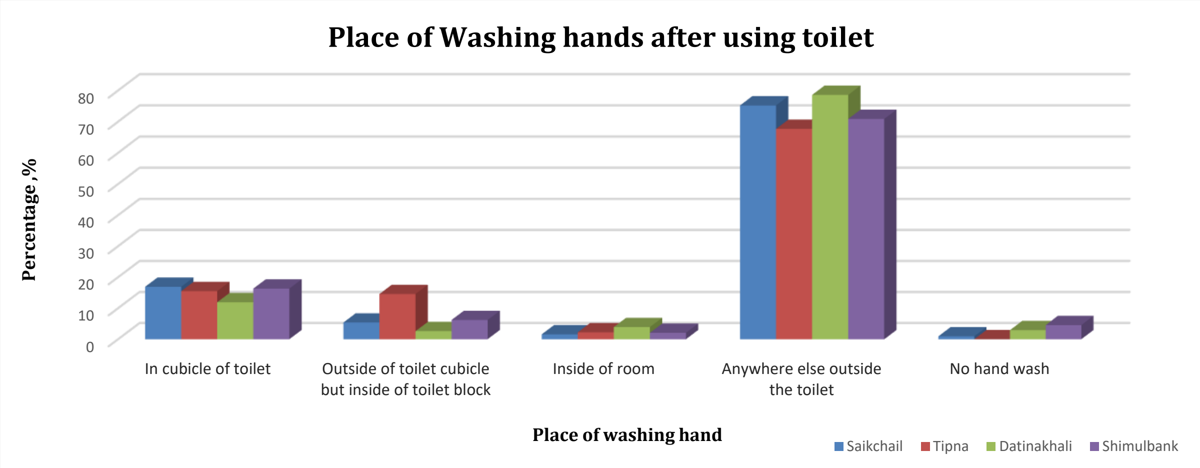


Figure 2.27: Place of washing hands after using toilet

The results of the survey showed that, with the exception of Shimulbank, where the percentage is 87%, 90% of people wash their hands except using the bathroom. Primarily, they wash their hands before eating, feeding the infants, and other activities. Except for using toilets, **Figure 2.28**, which is pasted below, describes their washing practices.

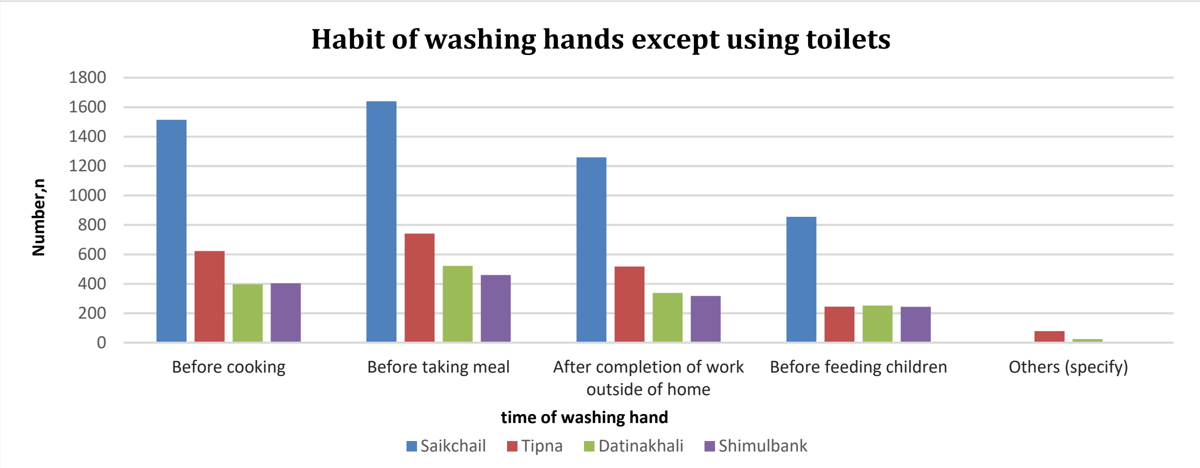


Figure 2.28: Habit of washing hands except using toilets

2.1.5 Assessment of DPHE Intervention

Since 1926, DPHE has worked to provide Bangladeshi citizens with access to clean water and sanitary facilities. Water Point Mapping (WPM) is an activity that involves gathering management, technical, and demographic data along with the locations of all public water points in a given area. The following Table 2.10 shows the current DPHE water supply intervention table:

Table 2.9: DPHE existing intervention for water supply in Arsenic contaminated Upazilas

Performance of Different Water Supply Technologies (Installation Year: 2006-2012)														
Technologies / Upazila	STW-6		DTW-6		DTW-TDev		PSF		RWH		SST/VSST		Total	Total
	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional
Monoharganj, Cumilla.	-	-	201	188	39	28	-	-	-	-	-	-	240	216
Dumuria, Khulna.	-	-	648	636	-	-	-	-	-	-	-	-	648	636
Dakshin sunamganj, Sunamganj.	-	-	184	178	18	18	-	-	-	-	-	-	202	196
Shyamnagar, Satkhira.	55	35	598	518	-	-	200	143	144	112	404	265	1401	1073

2.2 Socio-Economic Context and Community Perception

Bangladesh is located in northern South Asia, with an area of 147,570 square kilometers and a population of approximately 168.10 million people, with a population density of 1,116 people per square kilometer. Over two-thirds of its population lives in rural areas, although the urban population is increasing at a very high rate, i.e., double the national growth rate. Bangladesh met the Millennium Development Targets for drinking water by increasing progress from 68% to 87% between 1990 and 2015. Remarkable progress has been made by reducing open defecation practices to around 1% by 2015 from 34% in 2003 and increasing access to improved sanitation to 64%. In the SDG era, 98.5 percent of the population has access to better water sources. However, only 42.6% of the population has access to safely managed drinking water services. In terms of sanitation, basic service coverage is 64.4% nationally. Safely managed sanitation coverage is 36.4% (estimated) for rural areas; no data is available for urban areas.

The national vision is to achieve universal access to safe and affordable drinking water for all and ensure access to adequate and equitable sanitation and hygiene by 2030. Bangladesh aims to achieve this in three five-year phases. Phase-1: 2016–2020: Achieve universal coverage in rural and urban populations using various water supply options; Phase-2: 2021–2025: Sustain universal coverage in rural and urban populations by increasing service delivery standards; Phase 3: 2026–2030: Work to maintain universal coverage in rural and urban areas.

2.2.1 Socio Economic Setting

This sub-section of this chapter deals with the social structure and poverty condition of four arsenic contaminated selected villages.

Demographic Profile

The demographic profile of the pilot villages is captured from the primary survey of the pilot villages. It is found that the arsenic-contaminated pilot villages include 3454 households consisting of 17084 people, of which 8837 (51.5%) are males and 8247 (48.5%) are females. The average sex ratio is 106:100, which refers to 106 males per 100 females. From the survey, it is observed that the Saikchail village of Cumilla district has the highest population (8929), comprising 1652 households (HH). The average household size in Saikchail is 4.8, which is higher than the national average of 4.2. The following **Table 2.11** represents the demographic data of the pilot villages.

Table 2.10: Demographic Profile of the Pilot Villages

Village	Total HH	Total Population	Total Male	Total Female	Sex Ratio	Avg. HH
Saikchail	1652	8929	4659	4270	109.1	5.4
Tipna	772	3270	1672	1598	104.6	4.24
Datinakhali	568	2256	1146	1110	103.2	3.97
Shimulbank	462	2629	1360	1269	107.2	5.69
Total	**3454**	**17084**	**8837**	**8247**	**424.1**	**19.3**

Source: CEGIS Field Survey, 2022

Moreover, the age composition shows that the rate of the adult population for both males and females is the highest in the pilot villages. On average in the pilot villages, about 32% of both males and females are adults. Because of lower infant and under-five mortality rates (U5MR), the percentage of children is also noticeable in the studied villages. The following **Table 2.12** presents the age structure of the studied villages.

Table 2.11: Age Structure of Population in the Pilot Villages

Village	Adult (> 18 years)		Children Under 5 years		Children(5-18 years)	
	Female (%)	Male (%)	Boy (%)	Girl (%)	Boy (%)	Girl (%)
Saikchail	29.6	33.1	5.4	5.1	13.7	13.1
Tipna	33.9	34.5	4.8	4.9	11.8	10.2
Datinakhali	35.3	33.6	5.0	4.3	12.2	9.6
Shimulbank	27.0	28.8	5.2	5.9	17.7	15.3

Source: CEGIS Field Survey, 2022

Gender and Marital Status of the HH Head

In the surveyed villages majority of the HH heads are male. The following **Table 2.13** shows that more than 90% of HH heads are male in every village. No third gender headed HHs have been found in those four villages.

Table 2.12: Sex of the HH Heads in the Villages

District	Village	% of Male	% of Female	% of Third gender
Cumilla	Saikchail	95.52	4.48	0
Khulna	Tipna	94.17	5.83	0
Satkhira	Datinakhali	90.49	9.51	0
Sunamganj	Shimulbank	91.77	8.23	0

Source: CEGIS Field Survey, 2022

It is also observed that the majority of the HH heads are married, and most of them are monogamous. A few polygamous male HH heads are also found in the studied villages. In the female headed HHs most of heads are widow. The marital status of the HH heads is presented in **Table 2.14.**

Table 2.13: Marital status of the HH heads

Village	Married (one wife)	Married (more than one wife)	Widow	Unmarried	Widower	Separated	Divorcee
Saikchail	88.3	6.4	3.6	0.9	0.5	0.3	0.1
Tipna	90.4	1.8	3.6	1.3	1.0	1.6	0.3
Datinakhali	89.6	0.5	5.1	1.2	0.5	1.6	1.4
Shimulbank	84.4	4.8	6.5	4.1	0.2		

Source: CEGIS Field Survey, 2022

Housing Condition and Housing Tenancy

The average housing condition of the four villages shows that the majority of the houses are tin-shaded. In Saikchail, about 77% of the houses are tin-shaded. On the other hand, in Tipna more than 38% and in Shimulbank more than 20% of houses are half-built. The following **Figure 2.29** shows the housing condition of the arsenic-contaminated area.

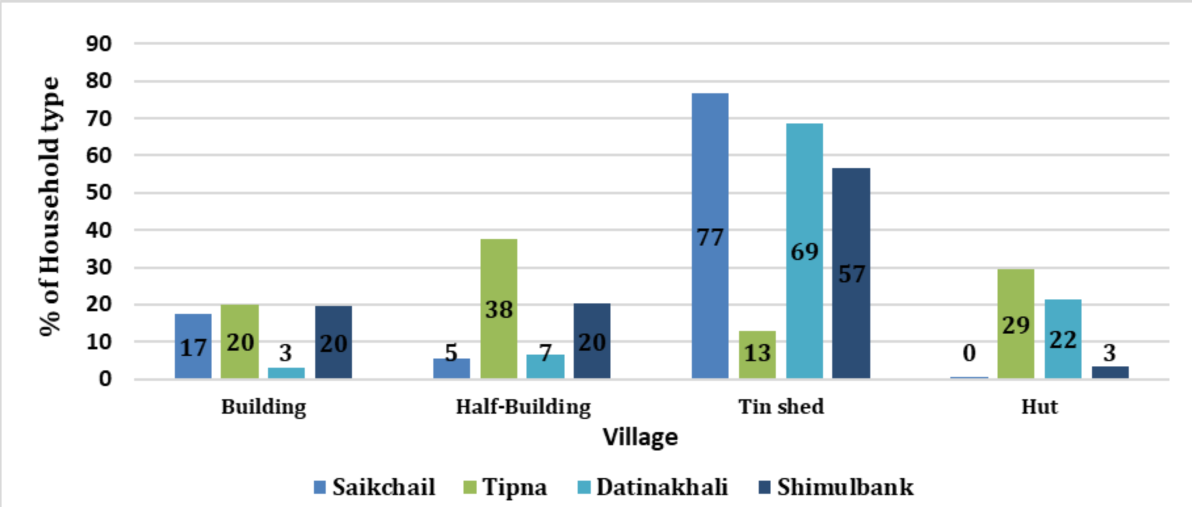


Figure 2.29: Housing Condition of arsenic contaminated villages.

Main Occupation of the HH Head

In the arsenic contaminated pilot villages, majority (more than 90%) of the HH head is employed. They are involved in different occupations to earn their livelihoods. Day labour is the main occupation for the majority of them in most of the villages followed by agriculture and business. In Datinakhali of Satkhira and Shimulbank of Sunamganj, majority of the HH heads' occupation is daily labour. Moreover, a remarkable number of HH heads is containing business as their main means of livelihoods. On the other hand, the HH heads' involvement in secondary occupations are found; significantly they are involved in agriculture followed by day labouring and business (Table 2.15). The following figure (Figure 3.30) and tables (Table 2.15 and Table 2.16) present the occupations of HH heads in the pilot villages.

Table 2.14: Main Occupation of the HH Head

Village	Government Job (%)	Private Job (%)	Business (%)	Agricultural (%)	Day Labourer (%)	Homemaker (%)	Transport Driving (%)	Expatriates (%)	Fisherman (%)	Made Servant (%)	Self-employed (%)	Village Doctor (%)	Others (%)
Saikchail	1.8	5.6	15.3	13.4	20.2	3.4	5.7	21.3	0.2	-	1.7	0.2	6.0
Tipna	1.7	5.6	16.6	31.0	20.6	1.3	14.6	-	0.1	0.9	-	-	5.7
Datinakhali	0.7	3.9	13.6	10.2	48.9	0.7	6.3	-	-	-	-	-	14.1
Shimulbank	0.7	5.2	7.4	21.0	32.9	3.7	0.7	12.6	2.6	2.4	3.5	0.4	0.4

Source: CEGIS Field Survey, 2022

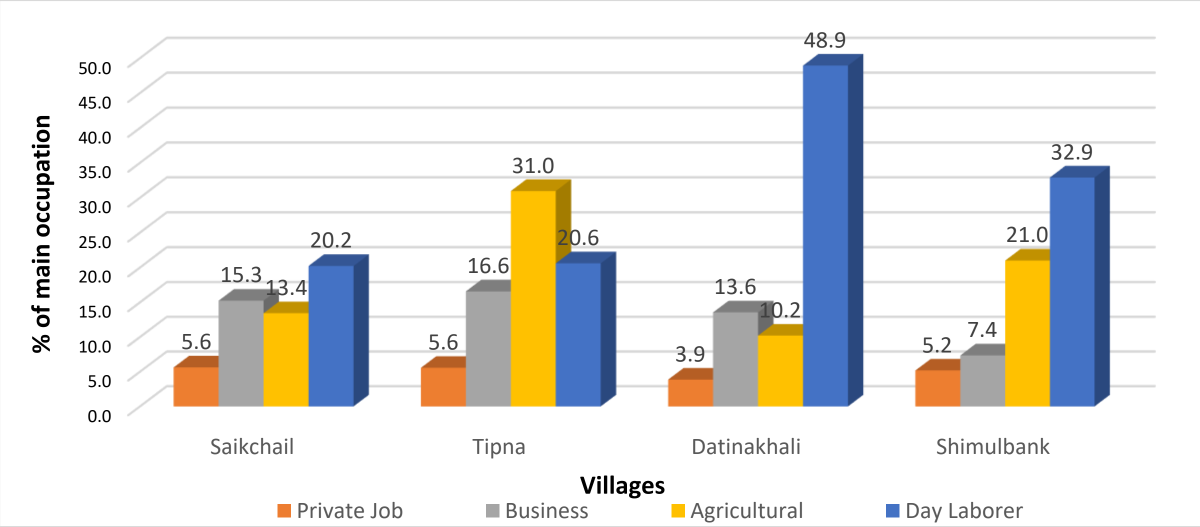


Figure 2.30: Main Occupation of the people arsenic contaminated villages.

In secondary occupations, people, especially from lower income groups, are involved in agricultural activities, day laborers, small businesses, and transport driving for a minimum of 4 to a maximum of 6 months in a year. The following Table 2.16 represents the status of secondary occupations in the pilot villages.

Table 2.15: Secondary Occupation of the HH Head

Village	Government job	Non-government job	Business	Agricultural	Laborer	Housewife	Transport Driver	Fisherman	Self-employed	Village Doctor
Saikchail	0.9	1.9	9.3	54.9	22.8	-	3.7	-	-	0.9
Tipna	-	0.6	13.9	48.2	27.8	-	7.4	-	-	1.1
Datinakhali	-	1.0	9.0	21.0	36.0	7.0	15.0	-	-	-

Village	Government job	Non-government job	Business	Agricultural	Laborer	Housewife	Transport Driver	Fisherman	Self-employed	Village Doctor
Shimulbank	-	2.5	5.1	53.2	38.0	-	1.3	-	-	-

Source: CEGIS Field Survey, 2022

The type of disability was also identified in the studied villages. According to the survey results, the percentage of physical disability is higher than any other disability. The following table (Table 2.17) represents the disability types found in the pilot villages.

Table 2.16: Type of Disability in the Pilot Villages

Village	Autistic	Physical	Mental	Visual impairment	Speech impairment	intellectual impairment	Hearing impairment	Hearing-Visual impairment	Cerebral palsy	Down syndrome	Multiple disability	Others
Saikchail	5.6	34.4	14.4	13.3	14.4	5.6	3.3	1.1	3.3		4.4	
Tipna	2	43.1	7.8	7.8	7.8	11.8	7.8				5.9	5.9
Datinakhali	7.3	49.1	5.5	14.6	10.9	5.5	7.3					
Shimulbank	12	40.0	12.0	14.0	8.0	4.0	4.0			2.0	4.0	

Source: CEGIS Field Survey, 2022

2.2.2 Beneficiary Community Description

Arsenic Contaminated Area

Saikchail, Tipna, Datinakhali, and Shimulbank are located Arsenic contaminated area and Datinakhali is in the coastal, Shimulbank is in the Haor area, and Tipna is in the Cyclone-prone area. The selected villages are among the selected 15 villages for the “My Village- My Town” project. The total household number is 1652, 772, 568, 462 in Saikchail, Tipna, Datinakhali and Shimulbank villages respectively. The survey shows that the adult male percentage is more than female percentage in villages.

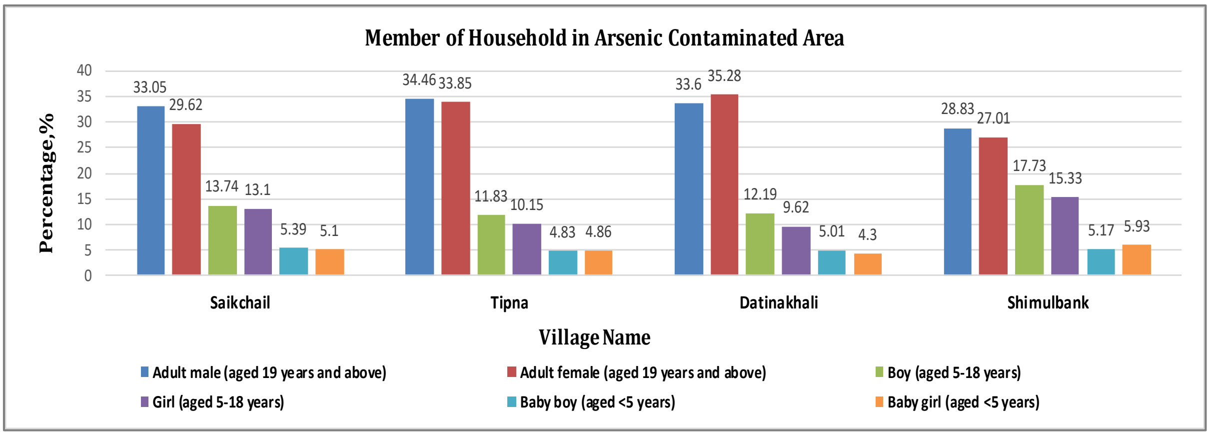


Figure 2.31: Member of Household in Arsenic Contaminated Area

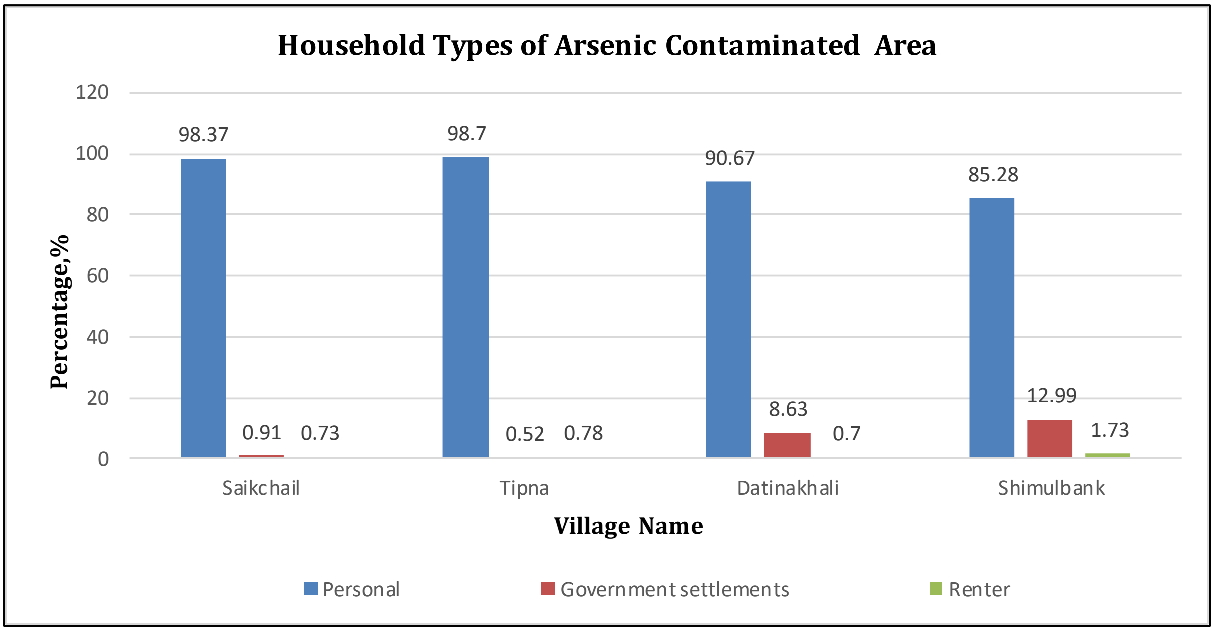


Figure 2.32: Household types of Arsenic Contaminated Area

The total population is 8929, 3270, 2256 and 2629 in Saikchail, Tipna, Datinakhali and Shimulbank villages respectively. The total number of the male population is much more than the female population in these villages here. Most of the household in these three villages of this area is of personal type.

2.2.3 Economic Activities

In the arsenic contaminated pilot villages, majority (more than 90%) of the HH head is employed. They are involved in different occupations to earn their livelihoods. Day labour is the main occupation for the majority of them in most of the villages followed by agriculture and business. In Datinakhali of Satkhira and Shimulbank of Sunamganj, majority of the HH heads' occupation is daily labour. Moreover, a remarkable number of HH heads is containing business as their main means of livelihoods. On the other hand, the HH heads' involvement in secondary occupations are found; significantly they are involved in agriculture followed by day labouring and business (Table 2.18). The following figure (Figure 2.34) and tables (Table 2.18 and Table 2.19) present the occupations of HH heads in the pilot villages.

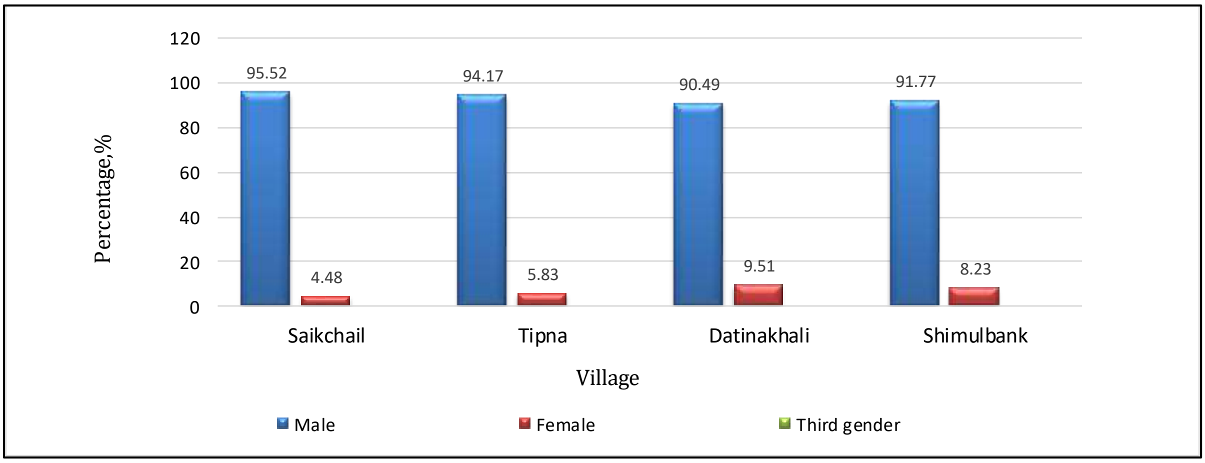


Figure 2.33: Gender Distribution of HH Head of Arsenic Contaminated Area

Table 2.17: Main Occupation of the HH Head

Village	Government Job (%)	Private Job (%)	Business (%)	Agricultural (%)	Day Labourer (%)	Homemaker (%)	Transport Driving (%)	Expatriates (%)	Fisherman (%)	Made Servant (%)	Self-employed (%)	Village Doctor (%)	Others (%)
Saikchail	1.8	5.6	15.3	13.4	20.2	3.4	5.7	21.3	0.2	-	1.7	0.2	6.0
Tipna	1.7	5.6	16.6	31.0	20.6	1.3	14.6	-	0.1	0.9	-	-	5.7
Datinakhali	0.7	3.9	13.6	10.2	48.9	0.7	6.3	-	-	-	-	-	14.1
Shimulbank	0.7	5.2	7.4	21.0	32.9	3.7	0.7	12.6	2.6	2.4	3.5	0.4	0.4

Source: CEGIS Field Survey, 2022

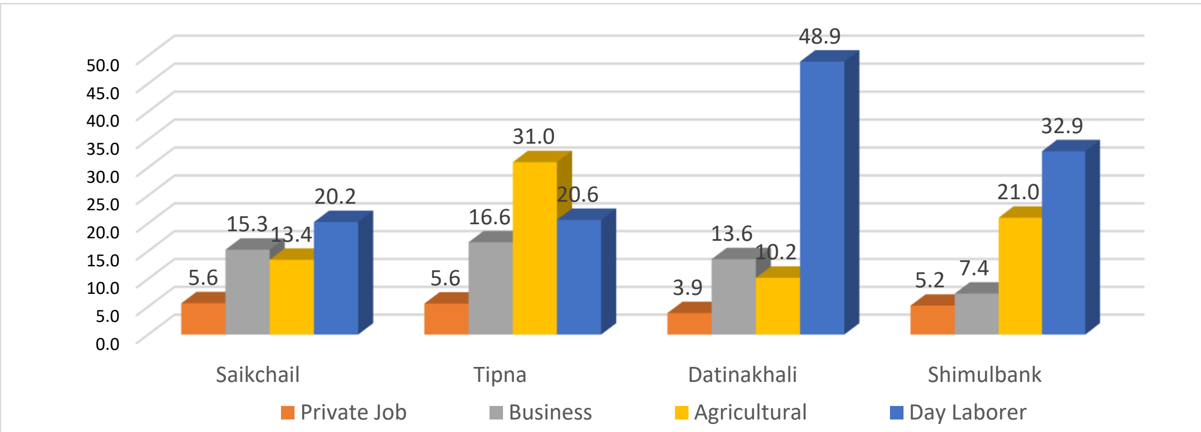


Figure 2.34: Main Occupation of the people arsenic contaminated villages

In secondary occupations, people, especially from lower income group involve in agricultural activities, day labourers, small business and transport driving for minimum 4 to maximum 6 months in a year. The following Table 2.19 represents the status of secondary occupations in the pilot villages.

Table 2.18: Secondary Occupation of the HH Head

Village	Government job	Non-government job	Business	Agricultural	Laborer	Housewife	Transport Driver	Fisherman	Self-employed	Village Doctor
Saikchail	0.9	1.9	9.3	54.9	22.8	-	3.7	-	-	0.9
Tipna	-	0.6	13.9	48.2	27.8	-	7.4	-	-	1.1
Datinakhali	-	1.0	9.0	21.0	36.0	7.0	15.0	-	-	-
Shimulbank	-	2.5	5.1	53.2	38.0	-	1.3	-	-	-

Source: CEGIS Field Survey, 2022

Income and Expenditure

The average monthly income of the HHs in the arsenic-contaminated pilot villages is more than BDT 10,000. After analyzing the monthly income-expenditure data, it is observed that the majority of the HHs are in a breakeven situation, as the difference between the amount of income and expenditure is minimal (on average BDT 4348, ranging from BDT 2668 to BDT 5691). The households in 4 villages can save around BDT 2,500 to BDT 5,500; the HHs in Datinakhali village can save only BDT 2668 from their income. It was mentioned earlier that the HHs' main sources of income are agriculture and daily labor; their monthly income is low, and they are forced to engage in secondary occupations to manage their livelihoods. But for those who are involved in government and private jobs and businesses, their income is higher than that of other occupational groups. The following **Table 2.20** represents the average monthly income and expenditure in the pilot villages.

Table 2.19: Average Monthly Income and Expenditure in the Pilot Villages

Village	Average Monthly Income (Tk.)	Average Monthly Expenditure(Tk.)
Saikchail	21,354	15,663
Tipna	17,398	12,712
Datinakhali	11,035	8,367
Shimulbank	18,020	13,674

Source: CEGIS Field Survey, 2022

3. Water Resources Assessment in the Villages

3.1 Water Availability Analysis

Water Availability

Water availability analysis is capable of portraying the behaviour of surface run-off, evapotranspiration percolation, or base flow in response to rainfall events for a certain catchment. Through a hydrologic model (SWAT) water availability assessment is conducted and detailed time series data for the selected 4 villages are assessed for the feasibility study.

To portray the water availability analysis, water balance assessment is performed. This computation includes all water receiving components (rainfall, snow fall etc.) within the system as well as water losses (evaporation, percolation, runoff etc.) from the system. The main principle of water balance is that the difference between total incoming water and total losses should equal to the storage change in the system. For water balance analysis of the study area, the calibrated SWAT models have been simulated for the time period of 1981 to 2022 and the hydrological components have been analysed to compute the average annual and monthly water balance. The following section discusses the average annual water balance of the selected 4 villages for the feasibility study.

Methodology

There were three steps to achieving the objectives: scenario development, hydrological model (SWAT) set up with data input from climate data and hydrological data, and water availability assessment based on which different response measures are identified. The detailed methodology of each step is briefly described in the following section.

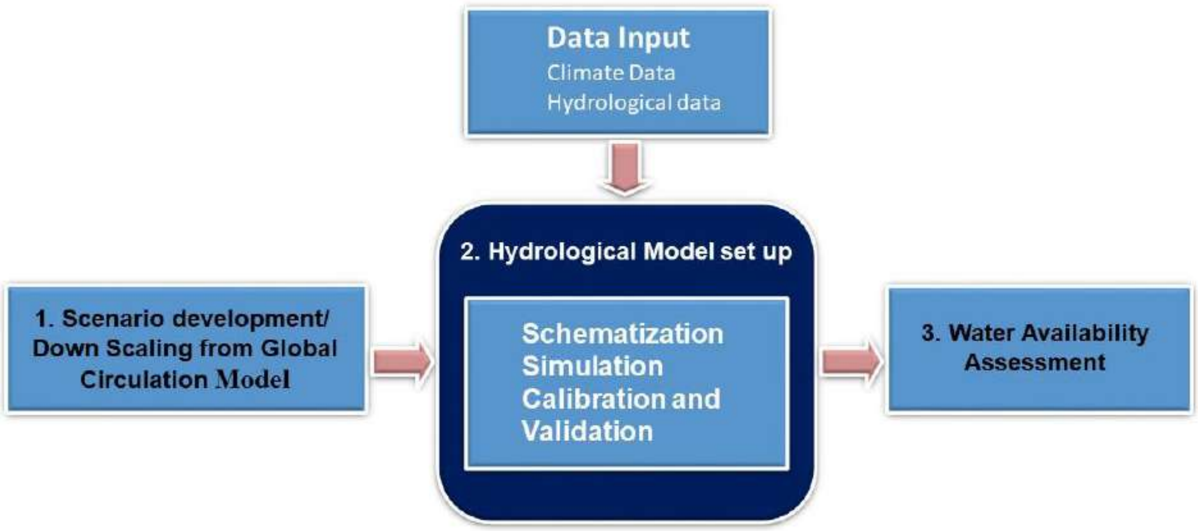


Figure 3.1: Overall study approach

Step 1: Scenario Development

In this study, an investigation was conducted to assess the future probable change in the inputs (weather data) of the water balance model which may impact on the spatial and temporal distribution of water availability in the study area. There are different types of downscaling and here, dynamic downscaling was used applying PRECIS (Providing Regional Climate for Impact Studies).

Step 2: Hydrological model setup

An extensive review of available hydrological modeling tools was performed to select a water balance modelling software. SWAT is a widely used catchment-scale model. It is a physically based semi-distributed model. It can predict the impact of land management practices (human activities) & climate change over time on water, sediment & agriculture. This model is open source and very easy to use in global respect, as assistance is relatively easily available. SWAT model is very much flexible, can assess surface water availability, easy to modify, and takes less time for simulation compared to other models. SWAT can quantify point & non-point pollution, drought types, magnitude, risk, and water resources. It can be easily coupled with other models like MODFLOW to assess groundwater availability. Therefore, the SWAT model was chosen to be used for the present study *(Arnold, 2005)*. In this model, the hydrological complexity mainly depends on topography to assess flow direction, drainage network to carry water, soil properties, and land use to estimate loss and storage, and the source of water as rainfall or outflow as the variability of the hydrological system.

The following set of consecutive activities were required and followed to set up an operational water balance model for the study area.

Schematization

Schematization of the model included defining boundary conditions, watersheds, and input variables in both time and space.

Watershed delineation is performed with the automatic delineation tool of SWAT 2012 using the DEM and river network. The Bangladesh Transverse Mercator (BTM) projection has been used for the DEM and all other GIS layers. All the watershed delineation steps such as filling sink, defining flow direction and accumulation have been done automatically through the SWAT user interface. Additional outlets have been manually incorporated. The overlay of land use, soil layer and slope class define the Hydrological Response Units (HRU)s. The discretization of the basin into HRUs allows a detailed simulation of the hydrological processes. HRU is the smallest unit for hydrological simulation with a unique combination of soil, land use and slope.

Simulation

Methods to be used by the different calculation units of the model, such as rainfall distribution (skewed normal/mixed exponential/..), channel water routing (Muskingum/variable storage/..), surface runoff (SCS Curve number/green Ampt. Infiltration) and potential evapotranspiration (Hargreaves/Penman-Monteith/..) were defined based on hydrological characteristics and data availability. The skewed distribution has been used to generate representative stream flow whereas the exponential distribution is an alternative to the skewed distribution. In this simulation, the skewed normal probability distribution function has been used to describe the distribution of rainfall amounts. SWAT uses Manning's equation to define the rate and velocity of flow. Water is routed through the channel network using the variable storage routing method or the Muskingum River routing method. In this simulation, the Muskingum method has been used. For estimating runoff, the SCS curve number (CN) method has been used and the variable CN: Moisture condition II curve number has been specified. For calculating Potential Evapotranspiration (PET), the Hargreaves method has been used since it requires less data (air temperature only). The details of these methods are described in the SWAT theory manual *(SWAT, 2009a).*

Calibration and Validation

In this step the calibration and validation periods were defined based on available observed data such as discharge data. Before calibration, sensitivity analysis was performed to rank the simulation parameters of the model for each sub basin. The calibration and validation results were then evaluated against four performance measures – Nash-Sutcliffe efficiency, mean relative bias, ratio of the root mean square error to the standard deviation of measured data and coefficient of determination.

Step 3: Water Availability Assessment

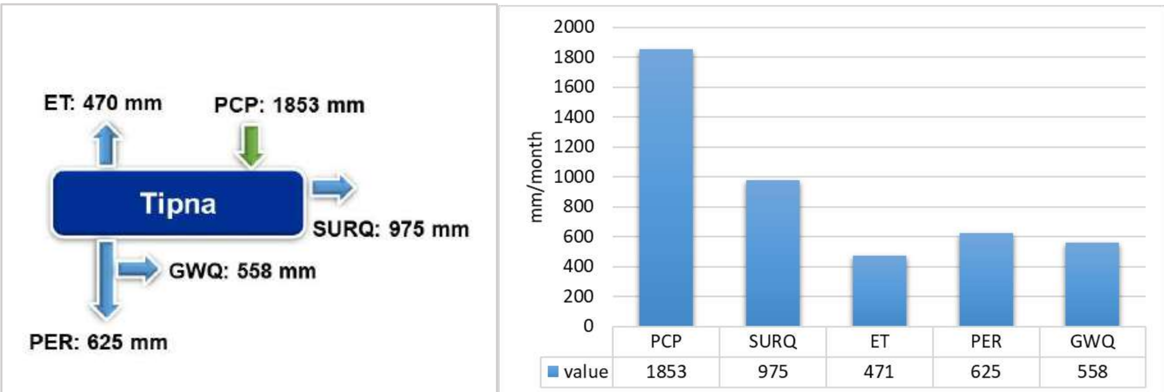
In this step, a SWAT model was set up for baseline condition to simulate temporal and spatial distribution of water in the study area.

Water Balance for the Village Tipna

The simulation results of the annual water for Tipna village which is located in south-central areas of Bangladesh are shown in Figure 3.2 for the simulation period of 1981 to 2022. Average annual rainfall of the village is 1853 while annual national average is about 2100. The monsoon starts from the month of May and reaches its peak about 338 mm in June. There is a decreasing trend of rainfall during the month of August, a slight increase in September, and then rapid decrease again. Monthly variation of water availability is illustrated in Figure: 3.3.

Input to the water balance is rainfall while losses occur through evapotranspiration and percolation and as water contributing to stream flow through surface runoff. The yearly actual evapotranspiration loss is 470 mm which 26% of annual rainfall; whereas yearly percolation is 625 mm.

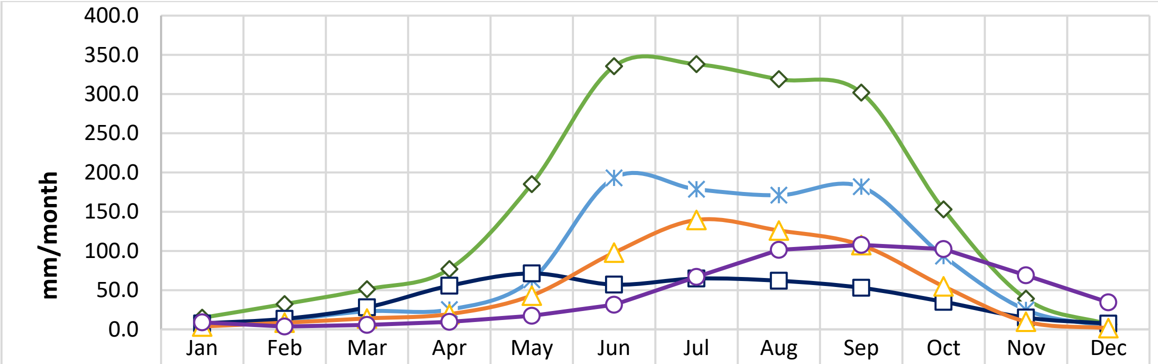
After the losses of water through evapotranspiration and percolation, the remaining water contributes to stream flow as overland flow and lateral (subsurface) flow. The annual average surface runoff for Tipna is 975 mm; whereas lateral flow is 558 mm.



PCP: Precipitation ET: Evapotranspiration PER: Percolation SURQ: Surface Runoff

GWQ: Groundwater contribution to stream flow

Figure 3.2: Average annual water balance



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PCP	14.8	32.3	51.1	76.8	185.3	335.5	338.1	318.9	301.9	152.9	39.1	6.3
SURQ	5.0	12.0	23.1	25.2	63.2	193.2	178.8	171.1	182.0	93.3	24.8	3.7
ET	7.6	13.4	28.1	55.6	71.4	57.1	64.8	62.0	53.0	35.2	15.0	7.3
PER	3.6	8.5	13.9	19.4	43.1	97.8	139.5	126.0	107.4	54.8	9.8	1.5
GWQ	8.9	3.6	5.6	9.5	17.4	31.3	66.9	101.4	107.8	102.4	69.0	34.4

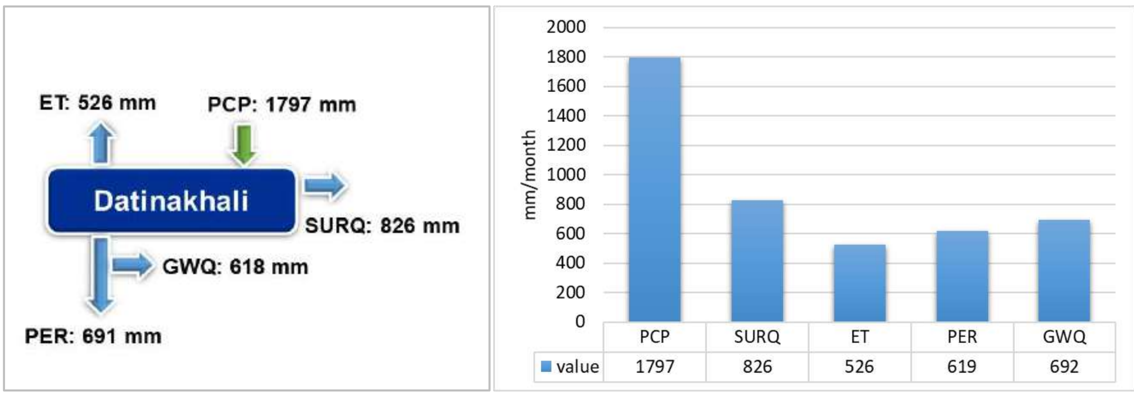
Figure 3.3: Average annual water balance

Water Balance for the Village Datinakhali

The simulation results of the annual water for Datinakhali village which is located in the south-central areas of Bangladesh are shown in Figure 3.4 for the simulation period of 1981 to 2022. Average annual rainfall of the village is 1797 while annual national average is about 2100. The monsoon starts in May and reaches its peak at about 352.6 mm in July. Monthly variation of water availability is illustrated in Figure 3.5.

Input to the water balance is rainfall while losses occur through evapotranspiration and percolation and as water contributes to stream flow through surface runoff. The yearly actual evapotranspiration loss is 526 mm which is 29% of annual rainfall; whereas yearly percolation is 691 mm.

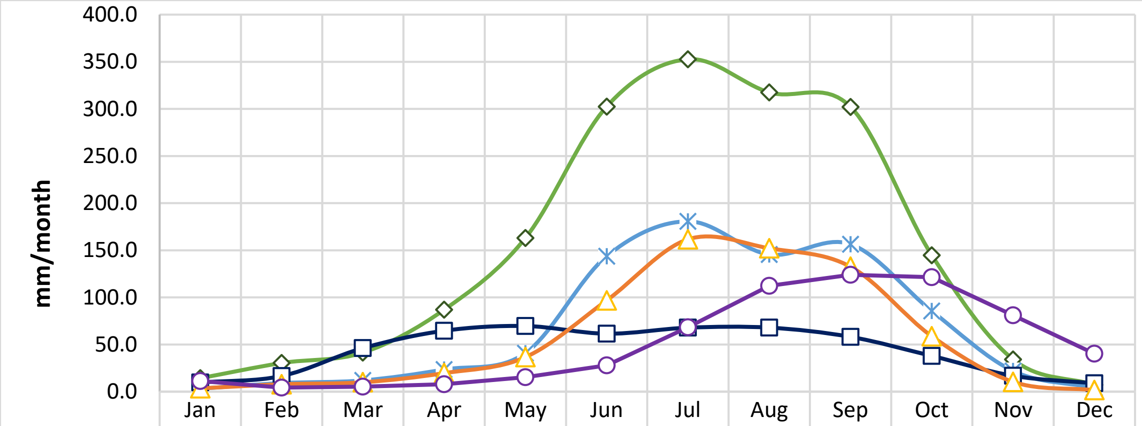
After the losses of water through evapotranspiration and percolation, the remaining water contributes to stream flow as overland flow and lateral (subsurface) flow. The annual average surface runoff for Datinakhali is 826 mm; whereas base flow is 618 mm. Base flow exceeds precipitation in October. The water from shallow aquifer also contributes to stream flow as base flow.



PCP: Precipitation ET: Evapotranspiration PER: Percolation SURQ: Surface Runoff

GWQ: Groundwater contribution to stream flow

Figure 3.4: Average annual water balance



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PCP	14.3	30.4	41.4	86.9	163.0	302.4	352.6	317.4	302.1	144.8	34.2	7.2
SURQ	3.1	9.0	11.9	23.4	40.9	143.7	180.7	145.5	156.4	85.5	21.9	4.1
ET	9.7	16.5	46.2	64.6	69.6	61.5	67.9	67.9	58.1	37.9	16.8	8.9
PER	3.5	7.9	10.0	19.7	36.6	96.8	161.6	152.1	132.6	58.8	10.4	1.7
GWQ	11.2	4.3	5.3	7.8	15.3	27.8	68.3	112.2	124.0	121.5	80.9	40.2

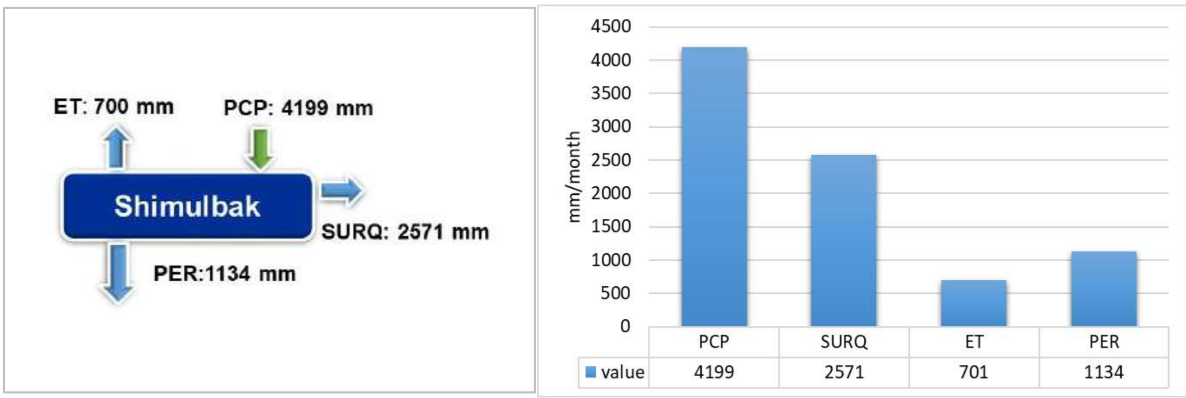
Figure 3.5: Average Monthly water balance

Water Balance for the Village Shimulbank

The simulation results of the annual water for Shimulbank village which is located in the northeast areas of Bangladesh are shown in Figure 3.6 for the simulation period of 1981 to 2022. Average annual rainfall of the village is 4199 while the annual national average is about 2100. The monsoon starts in May and reaches its peak at about 822.7 mm in July. Monthly variation of water availability is illustrated in Figure 3.7.

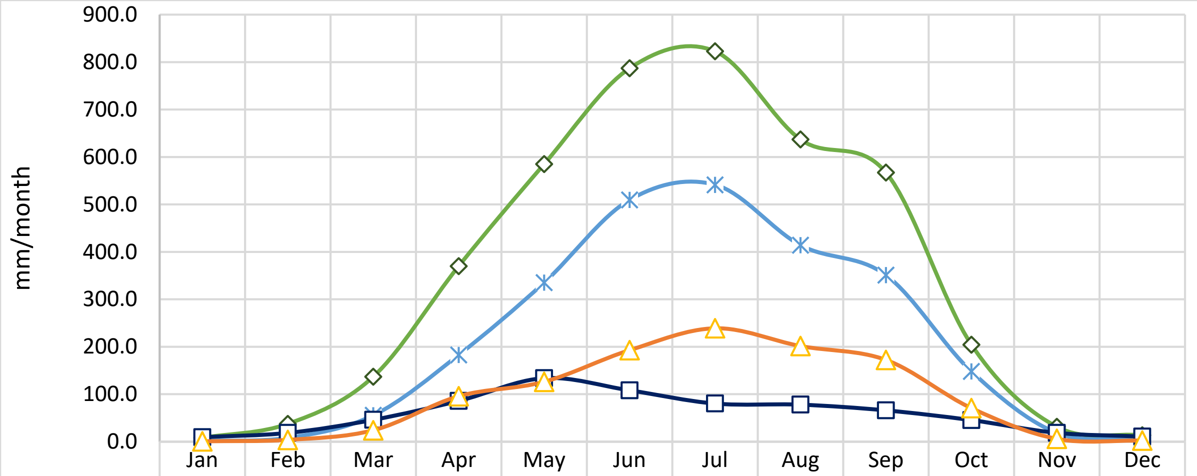
Input to the water balance is rainfall while losses occur through evapotranspiration and percolation and as water contributes to stream flow through surface runoff. The yearly actual evapotranspiration loss is 700 mm which is 18% of annual rainfall; whereas yearly percolation is 1134 mm.

After the losses of water through evapotranspiration and percolation, the remaining water contributes to stream flow as overland flow and lateral (subsurface) flow. The annual average surface runoff for Shimulbank is 2551 mm. The water from shallow aquifer also contributes to stream flow as base flow



PCP: Precipitation ET: Evapotranspiration PER: Percolation SURQ: Surface Runoff
GWQ: Groundwater contribution to stream flow

Figure 3.6: Average annual water balance



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PCP	8.0	37.4	136.7	369.9	584.9	786.9	822.7	636.8	567.2	204.3	31.3	13.2
SURQ	1.5	8.1	55.4	182.8	335.1	509.4	541.3	413.9	350.9	147.9	18.5	6.5
ET	9.4	18.5	46.0	85.9	133.9	108.2	80.3	78.0	65.9	45.4	18.6	10.8
PER	0.6	3.7	23.9	95.7	126.2	192.8	239.0	201.5	172.3	70.6	5.8	2.1

Figure 3.7: Average Monthly water balance

3.1.1 Identification of Suitable Aquifer

To identify the suitable aquifer for a safe piped water supply, drilling test well data was collected from primary and secondary sources. In the cases of Shimulbank village, drilling test well data was not collected because tertiary rocks are encountered at shallow depths in those villages. Water samples was collected from the test well and tested. Table 3.1 shows the suitable aquifer for a safe piped water supply and water quality of the aquifer.

<u>District: Cumilla, Upazila: Monoharganj, Union: Bipulashar, Village: Saikchail</u>

In case of Saikchail village of Cumilla, suitable aquifer has been found at a depth of 210 m. Water quality test result from test well shows iron (Fe) concentration is 3.35-5.25 mg/I, chloride (CI-) concentration is (69-119) mg/I and arsenic (As) concentration is (0.001-0.02) mg/l. From the water quality result, it is seen that arsenic and chloride concentration are with in allowable limit of drinking water standards (ECR 1997). Iron concentration exceeds the allowable limit of drinking water standards (ECR 1997).

Table 3.1: Depth and water quality of the test wells in Saikchail Village of Monoharganj Upazila under Cumilla district

SL	Latitude	Longitude	Depth of Water Collection (m)	Water Quality Parameters		
				Fe (mg/l)	As (mg/l)	Cl^- (mg/l)
1.	23.08865	91.090376	210.36	3.35	0.001	94
2.	23.093696	91.089328	207.70	5.25	0.02	69
3.	23.09632	91.089301	207.62	4.50	0.002	119
Drinking Water Standards (ECR, 1997)				**0.3-1.0**	**0.05**	**150-600**

District: Khulna, Upazila: Dumuria, Union: Khurnia, Village: Tipna

In Tipna village, suitable aquifer has been found at a depth of 223 m. Water quality test result from test well shows iron (Fe) concentration is 0.55 mg/l, chloride (CI-) concentration is 30 mg/l and arsenic (As) concentration is 0.008 mg/l. From the water quality result, it is seen that iron, arsenic and chloride concentration are with in allowable limit of drinking water standards (ECR 1997).

Table 3.2: Depth and water quality of the test wells in Tipna Village of Dumuria Upazila under Khulna district

SL	Latitude	Longitude	Depth of Water Collection (m)	Water Quality Parameters		
				Fe (mg/l)	As (mg/l)	CI^- (mg/l)
1.	22.8181	89.37707	223	0.55	0.008	30
Drinking Water Standards (ECR, 1997)				**0.3-1.0**	**0.05**	**150-600**

Water Level Analysis

Data Collection

Annual groundwater data for the four villages in arsenic contaminated area have been collected from BWDB through National Water Resources Database website for the years 1984 to 2013. For some villages where data was not found the nearest station is considered. Then the trend analysis has been made and graphically represented for this time series data. The study tried to identify the increasing or decreasing pattern of the groundwater level. The result of the trend analysis is discussed below.

Groundwater Fluctuation

Datinakhali, Satkhira

For Datinakhali village, annual groundwater data for a thirty (30) year period have been studied and visually shown in the Figure 3.8. The graph depicts a slightly declining trend in the area's water level. The value was found to be 1.44 m in 1990 and 3.99 m in 2007. This area's groundwater is still only a relatively short distance below the surface.

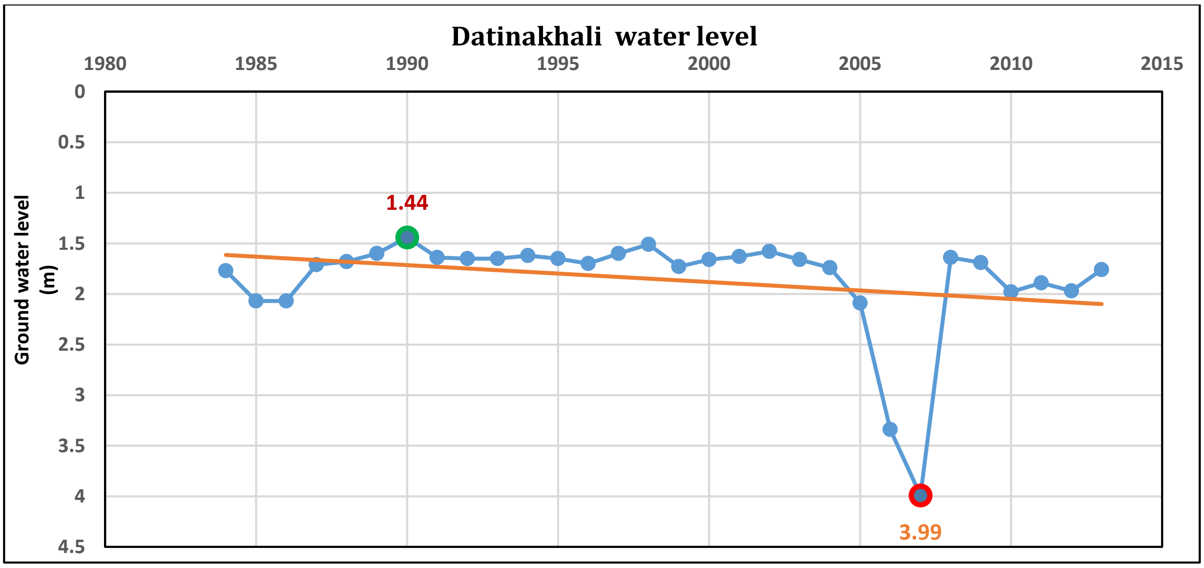


Figure 3.8: Annual groundwater trend (1984-2013) in Datinakhali village

Shimulbank, Sunamganj

Annual groundwater data for a twenty-two (22) years period for Shimulbank village have been analyzed and graphically represented in Figure 3.9. There were some missing values in this time period also the recent data of this area cannot be found. The time series data shows that the groundwater occurs at a very shallow depth in this village. The figure shows a declining curve of groundwater level for this area. However, recent data indicate an upward trend in groundwater levels. In 2002 the value was found 3.94m and in 2004 it was found 1.56 m. The rainfall intensity is high enough in this area. Also, there was a massive flood in 2002 in Bangladesh which could be a reason behind the sharp upward shift of groundwater from 2002 to 2004 in this station.

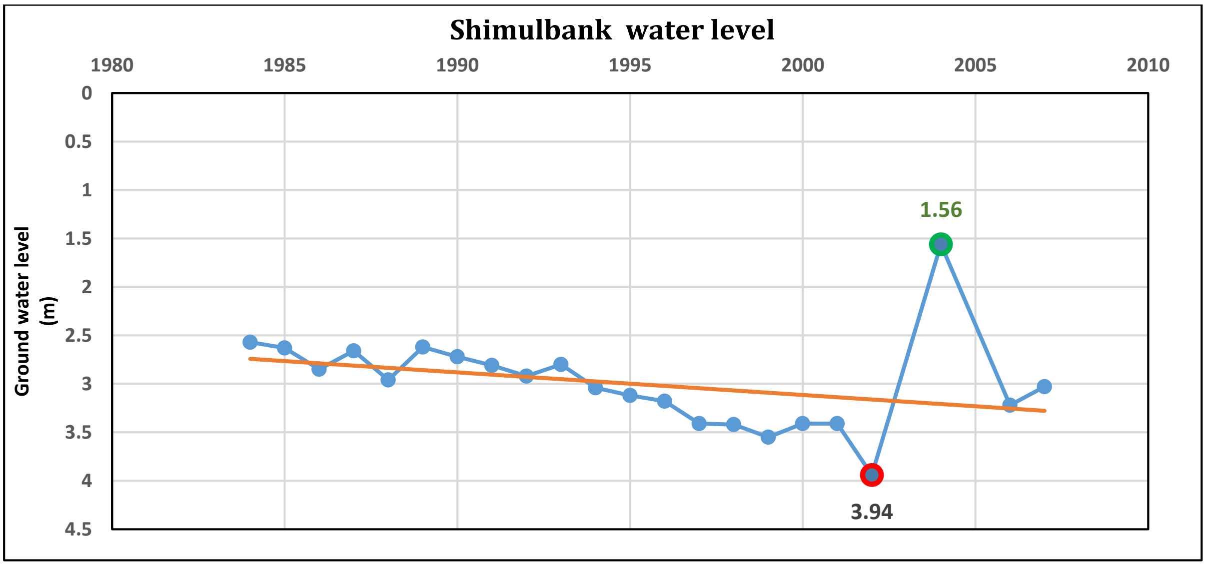


Figure 3.9: Annual groundwater trend (1984-2013) in Shimulbank village

Saikchail, Cumilla

Annual groundwater data for a thirty (30) years period for Saikchail village have been analyzed and graphically represented in Figure 3.10. The figure shows an upward trend in water level. In 1987 the value was found 2.73m and in 2000 the value was found 1.35m.

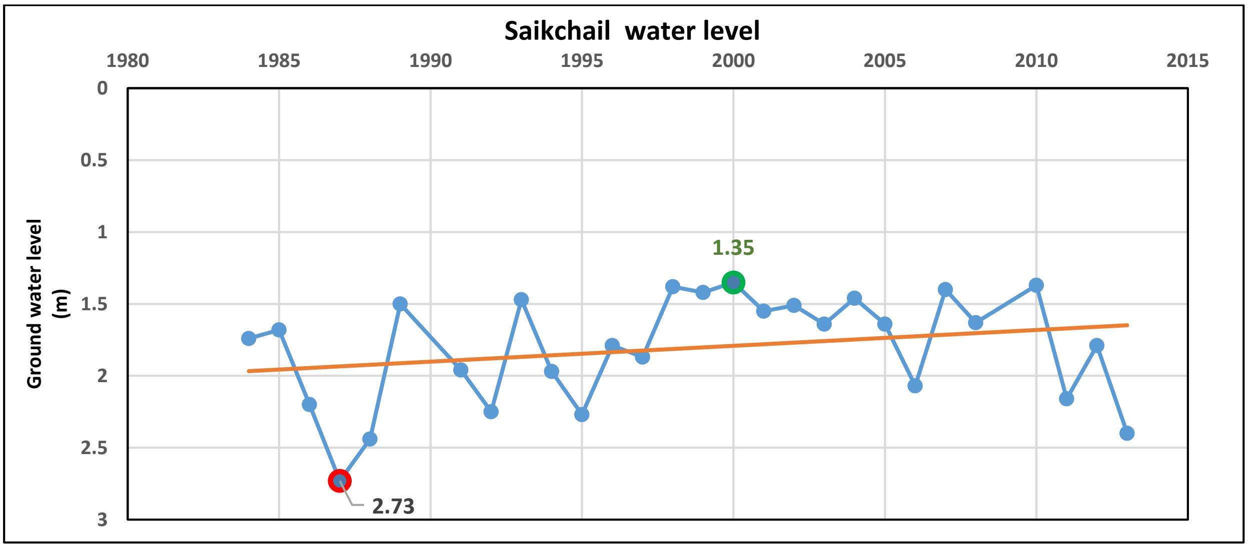


Figure 3.10: Annual groundwater trend (1984-2013) in Saikchail village

Tipna, Khluna

Annual groundwater data for a thirty (30) years period for Tipna village have been analyzed and graphically represented in the Figure 3.11. The groundwater level is trending slightly downward, as shown by the graph. The time series data shows that the water level has three consecutive upward trends from 2010 to 2012 followed by a significant fall in 2013. In 2012 the groundwater level was observed at 1.12 m and in 2013 it was observed at 3.89 m. The fall may be due to the less rainfall in 2012 in the Khulna region.

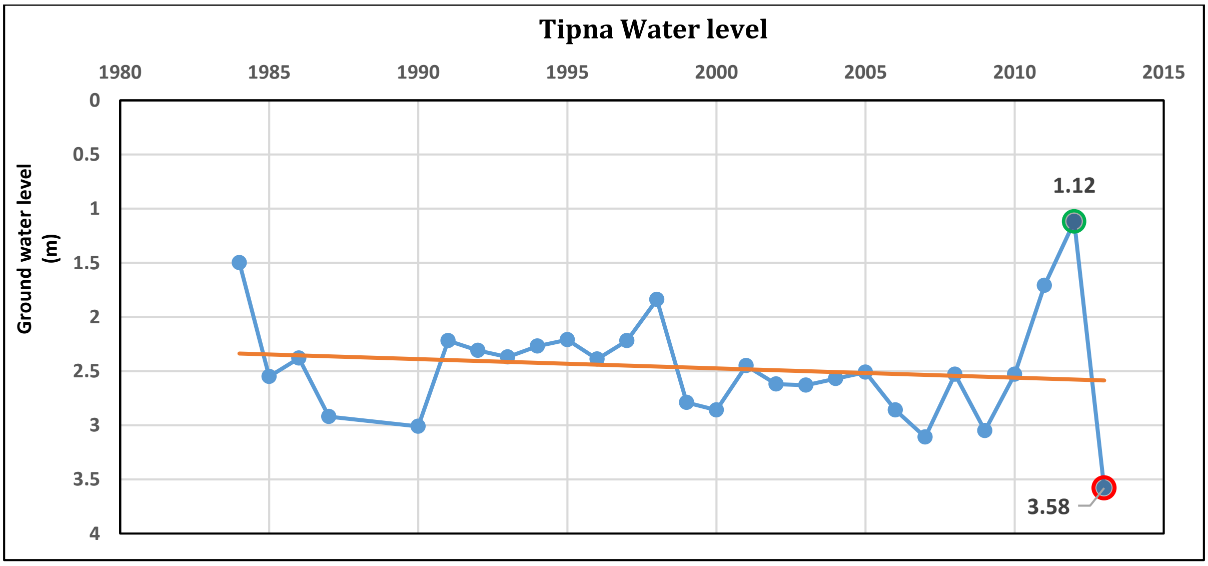


Figure 3.11: Annual groundwater trend (1984-2013) in Tipna village

3.2 Hydrogeological Assessment

Based on the physiography, geology, and suitability of the region for groundwater development, Bangladesh was hydrogeologically classified as (i) a younger alluvium, a complex geology area, an older alluvium area, and a coastal area (BGS, 1979). Hydrogeologically, the area is complex and is characterized by a series of folded Tertiary formations. The groundwater survey has led to the identification of 15 zones for groundwater developments (UNDP, 1982). Each zone has been classified and rated as to its development potential in relation to the other zones (Figure 3.12). As per analysis, villages Tipna and Datinakhali lie in Zone-N. The groundwater conditions are highly variable, and development is highly impaired by the low quality of water caused by the intrusion of brackish and saline water. The development of the main and composite aquifers is limited to isolated freshwater areas. The groundwater potential of the village of Datinakhali, which lies in the coastal zone, depends upon the development of the deep aquifer. Again, the village of Shimulbank lies in Zone-I, which covers the plains of Sylhet district, known as the Sylhet Basin. But the area may be able to sustain groundwater development; rainfall in the zone is nearly the highest in the country, and recharge potentials are probably high. The surface layer of the basin is expected to be predominantly silt and clay. Aquifers in the area may be able to sustain the deep tubewell discharges on the list of 28.3 lit/sec (1 cusec) on an intensive basis of development. Next, the village of Saikchail lies in Zone-G, which includes the southwestern section of Cumilla district and the northern part of Noakhali district. The sediments consist primarily of floodplain deposits from the Meghna River. The main aquifer is located at depths ranging from 16 to 100 meters below ground surface, with the zone's average depth being 60 meters. This zone should only be considered for deep tubewell development with discharges of up to 56.6 liters per second (2 cusecs). Special attention should be given to the development of areas adjacent to the coastal zone and the lower Meghna River owing to the possibility of increased saline water intrusion.

The basis of the classification involved:

- Approximate land area for development.
- Physical characteristics of aquifer
- Hydraulic characteristics such as transmissivity, maximum depths to the water level,
- Water quality includes Iron content, Chloride content and total hardness.
- Estimated recharge potential of an area
- Finally, the development potential like recommended deep tubewell discharge, well spacing, projected deep tubewell pumping level

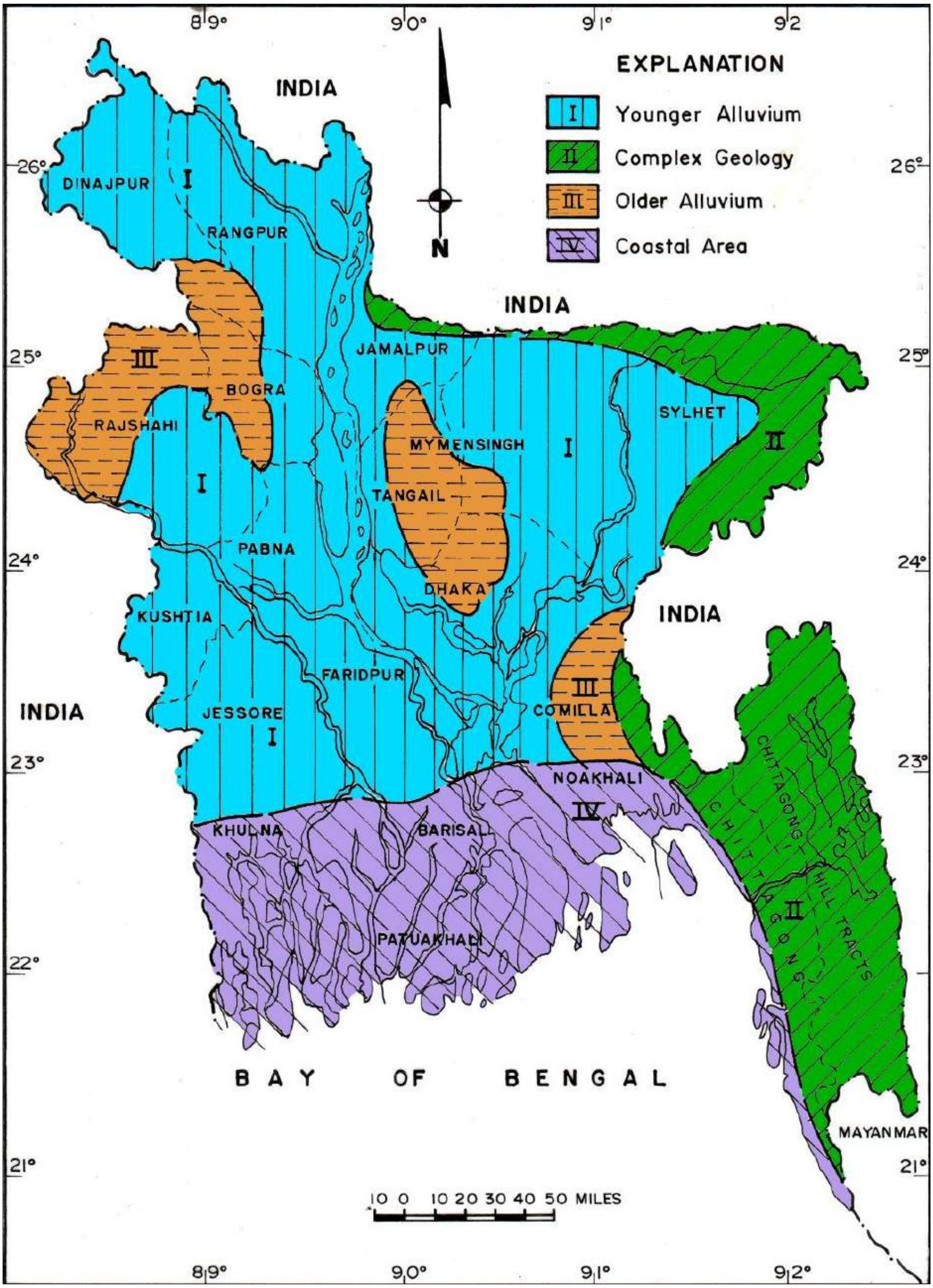


Figure 3.12: Hydrogeological Classification of Bangladesh (bgs 1979)

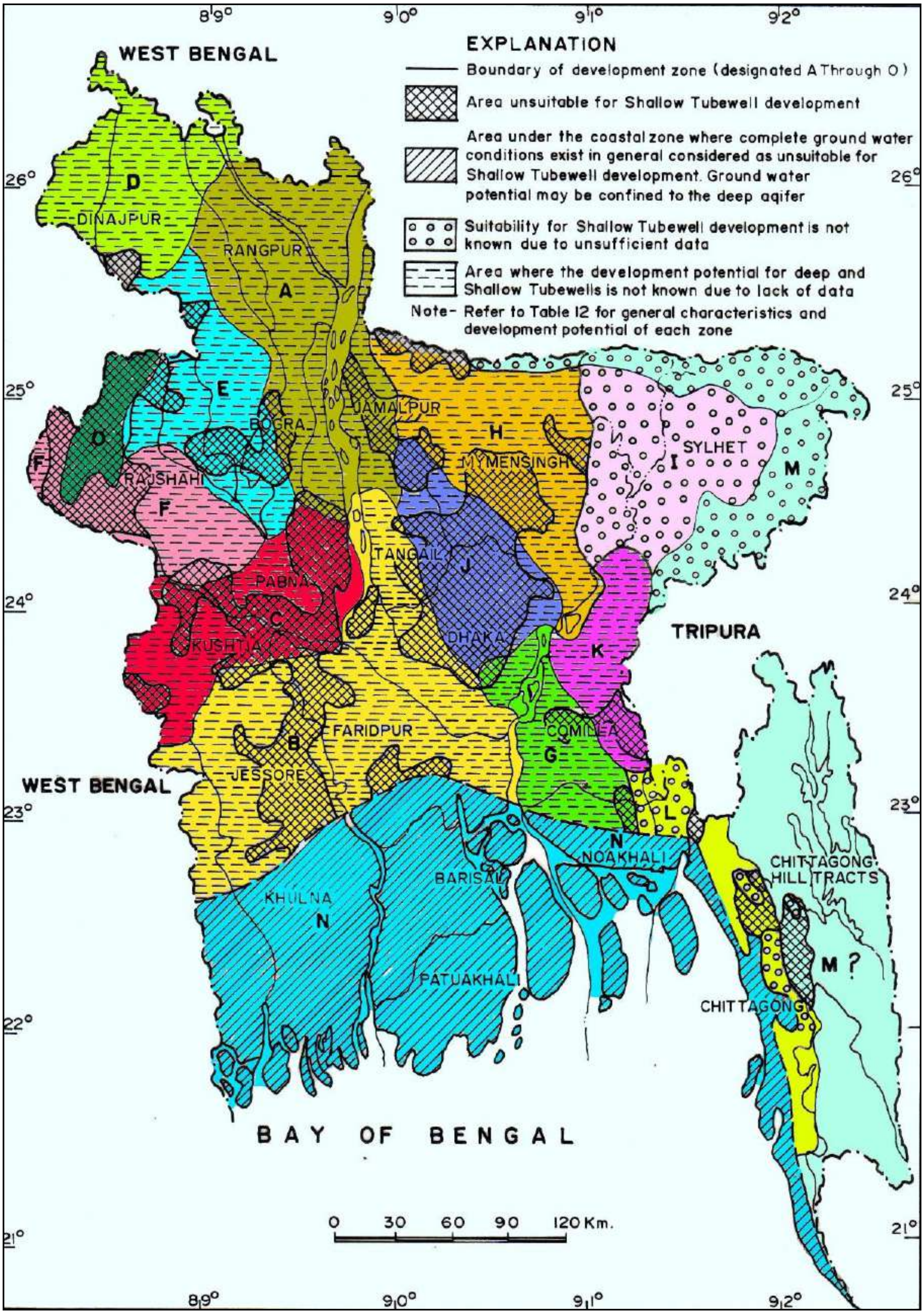


Figure 3.13: Major Groundwater Development Zone of (UNDP 1982)

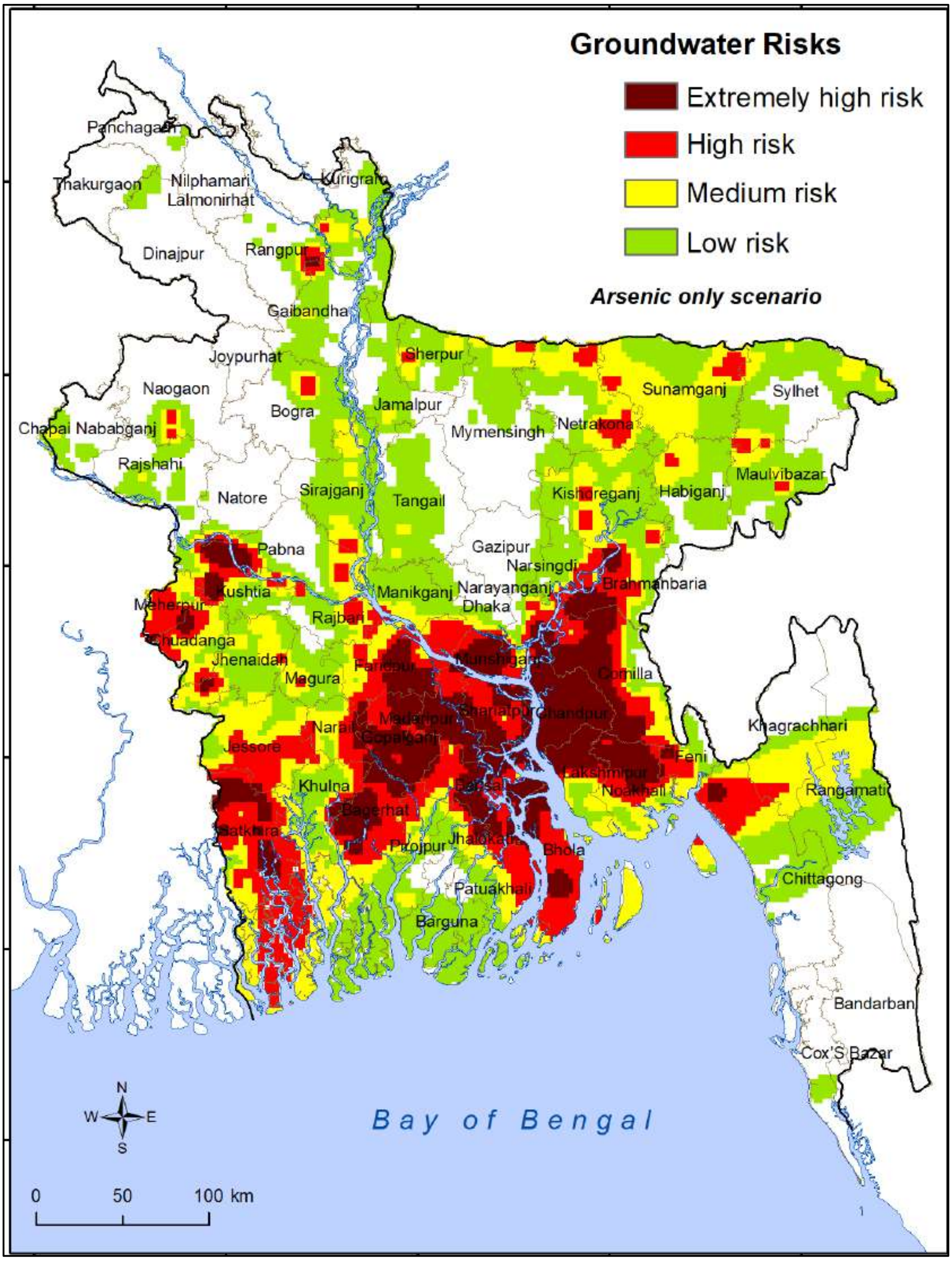


Figure 3.14: Groundwater risk maps at the national scale in Bangladesh featuring risks imposed by groundwater arsenic alone

The map shows four zones: extremely high, high, medium and low risks to shallow groundwater based on concentrations of arsenic (>200, >100, >50 and >10 μg/L, respectively) in shallow groundwater (Source: Shamsudduha et al., 2019).

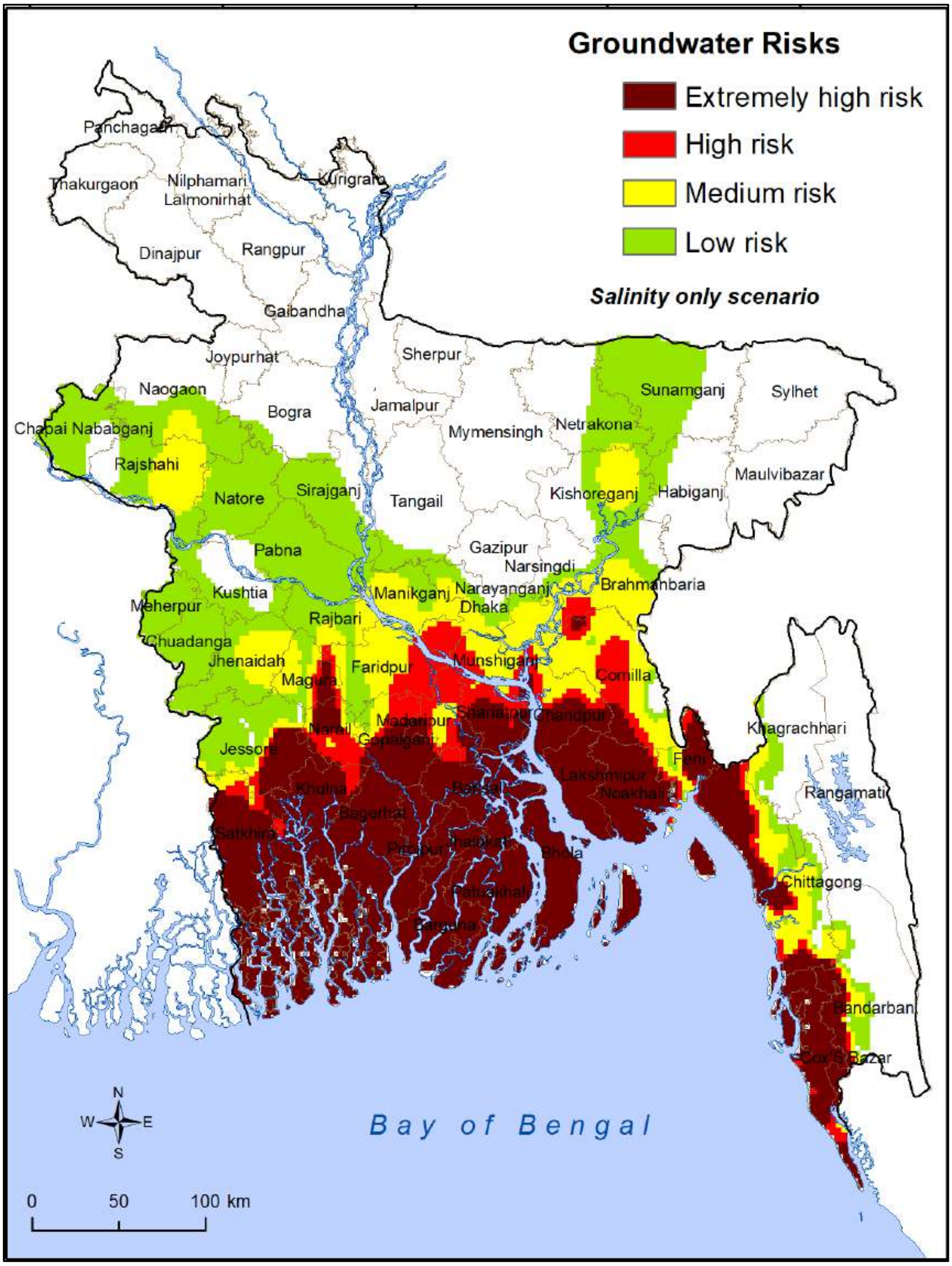


Figure 3.15: Groundwater risk maps at the national scale in Bangladesh featuring risks imposed by groundwater salinity (EC: electrical conductivity) alone

The map shows four zones: extremely high, high, medium and low risks to shallow groundwater based on values of EC (>2000, >1500, >750 and >500 µS/cm, respectively) in shallow groundwater. (Source: Shamsudduha et al., 2019).

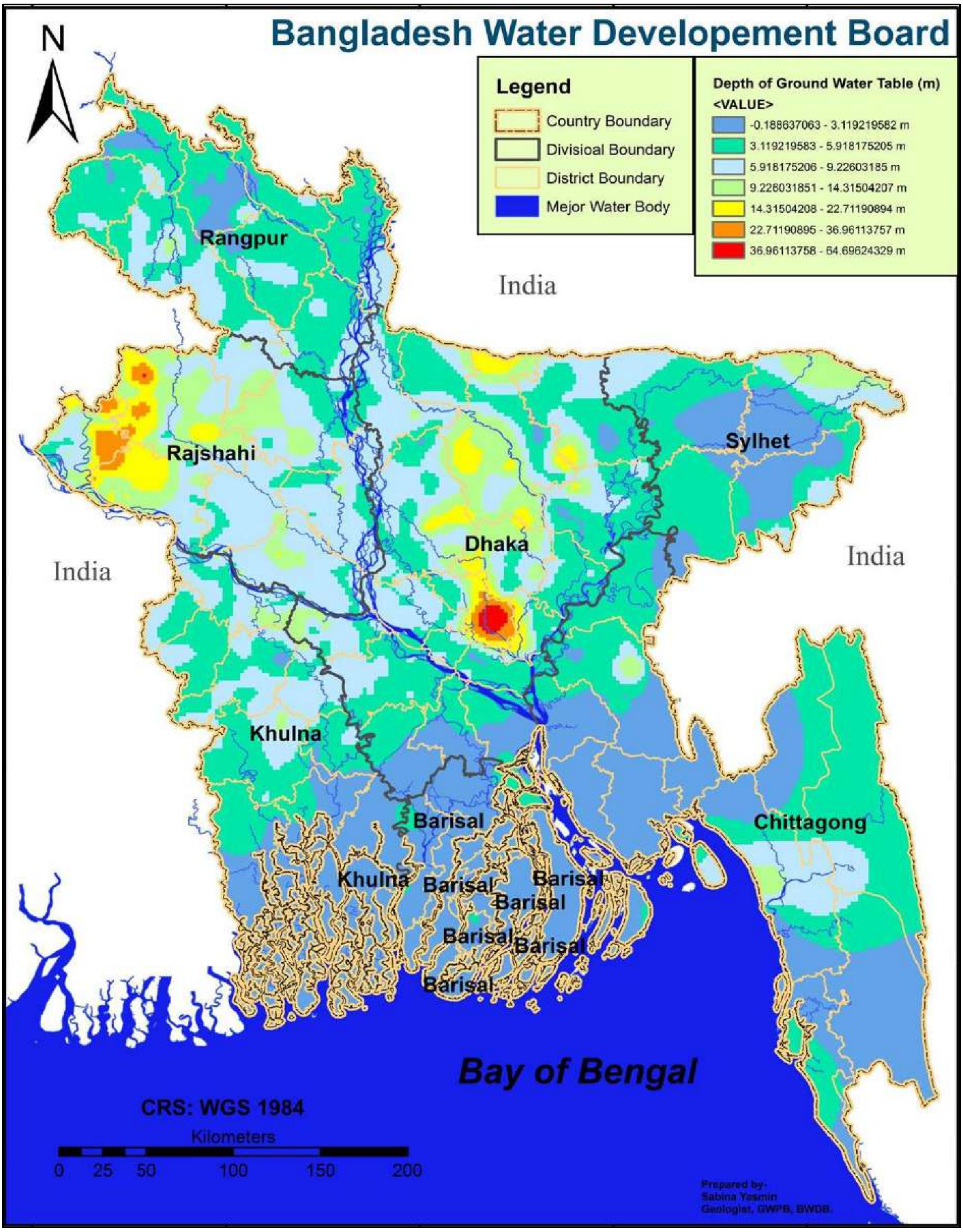


Figure 3.16: Depth to Groundwater Table in dry season 2016

Village- Datinakhali, Union- Buri-goalini, Upazila- Shyamnagar, District- Satkhira

Current prime water supply technology includes PSF, RWHS, SST/VSST and STW, No 6, (Nationwide Public water point mapping. DPHE 2014). Good quality water generally does not occur at the subsurface aquifer.

The area is in the risk of high salinity in groundwater (Figure 3.15) and also in the risk of the occurrence of high arsenic in shallow groundwater (Figure 3.14).

Groundwater conditions are highly variable and development is highly impaired by the low quality of water affected by the intrusion of brackish and saline water. The development of the main and composite aquifers is limited to isolated fresh water areas. The ground water potential of the coastal zone depends upon the development of the deep aquifer.

Groundwater supply from tubewells is not a reliable and sustainable for this area and therefore, test well drilling is not required for this area.

The suggested water supply technology for this area is i) PSF, ii) RWHS, iii) SST/ VSST and iv) STW, No 6. Treated surface water may also be supplied for potable uses.

Village- Shekchail, Union- Bipulshar, Upazila- Monoharganj, District- Cumilla

Current prime water supply technology includes DTW: Deep Tubewell, No 6/T. Dev (Nationwide Public water point mapping. DPHE 2014). Good quality water generally occurs at a depth of 150 feet below ground surface.

Hydrogeologically, the area has good aquifer system at the subsurface to supply potable water to the villages. The aquifer is composed of floodplain deposits of the Meghna-Gumti River. Groundwater conditions are suitable for deep tubewell development. The area is covered by estuarine silts with a known maximum thickness of about 60 metres. The depth to the main aquifer ranges from 20 to 80 mbgs. The area may be able to sustain development of deep tubewells with discharges of up to 56.6 lit/sec (2 cusecs).

Drilling test bore hole and construction of piezometer of maximum 200 to 300m is suggested. Deep tubewells of about 200 to 300m depth can be constructed to abstract water for the inhabitants of the villages.

The depth of groundwater level is not very high and the current trend of groundwater level is almost steady (Figure 3.16 and 3.17).

The area is in the risk of high salinity in groundwater (Figure 3.15) and in the risk of the occurrence of high arsenic in shallow groundwater (Figure 3.14). Laboratory testing of Alkalinity, Hardness, Cl, Fe, Mn and As of the collected sample from the constructed piezometer as well as few pre-existing wells of known depths is also suggested.

WHO 4th edition (2011) Guideline Value for drinking water quality did not include Fe and Mn as health-related parameter. Manganese and iron are both internationally known causes of aesthetic issues in drinking water.

Village- Tipna, Union- Khurnia, Upazila- Dumuria, District- Khulna

Current prime water supply technology includes STW: Shallow Tubewell, No 6/T. Dev and DTW: Deep Tubewell, No 6/T. Dev (Nationwide Public water point mapping. DPHE 2014). Good quality water generally occurs at a depth of 700 feet below ground surface.

The area is in the risk of high salinity in groundwater (Figure 3.15) and also in the risk of the occurrence of high arsenic in shallow groundwater (Figure 3.14).

Groundwater conditions are highly variable and development is highly impaired by the low quality of water affected by the intrusion of brackish and saline water. The development of the main and composite aquifers is limited to isolated fresh water areas. The ground water potential of the coastal zone depends upon the development of the deep aquifer.

Drilling test bore hole and construction of piezometer of maximum 250 to 300m is suggested. Deep tubewells of about 250 to 300m depth can be constructed to abstract water for the inhabitants of the villages.

The depth of groundwater level is not very high and the current trend of groundwater level is almost steady (Figure 3.16 and 3.17).

Laboratory testing of Alkalinity, Hardness, Cl, Fe, Mn and As of the collected sample from the constructed piezometer as well as few pre-existing wells of known depths is also suggested.

WHO 4th edition (2011) Guideline Value for drinking water quality did not include Fe and Mn as health-related parameter. Manganese and iron are both internationally known causes of aesthetic issues in drinking water.

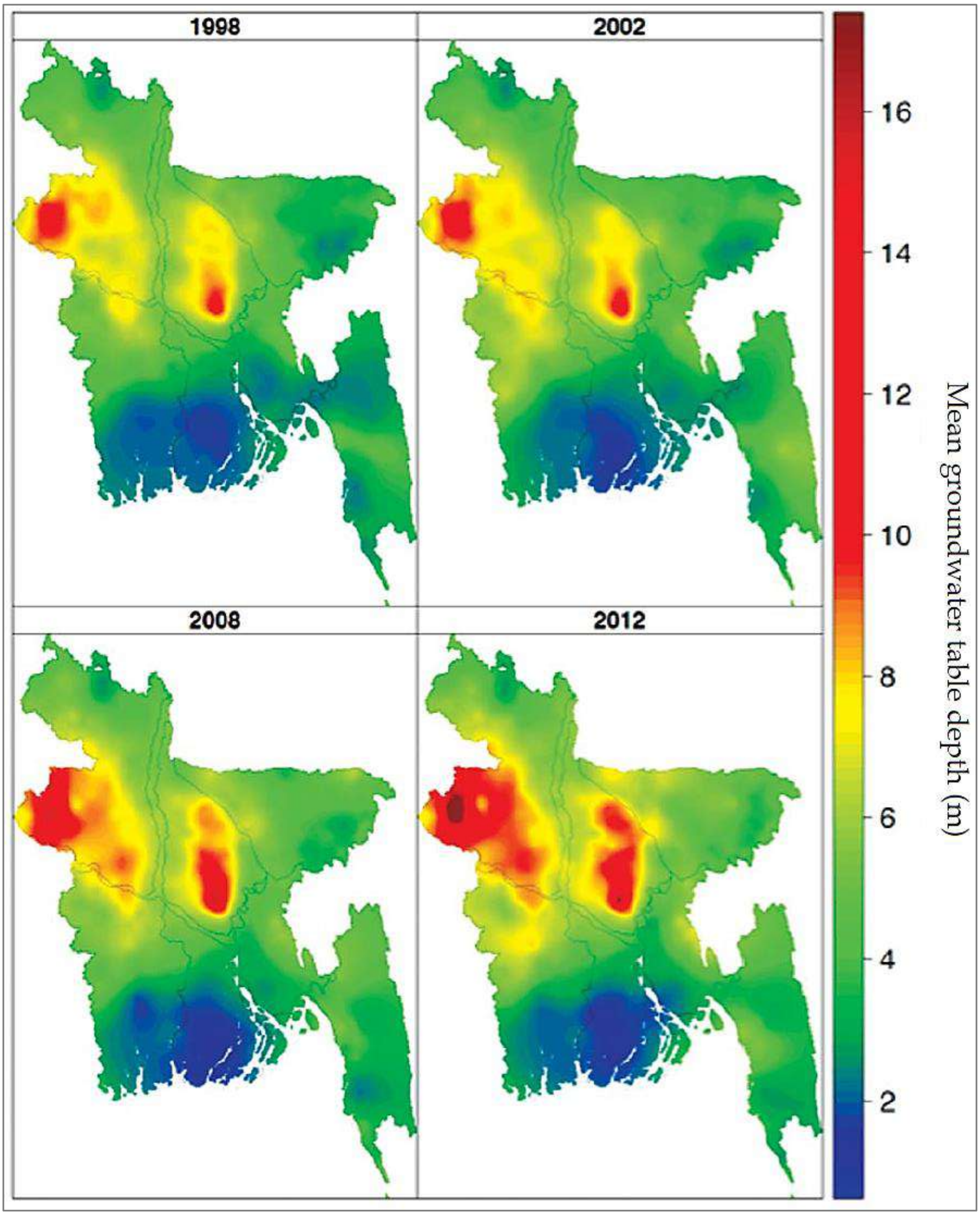


Figure 3.17: Mean ground water table depth (m) for the height of the dry season (March, April and May)

Surface maps were created using multi–Gaussian Kriging from the time series data of observed groundwater levels from the Bangladesh Water Development Board (BWDB). (Source: Qureshi et al. 2014).

<u>Village- Shimulbank, Union- Shimulbank, Upazila- Dakkhin Sunamganj, District- Sunamganj</u>

Current prime water supply technology includes DTW: Deep Tubewell, No 6/ T. Dev, (Nationwide Public water point mapping. DPHE 2014). Good quality water generally occurs at a depth of 650 feet below ground surface.

Hydrogeologically, the area is complex and is characterized by a series of folded Tertiary formations. The area is considered unfavorable for extensive ground water development. The aquifers have low transmissivities and intensive development would therefore incur large drawdown. However, wells can be developed successfully on an individual basis. This is substantiated by the existence of successful irrigation wells in tea plantation within the area.

Owing to the complex hydrogeology of the area, detailed investigations, including test drilling, will be required to evaluate each potential development site.

Drilling test bore hole and construction of piezometer of maximum 300m is suggested. Deep tubewells of about 300m depth can be constructed to abstract water for the inhabitants of the villages.

The depth of groundwater level is not very high and the current trend of groundwater level is almost steady (Figure 3.16 and 3.17).

The area is almost free from the risk of high salinity in groundwater (Figure 3.15) but there is moderate risk of the occurrence of arsenic in shallow groundwater (Figure 3.14). Laboratory testing of Alkalinity, Hardness, Cl, Fe, Mn and As of the collected sample from the constructed piezometer as well as few pre-existing wells of known depths is also suggested.

WHO 4th edition (2011) Guideline Value for drinking water quality did not include Fe and Mn as health-related parameter. Manganese and iron are both internationally known causes of aesthetic issues in drinking water.

3.3 Climate Change Risk Assessment

Assessment of future climate change is of great importance for a sustainable planning of water resources of Bangladesh. Global climate change is impacting the temperature, rainfall and overall hydrologic cycle of Bangladesh as well as in the Ganges basin. Therefore, the assessment of future climate change in the water resources availability and water demand is essential for long term future planning.

The assessment of future climate change is done by IPCC through the Coupled Model Inter-comparison Project (CMIP). A set of Global Circulation Models (GCM) simulate plausible future climate conditions based of different scenarios. Recently, IPCC released its 6th Assessment Report that utilizes CMIP6 GCMs. In this report, IPCC has introduced the Shared Socioeconomic Pathways (SSPs) scenarios.

Shared Socioeconomic Pathways (SSPs) are scenarios of projected socioeconomic global changes up to 2100. The SSPs are based on five narratives describing broad socioeconomic trends that could shape future society. These are intended to span the range of plausible futures.

They include: a world of sustainability-focused growth and equality (SSP1); a “middle of the road” world where trends broadly follow their historical patterns (SSP2); a fragmented world of “resurgent nationalism” (SSP3); a world of ever-increasing inequality (SSP4); and a world of rapid and unconstrained growth in economic output and energy use (SSP5).

These narratives describe alternative pathways for future society. They present baselines of how things would look in the absence of climate policy, and allow researchers to examine barriers and opportunities for climate mitigation and adaptation in each possible future world when combined with mitigation targets.

SSP1 and SSP5 envision relatively optimistic trends for human development, with “substantial investments in education and health, rapid economic growth, and well-functioning institutions”. They differ in that SSP5 assumes this will be driven by an energy-intensive, fossil fuel-based economy, while in SSP1 there is an increasing shift toward sustainable practices.

For the present study, SSP1, SSP3 and SSP5 based outputs has been used for future climate change assessment as these scenarios represent average and two extreme ends of the future climate.

The assessment of local climate change impact demands downscaling of General Circulation Model (GCM) data which are very coarse in resolution (approximately 100-300 km) to capture local phenomena. Two types of downscaling techniques are available i.e. dynamic downscaling and statistical downscaling, having pros and cons in both techniques. However, future projections through either dynamically or statistically downscaled GCM datasets have proven evidences to generate high resolution, dependable and appropriate local level climate change information.

CEGIS has extensive experiences on performing climate change analysis for future scenarios development through both dynamic and statistical downscaling. Particularly, CEGIS has proven and strong expertise to process and analyse the GCM and downscaled data and also performing statistical and dynamic downscaling for Bangladesh.

The GCM and dynamically downscaled RCM outputs contain significant system biases with respect to the actual scenario during historical simulation. IPCC (2015) identified the significance of bias correction in regional climate projections and their use in impacts and risk analysis studies with possible guidelines to correct biases. Dhaubanjar et al., (2018) appealed that bias correction is needed and a useful step prior to using RCMs in climate change impact assessment at local scale.

There are many available bias correction methods particularly for correction of rainfall and temperature data, e.g., linear scaling, distribution-based scaling, quantile mapping, ISI-MIP, cumulative distribution function etc. Choice of methods varies with the purpose of bias correction and aim of the climate modeling output analysis.

The climate change assessment following the new SSP scenario based projection has been utilized the CHELSA (Climatologies at high resolution for the earth’s land surface areas) dataset. CHELSA is a very high resolution (30 arc sec, ~1km) mechanistical statistical downscaling of GCM data following Karger et al. (2021). The dataset utilizes Inter Sectoral Impact Model Inter comparison Project (ISIMIP) suggested trend-preserving bias correction method following Lange (2019).

The downscaling exercises and future climate change anomalies assessment through bias correction has been performed on Maximum Temperature, Minimum Temperature and Rainfall (precipitation) for three different SSPs of CMIP6 dataset in different time slices up to 2100. The time slices considered was 2050s (2036-2065) under two SSP scenarios i.e. SSP126, SSP370 and SSP585. In accordance with IPCC practice, the base period for the climate change analysis will be considered from 1981 to 2022. The precipitation and temperature are assumed to change in the future under various climate change scenarios. To understand the climate change of the selected villages; change in rainfall and temperature for three climate change scenarios SSP126, SSP370, and SSP585 are summarized in the following tables:

Table 3.3: Change in Rainfall for Shimulbank Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	-1.70	-10.45	-5.21	4.19	-2.14	-3.76	3.09	2.18	3.00	9.12	-5.01	-2.33
SSP370	-2.83	-7.00	-14.67	6.13	-0.71	-0.32	2.35	6.98	5.28	0.34	-8.48	-9.92
SSP585	-2.83	-6.82	-2.51	6.09	1.40	2.98	4.90	4.57	2.49	4.68	-8.84	-4.19

Table 3.4: Change in Temperature for Shimulbank Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.62	1.94	1.66	1.36	1.40	1.52	1.22	1.20	1.44	1.60	1.54	1.70
SSP370	2.12	2.34	1.96	1.50	1.42	1.70	1.62	1.62	1.98	2.22	2.18	2.02
SSP585	2.56	2.46	2.30	1.98	1.86	1.92	1.88	2.02	2.40	2.54	2.60	2.54

Table 3.5: Change in Rainfall for Datinakhali Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	0.25	-2.90	3.07	10.33	0.20	-1.01	2.71	8.16	10.70	13.52	14.27	-4.95
SSP370	0.76	-5.87	-10.40	2.84	-9.23	-7.21	0.26	0.31	8.77	3.68	-8.02	-8.07
SSP585	-1.52	8.33	0.84	9.36	3.29	-4.12	4.09	9.51	6.96	5.18	6.76	-2.57

Table 3.6: Change in Temperature for Datinakhali Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.36	1.64	1.30	1.20	1.28	1.42	1.14	0.96	1.20	1.32	1.34	1.40
SSP370	1.84	1.94	1.62	1.26	1.28	1.60	1.42	1.46	1.68	1.88	1.82	1.52
SSP585	2.14	2.10	1.92	1.68	1.64	1.88	1.68	1.58	1.90	2.06	2.00	1.90

Table 3.7: Change in Rainfall for Saikchail Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	-2.39	-6.67	0.34	-0.81	-0.79	-4.74	4.14	9.39	11.44	14.85	2.18	-5.19
SSP370	-2.39	-4.89	-12.18	1.56	-3.80	-7.28	5.20	14.97	12.94	6.08	-8.24	-8.89
SSP585	-4.40	4.30	-2.73	-1.87	1.67	-0.85	3.68	13.72	11.05	8.50	-3.94	0.99

Table 3.8: Change in Temperature for Saikchail Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.44	1.76	1.46	1.28	1.34	1.46	1.10	1.04	1.24	1.40	1.42	1.50
SSP370	1.84	1.98	1.66	1.26	1.30	1.54	1.42	1.40	1.68	1.98	1.98	1.74
SSP585	2.28	2.12	1.92	1.66	1.70	1.82	1.70	1.70	2.00	2.22	2.40	2.24

Table 3.9: Change in Rainfall for Tipna Village by 2050s Different Climate Change Scenario

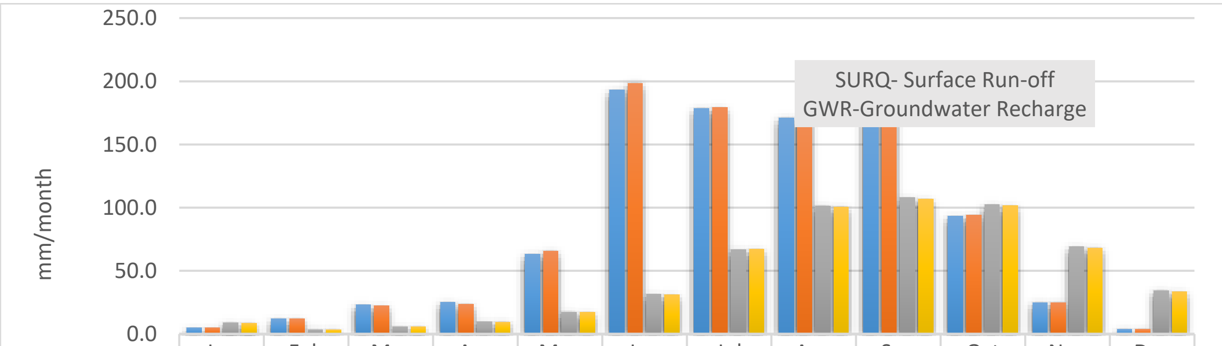
Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	-1.78	-3.54	1.88	8.28	-0.74	-1.24	2.07	6.93	10.10	13.44	11.62	-5.05
SSP370	0.68	-6.16	-11.20	2.78	-8.72	-6.60	-0.24	-0.07	9.77	4.75	-7.46	-8.00
SSP585	-2.33	7.80	1.46	7.54	1.90	-3.41	3.55	9.32	7.43	5.24	6.92	-1.05

Table 3.10: Change in Temperature for Tipna Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.42	1.70	1.32	1.18	1.28	1.38	1.16	0.96	1.20	1.32	1.34	1.42
SSP370	1.84	2.00	1.64	1.26	1.26	1.60	1.42	1.44	1.70	1.90	1.84	1.54
SSP585	2.16	2.08	1.92	1.66	1.62	1.82	1.68	1.58	1.90	2.08	2.04	1.92

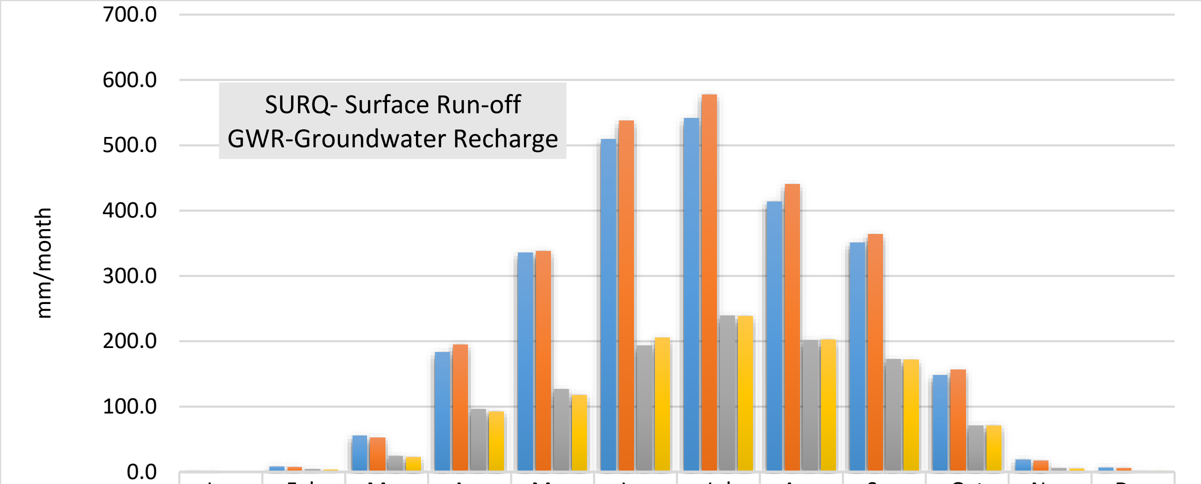
Impact by Climate Change

The section discusses the impact of climate change on the average monthly flow of surface run-off and groundwater for the four villages selected for the feasibility study to be conducted. SWAT model simulation for climate change impact was performed for the period 2036-2065 (2050s) under SSP585 and the generated average monthly GW recharge and surface runoff are compared with base condition.



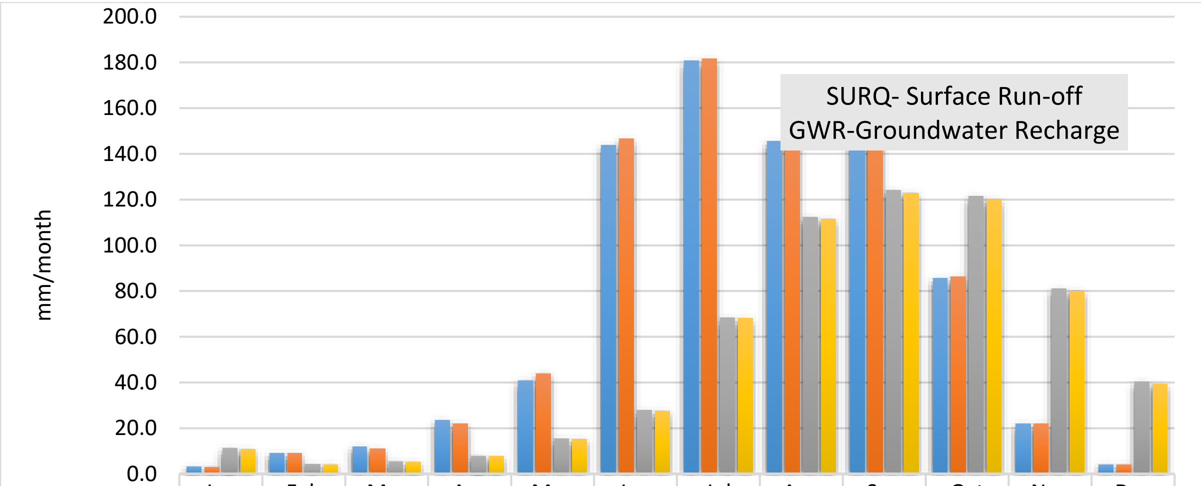
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SURQ_base	5.0	12.0	23.1	25.2	63.2	193.2	178.8	171.1	182.0	93.3	24.8	3.7
SURQ_585	5.0	11.9	22.5	23.5	65.8	198.5	179.2	171.9	183.4	94.0	24.9	3.7
GWR_base	8.9	3.6	5.6	9.5	17.4	31.3	66.9	101.4	107.8	102.4	69.0	34.4
GWR_585	8.5	3.6	5.6	9.4	17.2	31.1	67.1	100.6	106.7	101.4	68.1	33.5

Figure 3.18: Comparison of Generated Average Monthly Surface Runoff and GW Recharge for Tipna Village



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SURQ_base	1.5	8.1	55.4	182.8	335.1	509.4	541.3	413.9	350.9	147.9	18.5	6.5
SURQ_585	1.4	7.0	52.4	194.8	338.0	537.3	577.7	440.1	363.5	156.4	16.9	5.9
GWR_base	0.6	3.7	23.9	95.7	126.2	192.8	239.0	201.5	172.3	70.6	5.8	2.1
GWR_585	0.6	3.4	22.1	92.4	117.6	205.3	238.8	202.8	171.6	70.9	5.1	2.0

Figure 3.19: Comparison of Generated Average Monthly Surface Runoff and GW Recharge for Shimulbank village



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SURQ_base	3.1	9.0	11.9	23.4	40.9	143.7	180.7	145.5	156.4	85.5	21.9	4.1
SURQ_585	3.0	9.0	11.1	21.9	43.9	146.6	181.6	146.2	157.6	86.1	22.0	4.1
GWR_base	11.2	4.3	5.3	7.8	15.3	27.8	68.3	112.2	124.0	121.5	80.9	40.2
GWR_585	10.8	4.1	5.1	7.7	15.2	27.5	68.0	111.5	122.8	120.2	80.0	39.3

Figure 3.20: Comparison of Generated Average Monthly Surface Runoff and GW Recharge for Datinakhali village

3.4 Potential Water Sources Identification

Three water sources (Surface water, Ground water & Rain water) available in the earth from where people can collect water for drinking and day to day using purpose. For identification the potential water sources, the three water sources must be taken into consideration in our country perspective. Although the groundwater quality is satisfactory for drinking purpose and available abundantly in the shallow aquifer, quality limitations of surface water impose economic constraints with additional treatment cost for system operation. Nevertheless, water availability in both sources may vary from place to place, and must be quantified before any planning and development of water supply scheme. In this arsenic contaminated area under the project the three possible sources were analysed for potential water sources identification.

Water availability from pond data

Water availability has been estimated from the available data collected from the field survey in terms of water volume. The availability is calculated using two parameters, which are water depth and the pond area. Two types of water depth collected during the field survey: (i) present or current water depth which means the depth of water in the pond at surveyed date and (ii) dry season water depth which means anticipated minimum water depth may exist during peak dry season (March – April). The present water depth has not been considered to calculate the water availability because of the pond survey is executed at different date starting from first week of June 2022 to second week of August 2022. Therefore, the dry season water depth of the pond has been used to calculate the water availability. The dry season water volume was calculated using the following formula: $W_{av} = P_a * D_{wd}$ Calculated dry season water volume is further classified in different categories and presented in Table 3.11.

It has been found that, 30% of the ponds falls under 1000 – 3000 m^3 volume class and which is the major class and the number of pond is approximately 185. The minimum number of pond is observed within the class of '0-100m^3 'which is 4% of the total surveyed pond. The total number of pond under all class is around 611.

Table 3.11: Village wise number of pond under different water volume class.

District	Upazila	Union	Village	Total Pond	Dry season water volume class (m3)						
					C1	C2	C3	C4	C5	C6	C7
					(No of Ponds)						
Cumilla	Monoharganj	Bipulshar	Saikchail	237	1	0	5	18	117	46	50
Khulna	Dumuria	Khurnia	Tipna	241	10	73	62	35	52	5	4
Satkhira	Shyamnagar	Labsa	Datinakhali	98	11	33	21	19	13	0	1
Sunamganj	Dakkhin Sunamganj	Shimulbank	Shimulbank	35	2	12	6	10	3	2	0
Total (%)				**100%**	**4%**	**19%**	**15%**	**13%**	**30%**	**9%**	**9%**

Pond Volume (m^3)	
C1	0-100
C2	100-300
C3	300-500
C4	500-1000
C5	1000-3000
C6	3000-5000
C7	>5000

Usages of the ponds

Data on usage of the pond has been analyzed from the field data and presented in Table 29. It may be noted that complex matrices (with 6 combination) has been developed through mathematical combination of analysis because each large number of ponds have multiple usages. From Table 29 it has been observed that more than 50 % of total ponds have been used for fish + bath/wash. And it has been observed that around 29% of the total surveyed ponds have been used for cooking + bath/wash and 12% of total surveyed ponds have been used for only bath/wash. 6% of the surveyed pond has been used for only fish culture (commercially) and no surveyed pond has been used for only irrigation. A few percent (2%) of the surveyed pond has not been used for any purpose.

Table 3.12: Summary result of uses of the pond

District	Upazila	Union	Village	Surveyed Pond	X1	X2	X3	X4	X5	X6
Cumilla	Monoharganj	Bipulshar	Saikchail	237	9	0	55	156	15	2
Khulna	Dumuria	Khurnia	Tipna	241	18	0	3	4	208	8
Satkhira	Shyamnagar	Labsa	Datinakhali	98	9	0	3	4	80	2
Sunamganj	Dakkhin Sunamganj	Shimulbank	Shimulbank	35	2	0	12	16	4	1
Total (%)					**6%**	**0%**	**12%**	**29%**	**50%**	**2%**

Usage of Pond			
X1	Only Fish	X4	Only cooking + Bath/Wash
X2	Only Irrigation	X5	Only Fish + Bath/Wash
X3	Only Bath/Wash	X6	Not Use

Vegetation coverage of pond

In rural areas most of the ponds are covered with vegetation such as water hyacinth, algae, water grass and other bushes. The coverage of vegetation inside the pond was collected from the field. Further these data were analyzed and presented in Table 3.13. It is found that 82% of the total surveyed pond falls under (< 25) % vegetation coverage, 10% under (25 –40) % vegetation coverage and 6% under (40 –60) % vegetation coverage. From Table 3.13 it is observed that 504 ponds out of 611 have vegetation coverage within 25% limit range. Further, the total surveyed pond has the vegetation type enlisted 'water hyacinth + algae +other', 'water hyacinth', 'algae' and substantial percentage of the total surveyed pond has the vegetation type 'other' category. The 'other' category of vegetation includes water grass, bushes and other tress etc.

Table 3.13 Percentage % of vegetation coverage of pond

District	Upazila	Union	Village	Total Pond	< 25%	25% - 40%	40% – 60%	>60%
Cumilla	Monoharganj	Bipulshar	Saikchail	237	205	19	10	3
Khulna	Dumuria	Khurnia	Tipna	241	206	18	16	1
Satkhira	Shyamnagar	Labsa	Datinakhali	98	69	16	10	3
Sunamganj	Dakkhin Sunamganj	Shimulbank	Shimulbank	35	24	7	3	1
			Total (%)	**100%**	**82%**	**10%**	**6%**	**1%**

Physical water quality (color)

The preliminary assessment of the water quality is investigated mainly observing the color. The color of water is identified as good, bad and medium by eye estimation. The color may deteriorate further during the driest part of the season when the water volume reduces further in the month of April-May. The pond water colors were presented in Table 3.14. Good quality of pond water has the color of ash, clean water and very clear. The Normal quality indicates the grey, brownish and some sort of green color. The bad quality indicates the black, muddy and deep reddish color.

Table 3.14: Village wise pond water color information.

District	Upazila	Union	Village	Total Pond	Water Color		
					Good	Normal	Bad
Cumilla	Monoharganj	Bipulshar	Saikchail	237	135	97	5
Khulna	Dumuria	Khurnia	Tipna	241	39	185	17
Satkhira	Shyamnagar	Labsa	Datinakhali	98	28	65	5
Sunamganj	Dakkhin Sunamganj	Shimulbank	Shimulbank	35	15	19	1
			Total (%)	**100%**	**36%**	**60%**	**5%**

From color data analysis result (Table 3.14) it is observed that 60% of the total surveyed pond has the normal water quality in terms of color, 36% of the total surveyed pond has the good water quality and 5% of the total surveyed pond has the bad water quality. Sample photographs of ponds with good, medium and bad water quality has been given in Figure 3.21-3.24 respectively.

Figure 3.21: High Vegetation covered pond in Hafizpur village, Narsingdi.

Figure 3.22: Pond with good color quality of water in Saikchail, Cumilla.

Figure 3.23: Pond with normal color quality of water in Saikchail, Cumilla

Figure 3.24: Pond with bad color quality of water in Charsarat and Tipna village respectively

Identification of potential ponds for safe water options

The physical parameters of the ponds were collected from the field and analyzed. The present study on pond survey only examines the physical parameters which will help in identifying the potential ponds for further investigation and selection with potential for drinking purposes. A water quality monitoring program may be executed to provide the alternative safe water options from the initially identified ponds for further assessment. It is not practically possible or it would be very cost effective to monitor the water quality for all the ponds for safe water options. Therefore, it is necessary to screen the ponds to identify potential ponds for alternate safe water technology through further water quality test. Potential grading of the pond will be useful for adaptation of safe water technology especially for PSF (CEGIS, 2005). The criteria were used for calculation of potentiality considering the design or recommended criteria through literature review. Generally in the areas where PSF systems have been developed, tubewells are not successful as suitable fresh water aquifers are not available at reasonable depths (WHO, 2005). The recommended criteria for PSF are as below:

- The pond must be large enough to ensure that it will not dry out in the dry season.
- It is also important to ensure that the salinity and iron content of the pond water not exceed 600 ppm and 5 ppm, respectively at any time of the year.
- Surface area should be 1/4 acre (11,000 square feet) or more. This ensures an adequate water supply.
- Depth should be at least 8 feet in the deepest part and side slopes should be 3:1 or flatter.
- Aquatic growth at the edge of the pond should be kept to a minimum. One of the better ways to reduce aquatic growth is to limit the amount of nitrogen and phosphorus that enters the pond.

Based on above criteria and available field data, several parameters were identified as an indicator for calculation of potentiality score and the parameters: (i) percentage of vegetation coverage, (ii) dry season water volume, (iii) usage of the pond, (iv) physical water quality of pond water (color of the pond water). Different Tables (3.15 to 3.21) were generated containing the indicator parameter and their score values. The relative score value has been used for the calculation of potential ponds with the upper limit value of 1 and lower limit value of 0 at different scale of interval. Further individual weighting factors for each indicator were assigned and the weighting factor for each indicator are given in Table 3.19. It may be noted that the score in the lookup tables and weights for different indicators have been used for calculation are possible to best judgement from the available data and may be updated with more precise data. Further the final potential score has been calculated using the following formula:

VF = V1 * 0.2 + V2 * 0.3 + V3 * 0.2+ V4 * 0.3

Where,

VF = Final potential score
V1 = Individual score for vegetation coverage of the pond
0.2 = weights for V1
V2 = Individual score for usage of the pond
0.3 = weights for V2
V3 = Individual score for color of the pond water
0.2 = weights for V3
V4 = Individual score for the pond volume

0.3 = weights for V4

From calculated scores, the potentiality class were generated are (i) High, (ii) Medium and (iii) Low. The potentially class with the score has been presented in Table 3.20.

Table 3.15: Criteria for % of vegetation coverage of the pond (V1)

% of vegetation coverage	Score
< 25%	1
25% - 40%	0.6
40% – 60%	0.3
>60%	0

Table 3.16: Criteria for usage of pond water, (V2)

Usage of Pond	Water Score
Cooking + Bath/ Wash	1
Only Bath / Wash	0.6
Fishing + Bath/Wash	0.4
Only Fishing	0.2
Other	0

Table 3.17: Criteria for physical color of pond water, (V3)

Water color	Score
Good	1
Normal	0.5
Bad	0

Table 3.18: Criteria for pond Volume, (V4)

Pond Volume (m^3)		Score
C1	0-100	1
C2	100-300	0.8
C3	300-500	0.7
C4	500-1000	0.6
C5	1000-3000	0.4
C6	3000-5000	0.2
C7	>5000	0

Table 3.19: Weights of different indicators

Indicator Parameter	Weights
V1	0.2
V2	0.3
V3	0.2
V4	0.3

Table 3.20: Potentiality class of the pond

Potential score	Potential class
VF > 0.6	High
VF = 0.6 – 0.4	Medium
VF < 0.4	Low/ Less

Using the setting criteria and proposed methodology village wise number of potential pond were calculated and analysis results were presented in Table 3.21. From the computation result of potential ponds it is observed that the total ponds have very less or low potentiality in four pilot villages of arsenic contaminated area. Thus the pond water is not a suitable potential source of water supply to the study villages.

Table 3.21: Village wise apparently potential ponds

District	Upazila	Union	Village	Total Pond	No of Potential ponds	
					Potential score, VF	Potential class
Cumilla	Monoharganj	Bipulshar	Saikchail	237	0.24	Low/ Less
Khulna	Dumuria	Khurnia	Tipna	241	0.24	Low/ Less
Satkhira	Shyamnagar	Labsa	Datinakhali	98	0.24	Low/ Less
Sunamganj	Dakkhin Sunamganj	Shimulbank	Shimulbank	35	0.25	Low/ Less

Water Resource Map

Water resource mapping is a crucial component of the geographical approach to land hydrology and the water sector, and it is extremely helpful in addressing water issues and managing water resources. The unique characteristics of water resources distinguish them from other natural resources. They are distinguished by a dual natural-social essence, with the water functioning as both a component of the natural environment and one of the main producing forces, with a significant impact on social history, infrastructure, and region formation. Water resources not only contain mass and energy characteristics, but they also provide the basis for human livelihoods and economic growth. Water resource maps of four villages of arsenic contaminated area was prepared by GIS Division. The existing water supply technologies in the studied villages served as the primary basis for creating the water resources map. For daily drinking water and household needs, people in those villages primarily rely on tube wells. Along with the land use of those villages, the water resources map displays government and private tubewells in two colour legends. All maps are providing below.

<u>Tipna, Khulna</u>

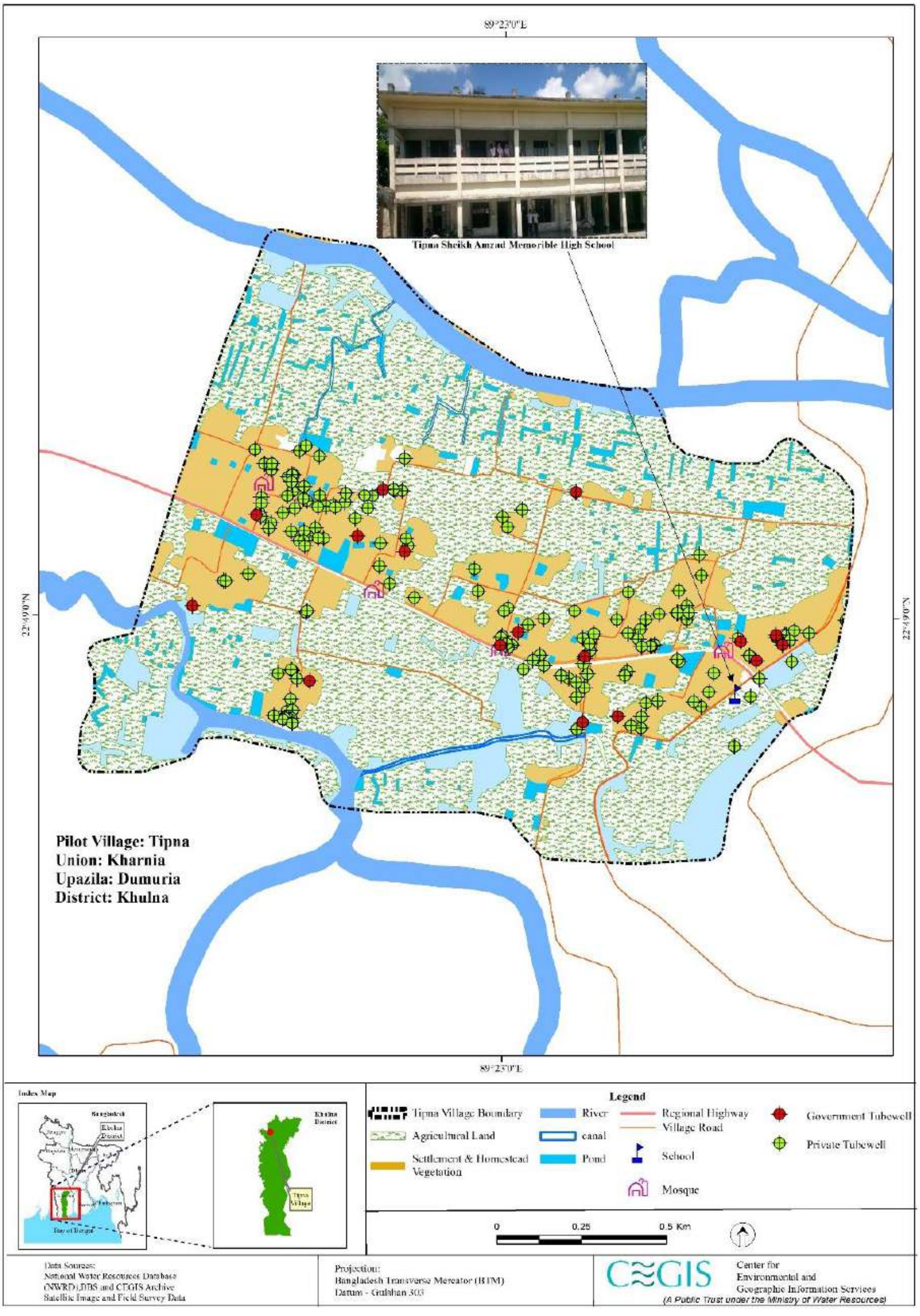


Figure 3.25: Water Resources Map of Tipna, Khulna

<u>Saikchail, Cumilla</u>

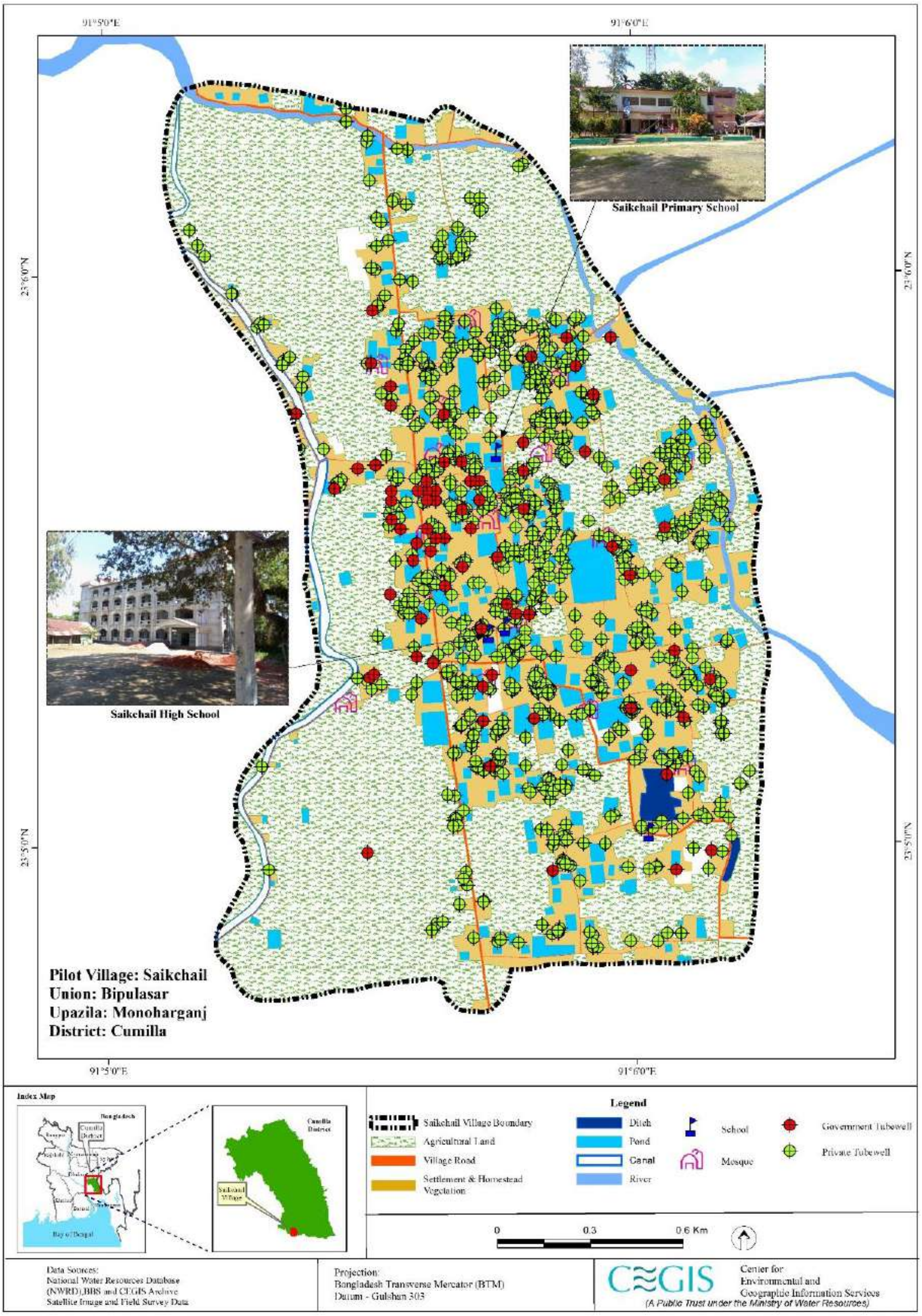


Figure 3.26: Water Resources Map of Saikchail, Cumilla

Datinakhali, Satkhira

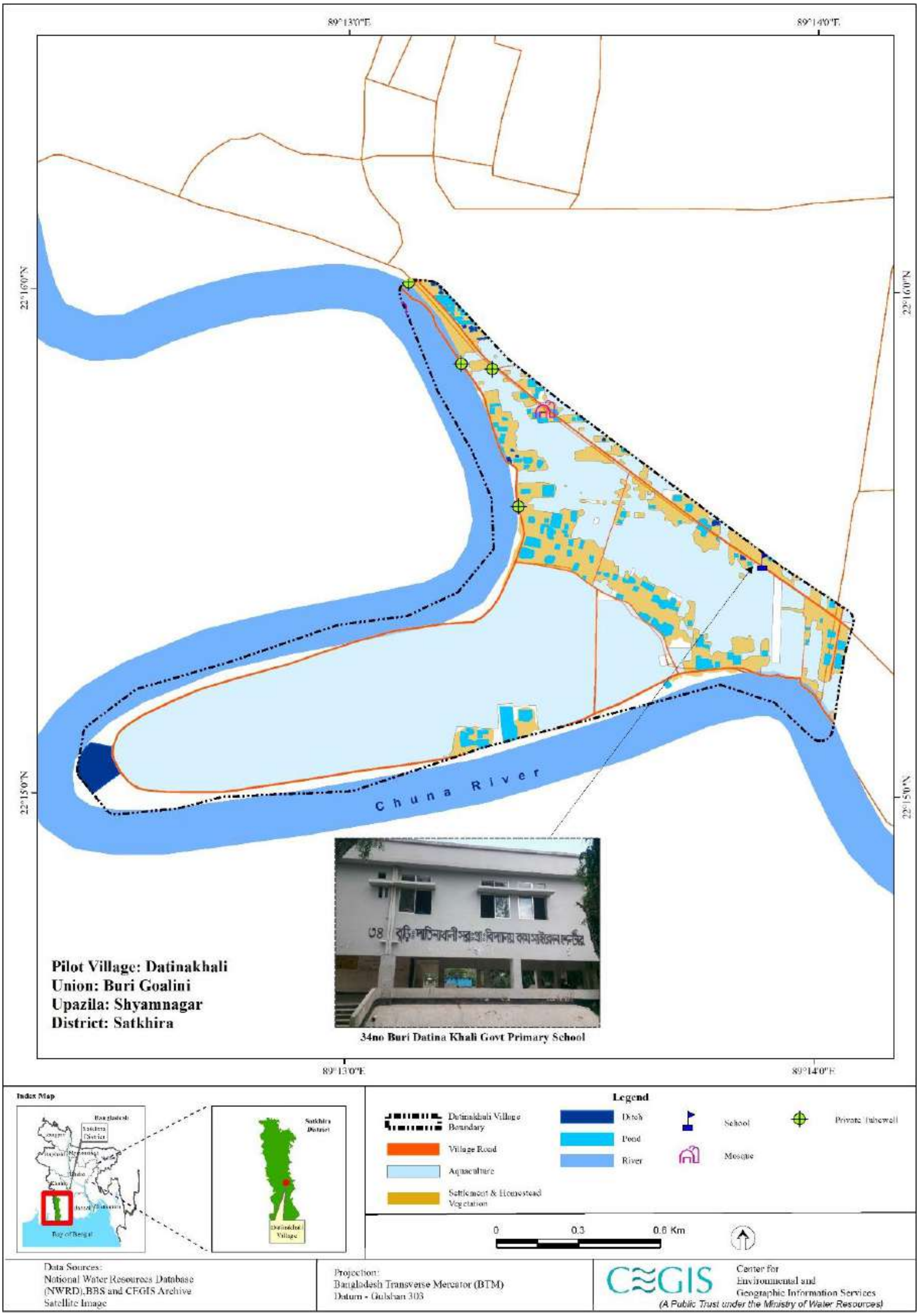


Figure 3.27: Water Resources Map of Datinakhali, Satkhira

Shimulbank, Sunamganj

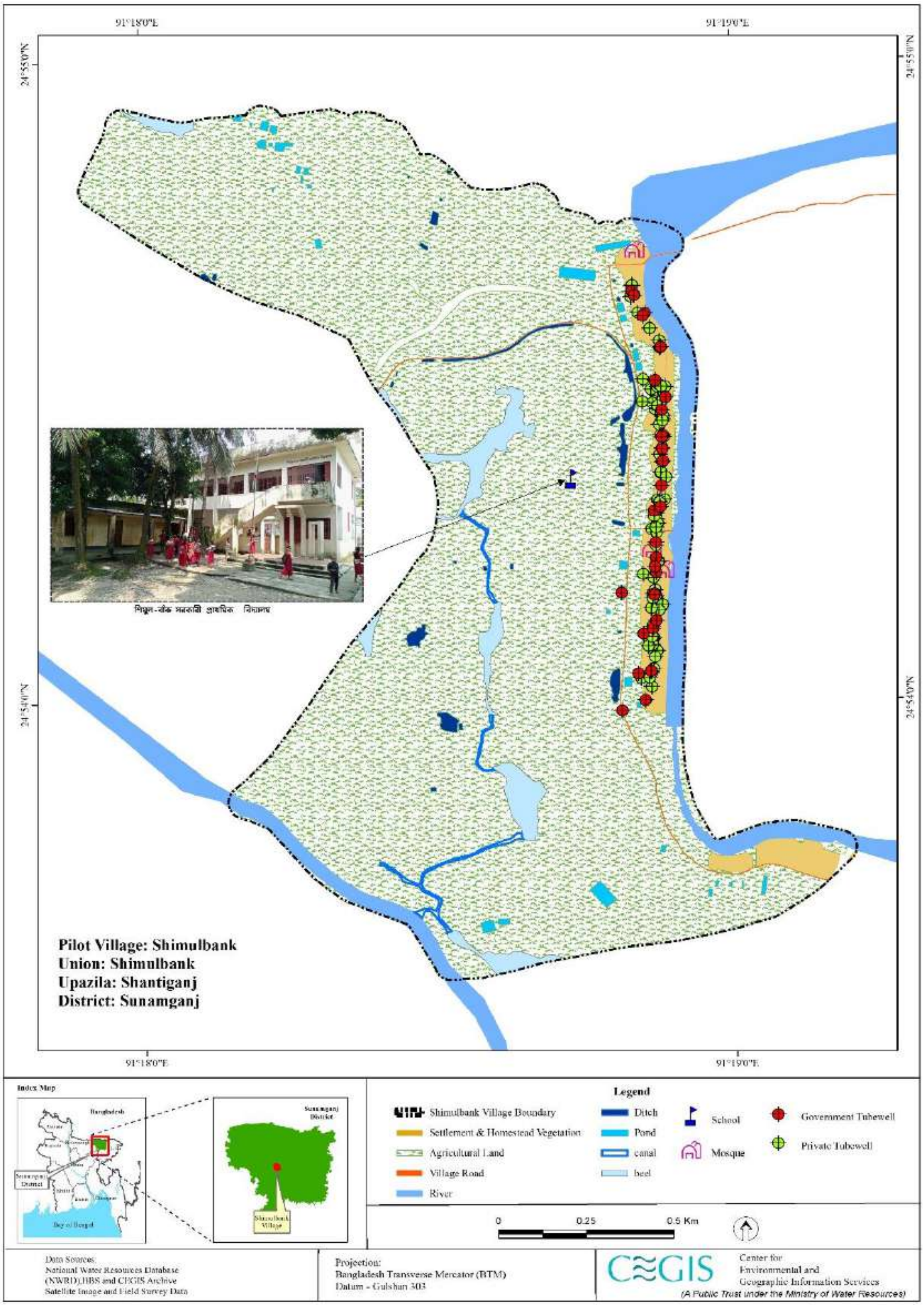


Figure 3.28: Water Resources Map of Shimulbank, Sunamganj

Dot Density map

Dot density maps are a simple but incredibly powerful approach to display density variations in geographic distributions throughout a landscape. A dot-density map is a type of thematic map that displays the values of one or more numeric data fields on the map using dots or other symbols. On a dot-density map, each dot represents a certain quantity of data. The water resources map revealed that the primary sources of water supply in those villages are tubewells (Government and private). After counting all the households, data on the precise location of the tubewells (by GPS), the population density, the water demand per person, and other factors are collected and evaluated. Following the collection of all the data, dot density maps were prepared to show how many tubewells, both public and private, are needed to cover each Household (HH). Based on an assessment of the current scene in those villages, the density of the dots is classified.Dot density maps of four villages are described below:

Tipna, Khulna

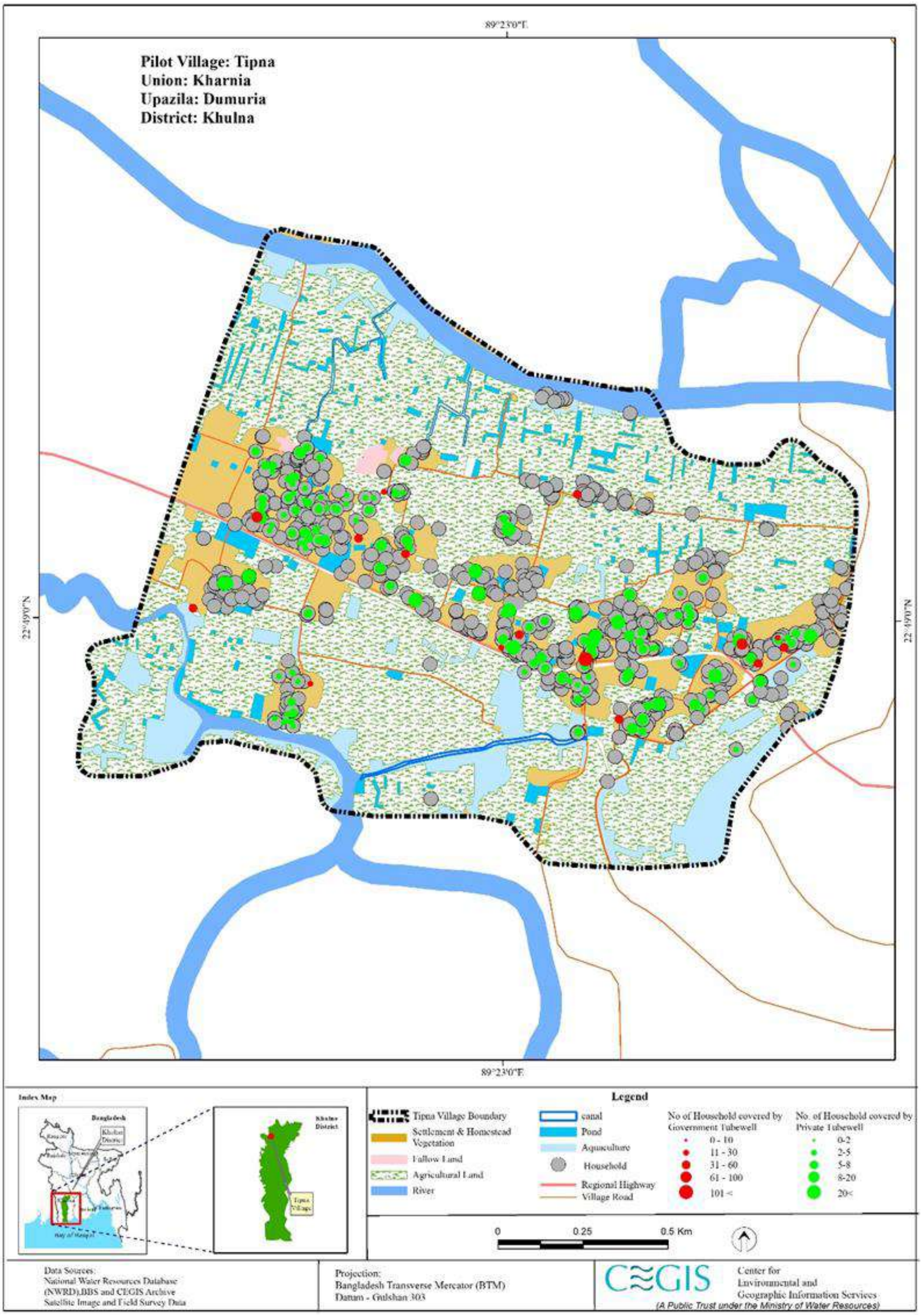


Figure 3.29: Dot Density Map of Tipna, Khulna

Saikchail, Cumilla

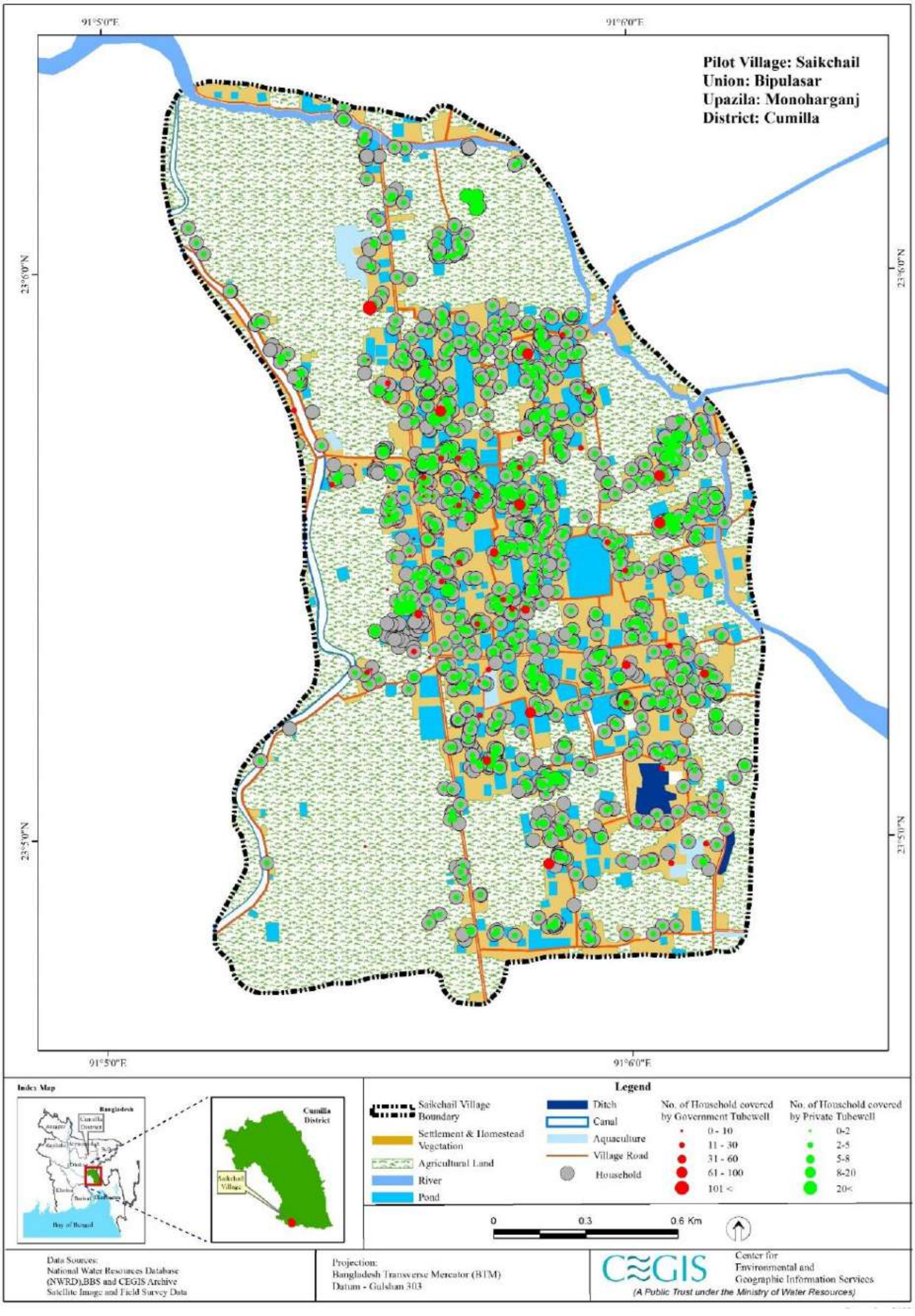


Figure 3.30: Dot Density Map of Saikchail, Cumilla

Datinakhali, Satkhira

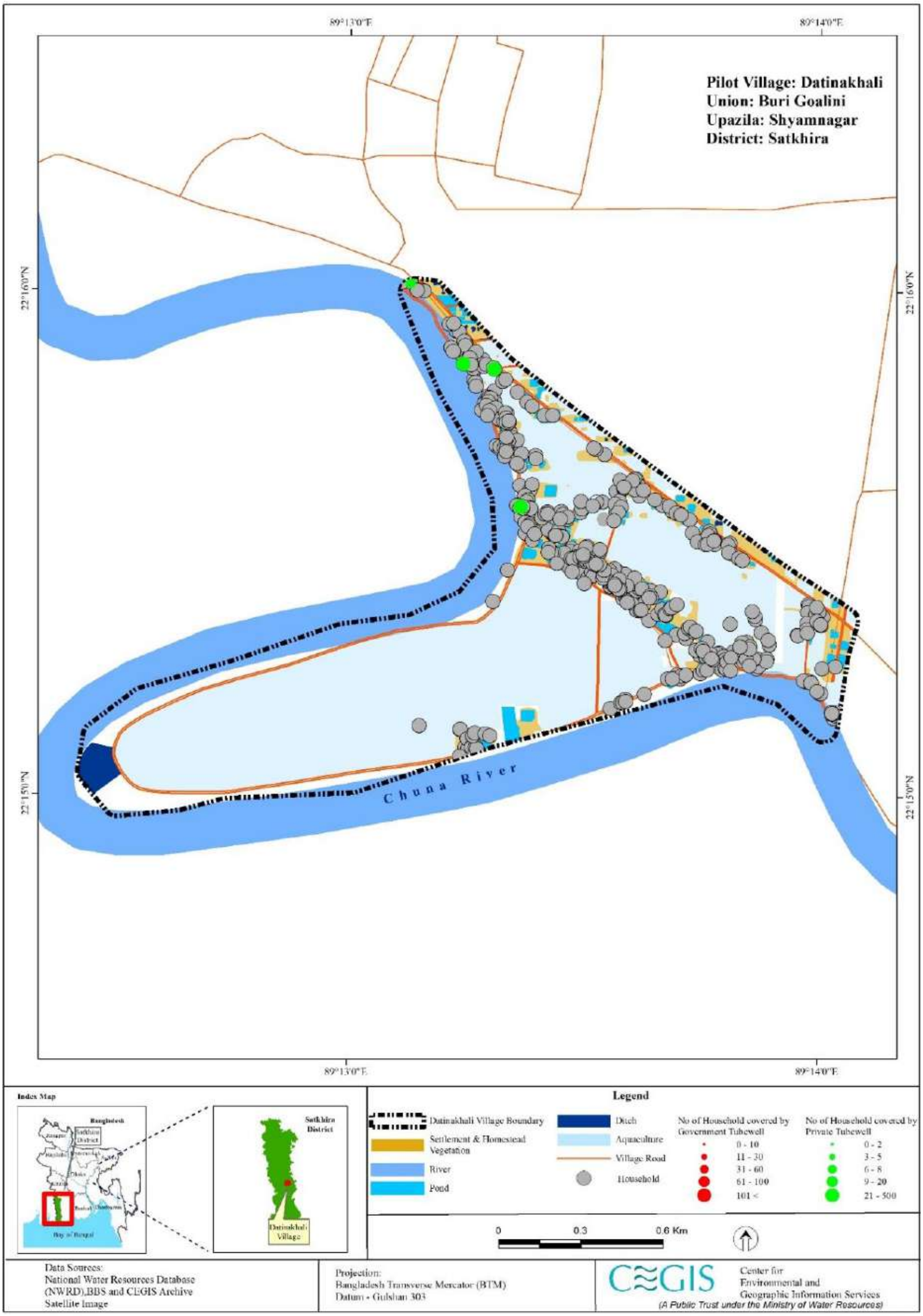


Figure 3.31: Dot Density Map of Datinakhali, Satkhira

<u>*Shimulbank, Sunamganj*</u>

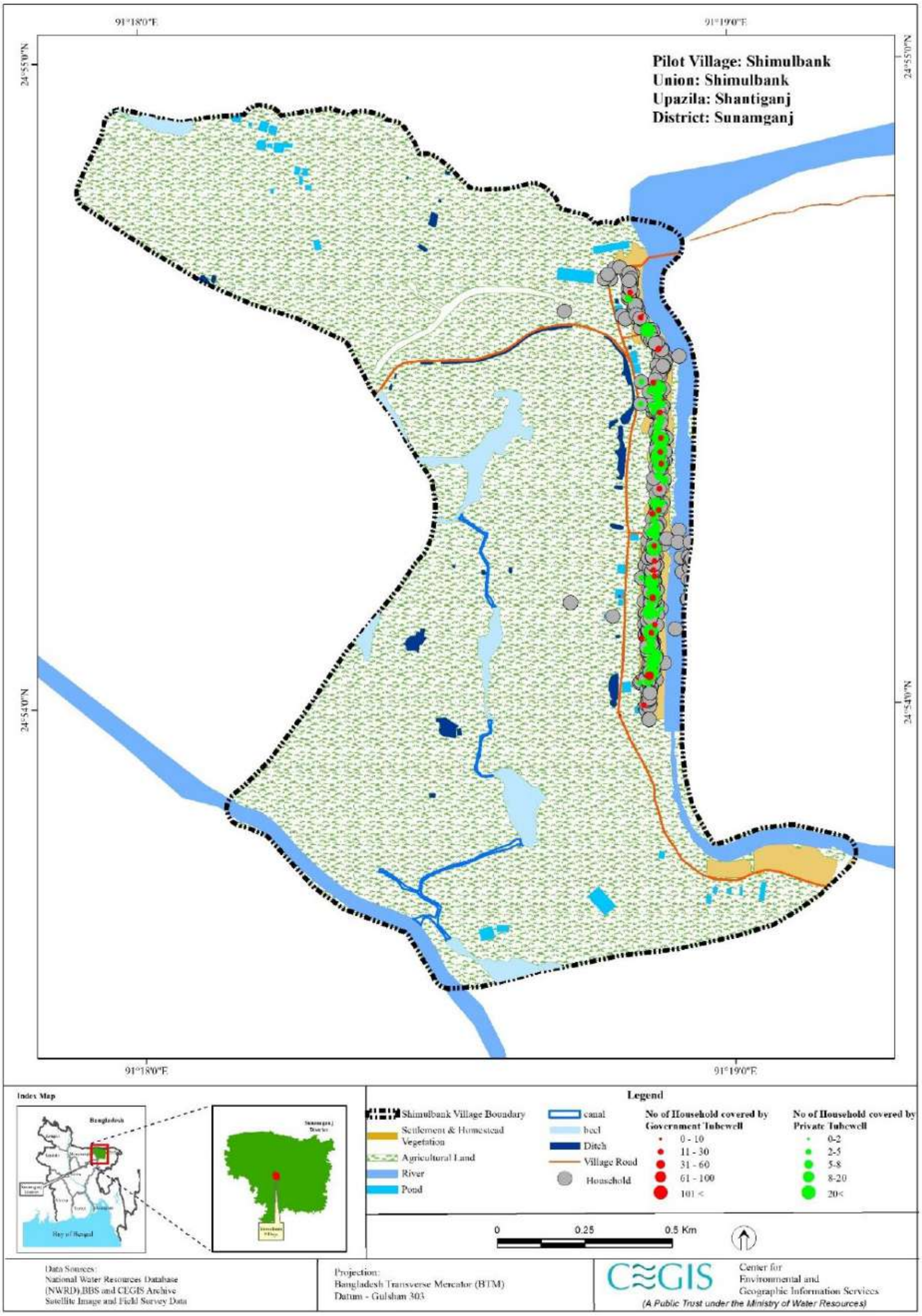


Figure 3.32: Dot Density Map of Shimulbank, Sunamganj

Assessment of available potential source of water for the water supply system was carried out. Ground water is found satisfactorily good in quantity and quality for maximum villages described in section 3.1 water availability analysis. Therefore, Ground water is recommended as a water source except for Datinakhali and Shimulbank village. As Datinakhali village ground water contain high level of salinity, so surface water or rainwater can be used. In Shimulbank, tertiary rocks are encountered at shallow depths and again, the village has also good amount of surface water. So, instead of groundwater, surface water can be a good option for this village.

Table 3.22 Potential Water Source and possible technology

SL.	Villages	Water source	Recommended technology
1.	Shimulbank	Surface water	Rural Pipeline water supply
2.	Datinakhali	Surface water, Rainwater	Rainwater harvesting plant, pond sand filter, water treatment plant
3.	Saikchail	Groundwater	Mini piped water supply, Deep tube well with submersible pump
4.	Tipna	Groundwater	Deep tube well with submersible pump

3.5 Planning Area Delineation

Delineating formal regions or areas entails assembling local units that share traits in accordance with a set of clearly defined criteria and that differ significantly from units outside the region based on a set of selected criteria. In this report, the planning area is delineated for the four villages in the arsenic-contaminated area under this project. After analyzing the land use, the dot density, and the water resources map of the villages, a planning area delineation map is prepared for four villages in the arsenic-contaminated area. The village area is divided into three planning blocks afterwards, when the type of water supply intervention for the villages has been decided. According to the service point location, which is chosen based on aspects like household density, distance from the service point, the quantity and quality of the available private and public technologies, and other factors, each planning block is given a ranking out of three. Planning Block-1 (PB-1) is known as a highly needed intervention zone, Planning Block-2 (PB-2) as a mediumly needed intervention zone, and Planning Block-3 (PB-3) as a less needed intervention zone. The term "service area" refers to the area where new interventions have been offered. Based on our assessments, this planning area delineation represents a tentative plan for designating the location of the interventions. The proposed interventions cannot all be implemented in the entire village at once, so the area division and block boundary demarcation have been done. The reason for this is that systemic and financial limitations prevent all workers, machines, and technological equipments from being used simultaneously. Therefore, a tentative planning zone with tentative locations for the interventions sorted by priority is proposed in this report for the four villages in the arsenic-contaminated area.

Village-Tipna, District-Khulna

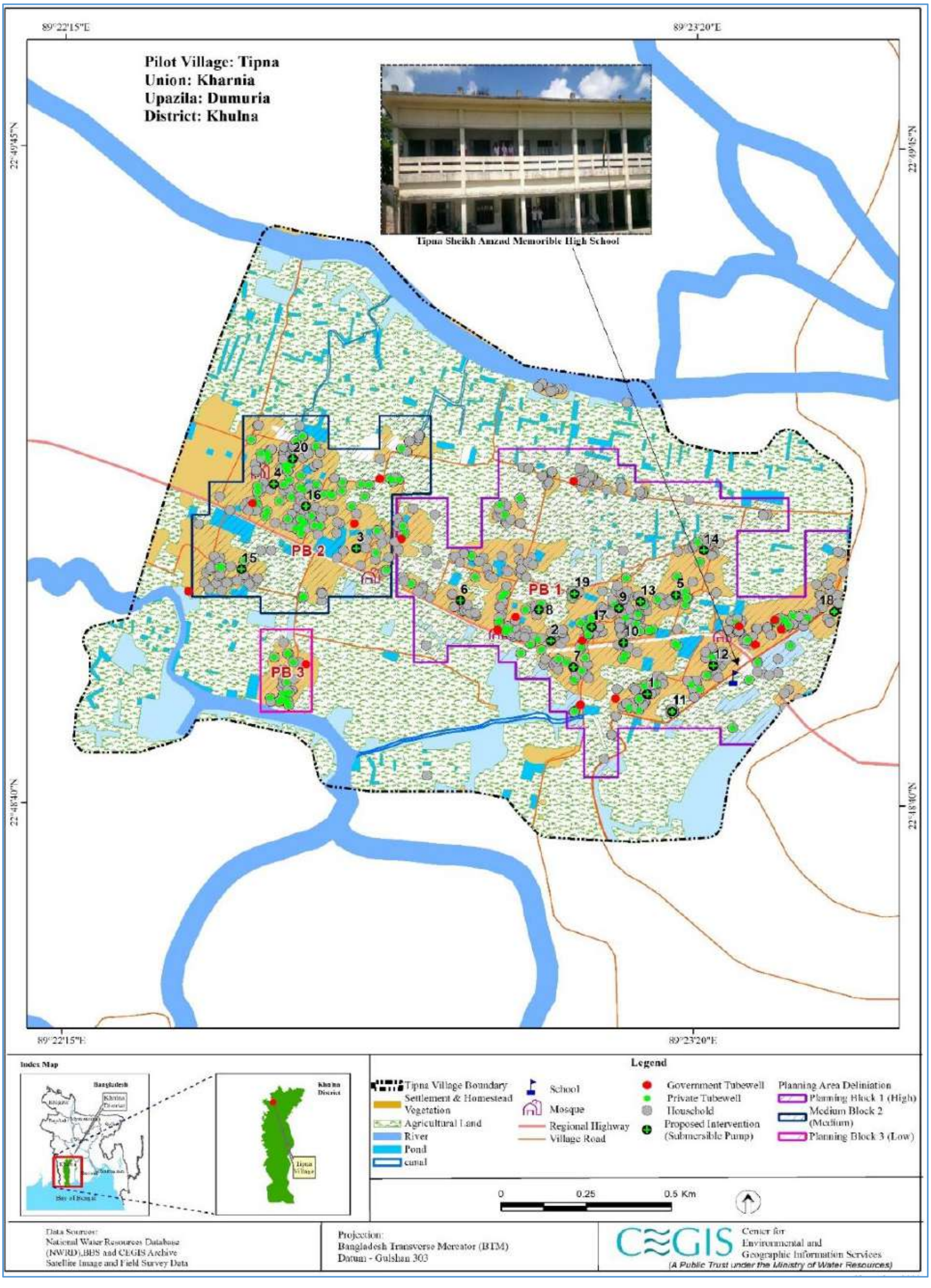


Figure 3.33: Planning area delineation of the village Tipna

In Tipna, 20 submersible pumps have been proposed, as opposed to the average of eight households. The intervention ID-16 has been assigned to a maximum of 16 households. Intervention ID-8 has the fewest households, four, with an average distance of 16m from the service point. The average number of households per intervention is 8, and the average distance between households and interventions is 53 meters. Due to the proximity of the intervention to the household, the time required to reach the water source will be less than one minute. Twenty submersible pumps with tube wells, distributed among three planning blocks in Tipna village, are the proposed intervention, depending on the necessity for the technologies.

Village-Datinakhali, District-Satkhira

300 Rainwater Harvesting Systems (RWHS), one Pond Sand Filter (PSF), and one RO plant have all been proposed for Datinakhali village. Instead of the typical two households, one RWHS is proposed. A maximum of 9 households can be served by the intervention ID-5, and the majority of interventions have chosen not to serve any households farther than 2.5 meters from the service point. Each intervention includes an average of two households, and there are four meters between each household and each intervention. The time needed to get to the water source will be less than a minute because the intervention is so close to the home. One water treatment plant (RO plant) facility, designated as Intervention ID-301 in Planning Block 1 (PB-1), is chosen. A total of 209 households were chosen for the pond sand filter (PSF) Intervention ID-302 in Planning Block 2 (PB-2); the average distance between a household and a pond sand filter is 250 meters.

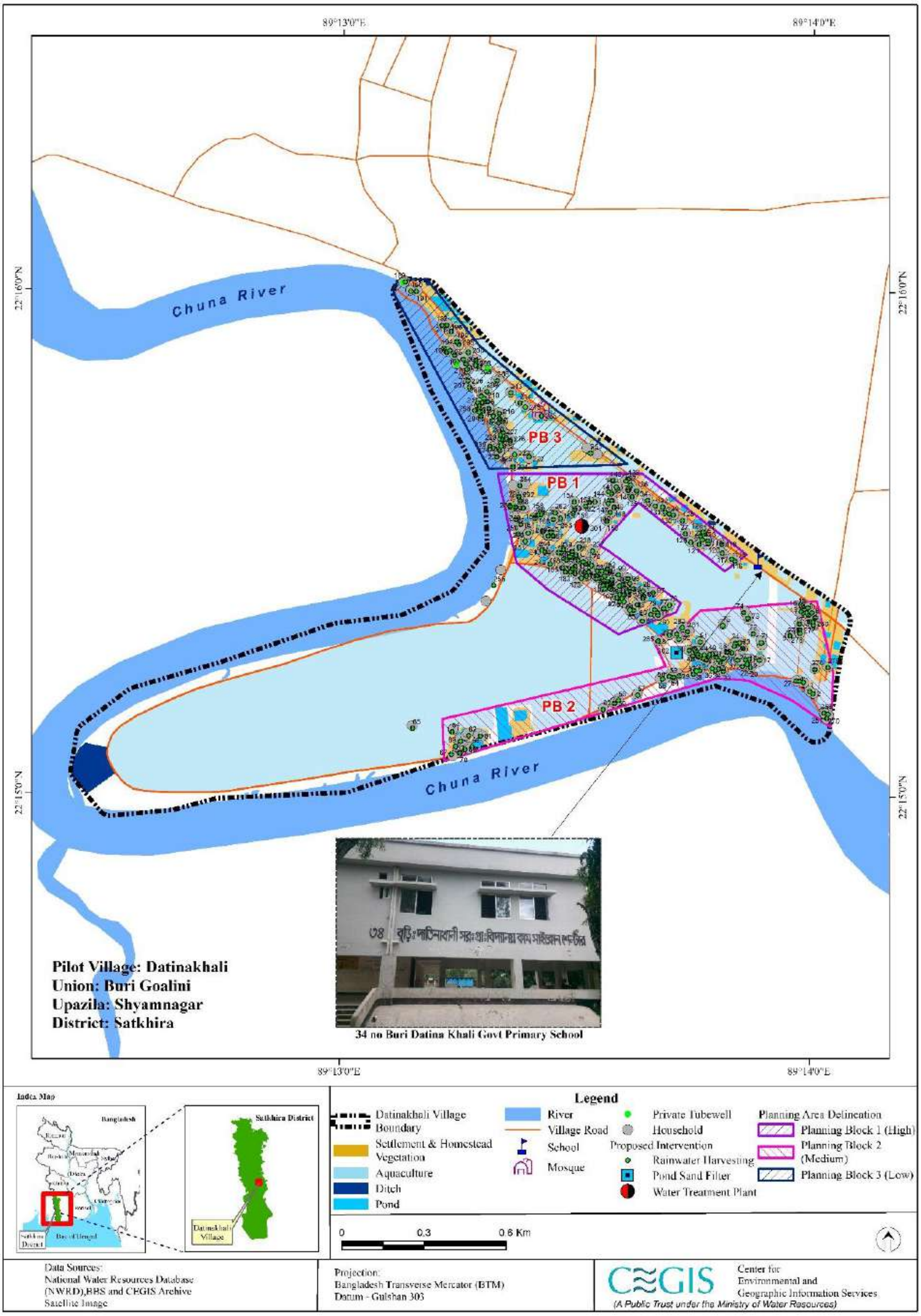


Figure 3.34: Planning area delineation of the village Datinakhali

Village-Saikchail, District-Cumilla

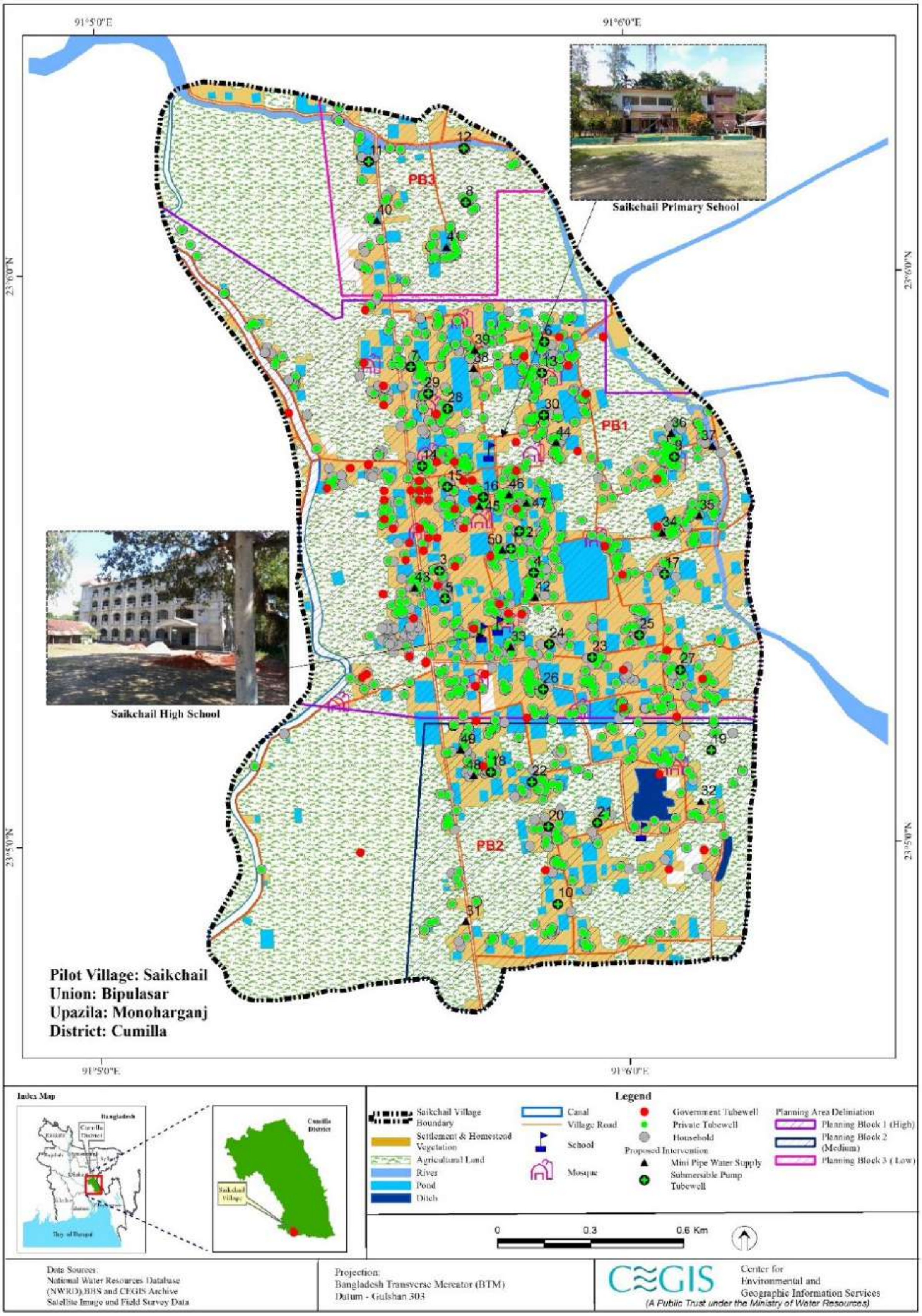


Figure 3.35: Planning area delineation of the village Saikchail

Saikchail village has received recommendations for both 30 deep submersible pumps with tube wells and 20 mini-piped water supply systems. The proposed deep submersible pump with tube well incorporates the typical seven households. Once more, one mini-piped water supply for an average of every six households is suggested. The mini-piped water supply intervention ID-36 has a capacity to serve up to 17 homes, but most interventions have decided not to provide service to any homes more than 29 meters away from the service point. An average of seven households are included in each intervention, and there are 39.5 meters between each household and each intervention. Because of how close the intervention is, it will only take a few minutes to reach the water source. The plan area map shows the deep submersible pump facility, referred to as Intervention ID-1 to ID-30, and the mini-piped water supply, referred to as Intervention ID-31 to ID-50.

Village-Shimulbank, District-Sunamganj:

One rural piped water supply has been suggested for Shimulbank. The proposed intervention will be served for 55 households. The typical distance between a household and an intervention is 281 meters.

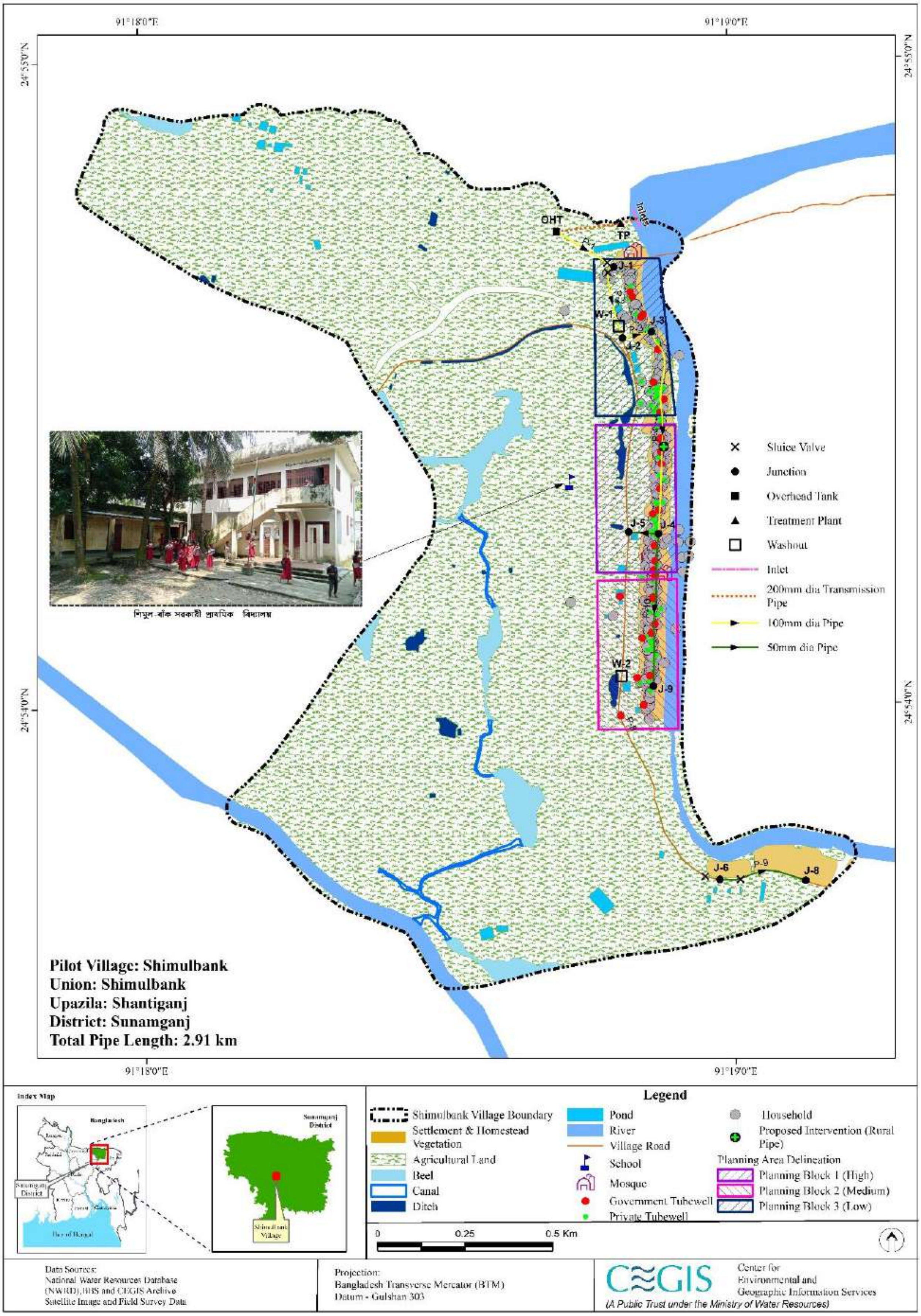


Figure 3.36: Planning area delineation of the village Shimulbank

3.6 Demand Analysis

Before designing the intervention related to water supply, the demand of water has been analysed. The demand analysis of water supply system design is given below.

3.6.1 Water Supply Demand

Demand Analysis: Identify the need for public investments by assessing:

Current Demand

Current demand for overall water use per person-day has been assessed based on data available[1] of arsenic contaminated pilot villages. Previous two years (2021 and 2020) data are related with the population growth[2] rate. On the basis of households in the six villages, annual average overall water demand for a village is calculated. Details are given in the following Table 3.23.

Future demand

After completion of the project, a 25-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in water likely to be used due to better living condition in upper middle income and at the beginning of higher income country.

Table 3.23: Current Demand for Overall Water Use before project implementation (Liter) in Saikchail.

District	Village	Number of household (HH)	Avg. HH size	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Cumilla	Saikchail	1652	5.4	8921	624456	18733680	2248	2219	2191
Khulna	Tipna	772	4.2	3273	229130	6873888	825	814	804
Satkhira	Datinakhali	568	4.0	2255	157847	4735416	568	561	554
Sunamganj	Shimulbank	462	5.7	2629	184015	5520438	662	654	646
Total				**17078**	**1195448**	**35863422**	**4303**	**4248**	**4195**

Source: BBS, Statistical Pocketbook, 2021, (Household size taken from household survey)

Note: Average water demand is estimated considering natural growth rate of population (1.3%)

Based on population growth rate, demand for drinking water forecasted through end of the project, has been made. Based on 2020, 2021, and 2022 years' overall water use data (estimated), overall water demand has been forecasted for a period of 20-year. In this case, Linear Regression model is used for projection. As population increases in the pilot villages, demand for water has been estimated at an increasing trend over the years. There three observations in the analysis, past water use, business as usual projection for a period, and forecasted for a period of 20-year. "Overall Water Demand and Projection before Project" and "Average Overall Water Demand and Projection after implementation" of six villages are calculated differently. The yearly average overall water demand

[1] DPHE report about 70 litre/person/day.

[2] BBS, Statistical Pocketbook, 2021, chapter II.

per village is estimated at five years gap from the 2020- 2045 year. Yearly average overall water demand before project and after implementation of plain land is estimated for the 2020- 2045 years at five years' gap shown in the following Table 3.24.

Table 3.24: Before Project and after implementation of project Overall Water Demand and Projection

Year	Yearly Overall Water Demand (Lac Litre) before project implementation				Yearly Overall Water Demand (Lac Litre) after projrct implementation			
	Saikchail	Tipna	Datinakhali	Shimulbank	Saikchail	Tipna	Datinakhali	Shimulbank
2020	2191	804	554	646	2191	804	554	646
2025	2334	856	590	688	2334	856	590	688
2030	2478	909	626	730	3221	1182	814	949
2035	2621	962	663	772	3407	1250	861	1004
2040	2765	1014	699	815	3594	1319	908	1059
2045	2908	1067	735	857	3781	1387	956	1114

The predicted data has been used to create two different types of graphs. The graph has an upward-trending linear trend before implementation, and this trend continues after implementation. In Apendix III, both graphs for four villages are displayed. It is anticipated that after project implementation, the overall water use will differ for the various villages.

There are many limitations and ways to meet the demand, such as governmental rules and advancements in technology. On the basis of the physical surroundings, proper project planning, implementation, management, and operation and maintenance are likely intended to meet the project's water demand.

3.6.2 Sanitation Demand

Demand Analysis: Identify the need for public investments by assessing:

Current Sanitation Status of Pilot Villages

Sanitation is an important tool for social well-being. It is the provision of facilities and services for the safe disposal of human urine, and feces and maintenance of hygienic conditions, through services such as garbage, collection and wastewater disposal[3]. According to questionnaire survey, latrine types and number identified in the pilot villages. Total of various latrines is calculated at 2488 numbers in households (HHs) of 3454. It indicates that some of the HHs do not have any latrine. About 27% of the HH have not any latrine. In the following Table, pit latrine i.e., single pit appears about 1340 and ventilated improved pit (VIP) stands at 463 number. Pit latrines need more cost for frequent cleaning of feces (waste matter remaining after food has been digested and discharged from bowels) in the pits.

[3] https://www.researchgate.net/publication/349988876_Sanitation

These are not environment friendly. The following Table 3-25 shows the current latrine status in pilot villages.

Table 3.25: Current Latrine Types and Number in the Arsenic Contaminated Villages

District	Village	Type of Latrine						
		Pit Latrine	Double Pit Latrine	VIP Latrine	Flash Latrine	Septic Tank Latrine	Open Latrine	Others
Khulna	Tipna	346	21	35	86	107	0	2
Satkhira	Datinakhali	292	7	15	47	18	0	0
Sunamganj	Shimulbank	116	15	41	33	59	21	1
Cumilla	Saikchail	586	65	372	176	177	2	1

Source: Questionnaire Survey, 2022.

Current demand

Current demand analysis for investment covers conversion of single pit and construction of twine pit latrine for better sanitation condition specially latrine type (single pit and twine pit). The following Table shows the current number of conversions of single pit latrine to twine pit latrine[4].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[5] rate and behavior of the people in current sanitation with reference to the national economic growth rate. In this regard, the previous data was calculated using an economic expansion (GDP growth rate) of approximately 5% for FY 2020-2021. Based on the assumption, gradually improved economic condition, previous number of single pit latrine was drawn down to the current number of single pit latrine to convert in twine pit. On the basis of DPHE data, current latrine type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table 3.26: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (HH)	HH size (4.2)	Number of Persons	Conversion Single Pit Latrine by Pilot Village and Adjacent Area			
					Single Pit Latrine	Year 2022	Year 2021	Year 2020
Khulna	Tipna	772	4.2	3242.4	300	300	315	331
Satkhira	Datinakhali	568	4	2272	410	410	430.5	452.025
Sunamganj	Shimulbank	462	5.7	2633.4	195	195	204.75	214.9875
Cumilla	Saikchail	1652	54	8921	390	390	410	430

Source: BBS, Statistical Pocketbook (Household size taken from household survey)

Note: Average water demand is estimated considering natural growth rate of population (1.3%)

Based on 2020, 2021, and 2022 years' overall water use data (estimated), the investment demand for conversion of single pit to twin pit has been forecasted for a period of 20-year. In this case, Linear Regression model is used for the projection. As population increases slowly (1.3 percent or less) with

[4] DPHE data for development of sanitation system in the pilot Villages.

[5] BBS, Statistical Pocketbook, 2021, chapter II.

better economic condition (GDP growth rate more than 5 percent, 7 or 8 percent), single pit will have become down in number. Thus, the demand for conversion is estimated to be decreasing trend over the years. There are for a period of 20-Year.

Future Demand

After completion of the project, a 25-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in new twine pit latrine likely to be used due to better living condition in upper middle income and at the beginning of higher income country. .

Estimated annual increase in demand for investment in construction of new twine pit latrine and decrease in investment in conversion of single pit are shown in the following Table 3-27.

Table 3.27: Before Project and after implementation of project Overall Sanitation Demand and Projection

Year	Before Project Conversion Number of Single Pit Latrine and Projection.				After Implementation Projected Complete twin pit latrine			
	Saikchail	Tipna	Datinakhali	Shimulbank	Saikchail	Tipna	Datinakhali	Shimulbank
2020	430	331	452	215	2191	141	193	244
2025	330	254	347	165	2334	151	206	260
2030	231	177	243	115	3221	160	218	275
2035	131	101	138	66	3407	169	231	291
2040	32	24	33	16	3594	178	241	307
2045	0	0	0	0	3781	187	256	323

After the implementation of the project, it is estimated that the investment in the construction of a new twine pit latrine varies differently for different villages. The related graphs after the implementation of the project have been shown in **Appendix III**. Various constraints and means exist to meet the demand, including government regulations, technological developments, etc. Based on the existing physical settings, proper project planning and implementation, as well as proper project management and O&M, are likely to be means of meeting the project's water demand.

4. Intervention and Options for Water Supply and Sanitation

4.1 Options for Intervention

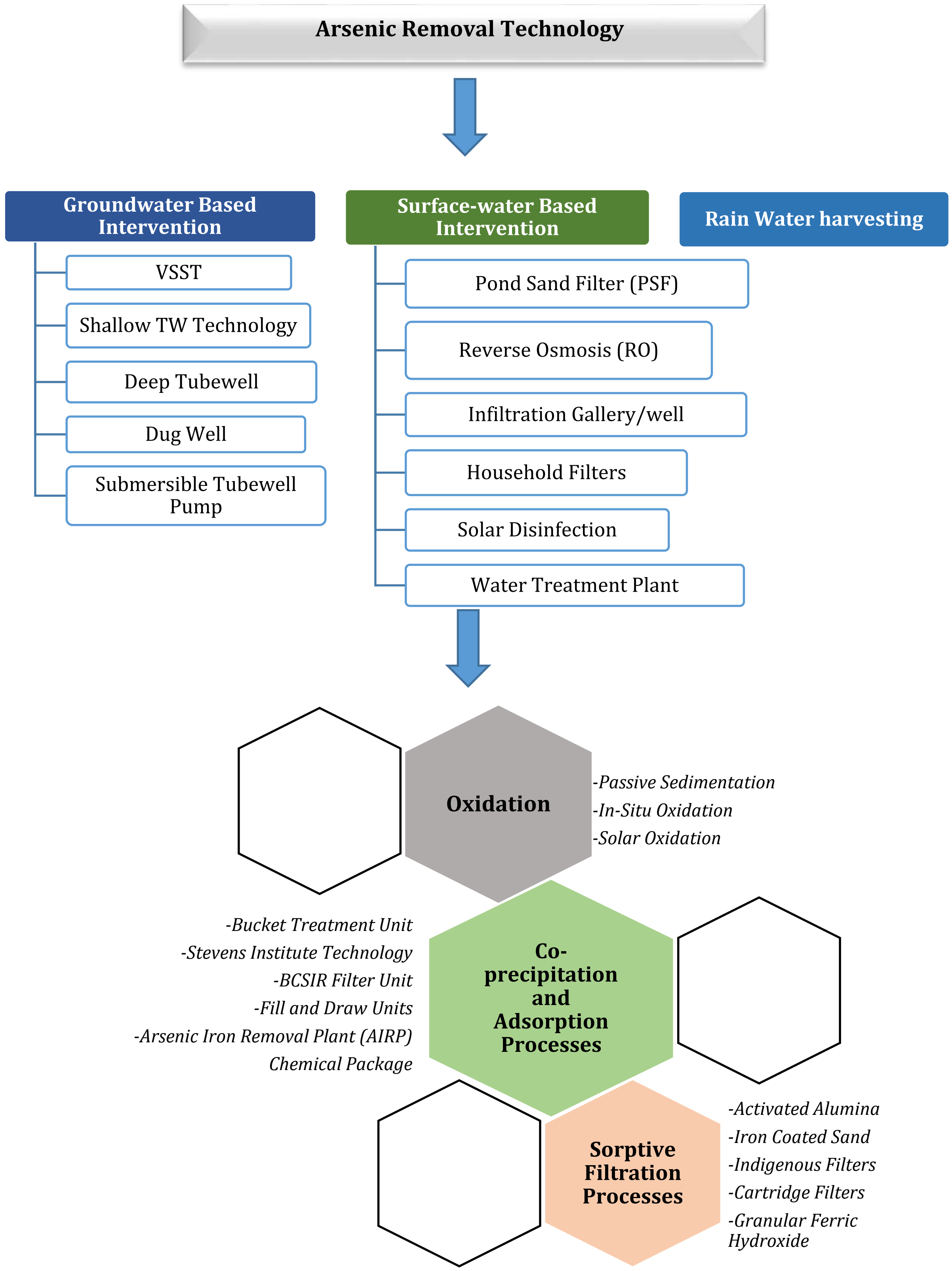
The primary issue of this project is sanitation, hygiene, and water supply, which has been approved with the broader goal of reducing mortality by providing safe water, sanitation facilities, and improving community hygiene attitude. The project's water supply is critical, and it must be free from pathogenic bacteria and chemical contamination. In Bangladesh, rural water supply is primarily based on low-cost tubewell technology that uses ground water. The tubewell water was prioritized for its safety, particularly in terms of bacterial contamination. However, the discovery of arsenic in ground water, particularly in shallow aquifers, posed a threat to the ground water-based water supply system. This project also focuses on the issue of arsenic as well as safe water options for the community.

Bangladesh's water supply is complex due to water chemical properties and geology. Arsenic contamination, for example, does not spread uniformly. In this report, the technical team has given solution to the arsenic contaminated villages entitled Saikchail, Tipna, Datinakhali & Shimulbank regarding water supply & sanitation. However, arsenic contamination varies with aquifer depth in a specific location. Aside from arsenic, ground water sources have been plagued by excessive iron, salinity, and water table depletion. On the other hand, in many parts of the country, there is no protected but perennial surface water source. As a result of the different hydro-geological conditions, one technology may not be suitable for the other areas. In that case, water technology must be prioritized up to a specific boundary, such as a village boundary.

Groundwater is the primary source of drinking water in Bangladesh. In fact, 95% of the drinking water obtained from tube wells comes from underground sources. Until recent time, it could be claimed that safe drinking water was available to 97% of the population. However, with the detection of arsenic contamination of groundwater in various areas of Bangladesh since 1993, this is no longer the case. It is not an exaggeration to say that the arsenic problem in Bangladesh has reached catastrophic proportions, unparalleled in the world. According to the most recent arsenic assessment, 59 of Bangladesh's 64 districts are already contaminated. It elicited a massive public reaction. There is also an increase in the number of people suffering from arsenical diseases, and the fear is spreading at an alarming rate among tubewell water users. According the maximum acceptable level of arsenic in drinking water, according to WHO guidelines, is 0.0 I mg/l. However, the maximum limit in Bangladesh is set at 0.05 mg/l.

There is no known effective treatment for arsenic toxicity. However, drinking arsenic-free water can help arsenic-affected people overcome the symptoms of arsenic toxicity. Thus, providing arsenic-free water to the vast population in arsenic-affected areas is critical and a major challenge confronting the nation. Despite the fact that the problem of arsenic contamination in groundwater is becoming more serious by the day, no one is certain about the best option(s) for providing arsenic-free water to the millions of people living in affected areas. The project has given importance on arsenic mitigation approach as arsenic contamination emerges as a great concern for surface water based rural water supply and sanitation system in Bangladesh highlighting the benefits and drawbacks of various options. Different Arsenic mitigation options for water supply & sanitation have been discussed below. The mitigations options are:

4.1.1 Water Supply



Very Shallow Shrouded Tubewell (VSST)

This is a unique technology used to install hand pump-mounted tubewells in fresh water pockets. The strainer of this type of tube well is typically shrouded by coarse sand to obstruct fine sand or clay and facilitate water pumping. By using suction-mode, the very shallow shrouded tubewells extract groundwater from shallow depths by creating a vacuum in the suction pipe. The suction hand pump can effectively extract water from 7.5 meters of static water level. This tubewell is installed in appropriately shallow pockets of fresh water. This type of tubewell is installed 8 to 10 meters below ground level. This is a low-cost option for the saline belt where appropriate fresh water is available.

Shallow Tubewell Technology

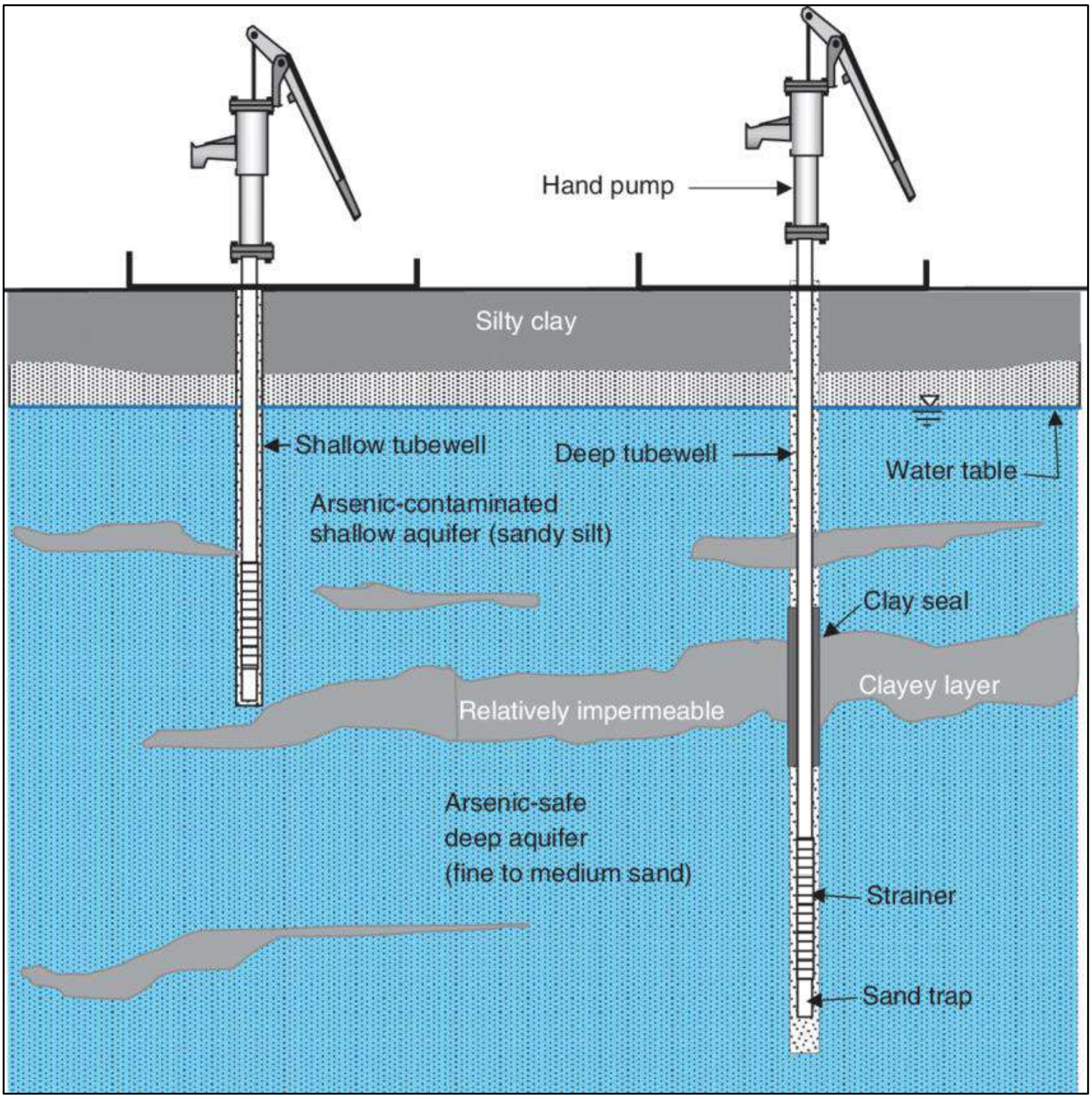


Figure 4.1: Manually operated deep and shallow tubewells in Bangladesh

In Shallow tubewell technology, handpumps are functioned in suction mode. The following handpupms are within this category,

- No.6 Handpump Tubewell
- Disco Pump Tubewell, etc.

No.6 Handpump Tubewell

The general components of a No.6 handpump tubewell are: handpump, blind pipe, strainer (screen) and sand trap. It is a suction mode handpump. A vacuum is created within the cylinder of the pump by raising the piston and water enters into the cylinder to fill-up the vacuum. In the second stroke when the piston is lowered down, the water enters in the upper chamber and comes out through the spout when the piston is again raised to create vacuum. The stroke length is 240mm. No.6 handpump is introduced by UNICEF, DPHE and also private sector.

Deep Tubewell

Deep aquifers in Bangladesh are relatively free of arsenic contamination. Deep tubewells that tap aquifers deeper than about 200 m have a very high probability (95-99%) of being arsenic-free. Very deep wells (depths greater than 200 meters) frequently appear to have low arsenic concentrations, often significantly less than 0.01 mg/l. According to a study conducted by DPHE/BGS/MML in 1999, only 4% of these wells had arsenic concentrations greater than 0.05 mg/I. Where drilling deep aquifer wells (>200m) is possible, the water can be anticipated to have an arsenic concentration of less than 0.05 mg/l. Deep tubewells installed in arsenic-affected areas can provide safe drinking water, provided the casing annulus is properly scaled to prevent aquifer cross-contamination.

Dug Well

The oldest method of groundwater withdrawal for water supplies is the dug well. Even in locations where tubewells, particularly in shallow aquifers, are contaminated, the water from the dug well has been found to be free of dissolved arsenic and iron. Dug wells are typically built without the use of any special equipment or skill. The diameter of the wells should be at least 1.2 meters for manual digging. Large diameter wells can be built for community water supply. The well's depth is determined by the depth of the water table and its seasonal fluctuations. Wells should be at least 1 m deep and at least 1m above the lowest water table. To meet increased water demand, community wells should be dug deeper to provide a larger surface area for water entry. Private Wells are typically less than 10 meters deep, whereas communal wells are typically 20-30 meters deep.

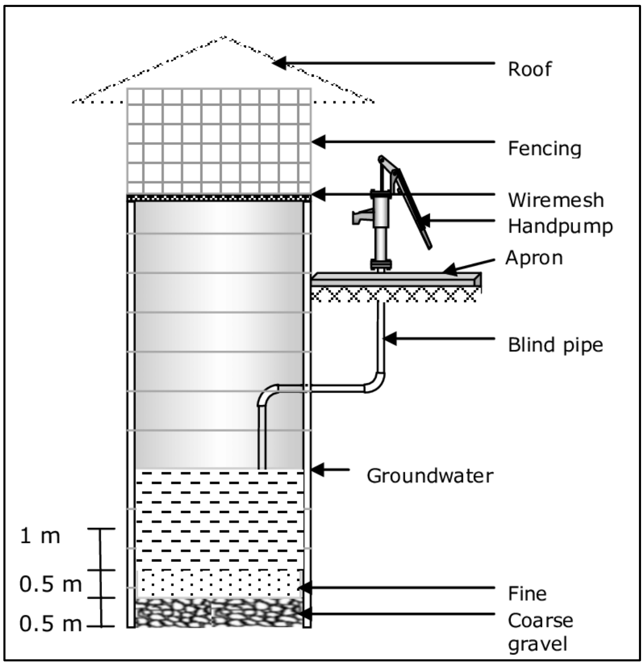


Figure 4.2: Schematic view of an improved dug well design

Submersible Tubewell Pump

Submersible well pumps are installed underground and completely submerged in a water reservoir. Both the pump and the motor in a submersible pump set are installed deep inside the tube well, reducing the suction head and allowing water to be lifted from depths as low as 450 meters. Thus, the pump can be single-stage or multi-stage, and it is coupled with a wet squirrel-cage induction motor, both of which operate completely submerged beneath the surface of the water. They transport water into an above-ground well pressure tank that is linked to the plumbing system.

Figure 4.3: Submersible Tubewell pump

Pond sand Filter (PSF)

A pond sand filter is a slow sand filter unit that is used for surface water treatment. If the turbidity of the water is high, a horizontal roughing filter is required. Raw pond water is pumped up from the pond; the turbidity passes through the roughing filter and is discharged into the filtration unit. An under drainage system filters the water before collecting it in a clear water reservoir. PSF is an excellent choice for arsenic mitigation as well as salinity-prone areas.

Reverse Osmosis Plant (RO)

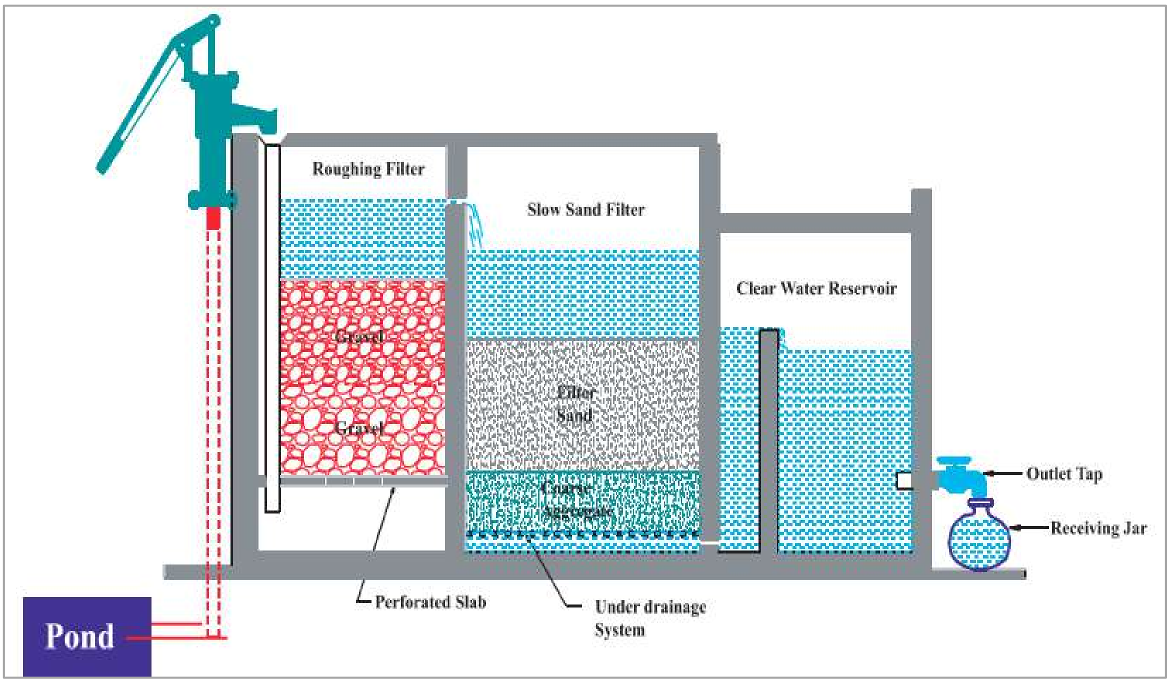


Figure 4.4: Pond Sand Filter

A reverse osmosis plant is a manufacturing facility that uses the reverse osmosis process. By forcing water through a membrane, reverse osmosis is a common method for purifying or desalinating the contaminated water. Water produced by reverse osmosis can be used for a variety of purposes, including desalination, wastewater treatment, contaminant concentration, and dissolved mineral reclamation.

Figure 4.5: Reverse Osmosis Plant

Infiltration Gallery/Well

Infiltration wells/galleries installed along the banks of rivers and ponds provide clean water for domestic use. Rivers or ponds with sandy soils are ideal for building irrigation wells/galleries. Sand beds are sometimes placed between the source and the infiltration well/gallery for water filtration. Aerated surface water infiltrates sailor well-graded sand and becomes significantly free from suspended impurities, including microorganisms. Water that has been treated with bleaching powder can be safely used for drinking as well as cooking. As surface water is the primary source of this well, it contains no arsenic.

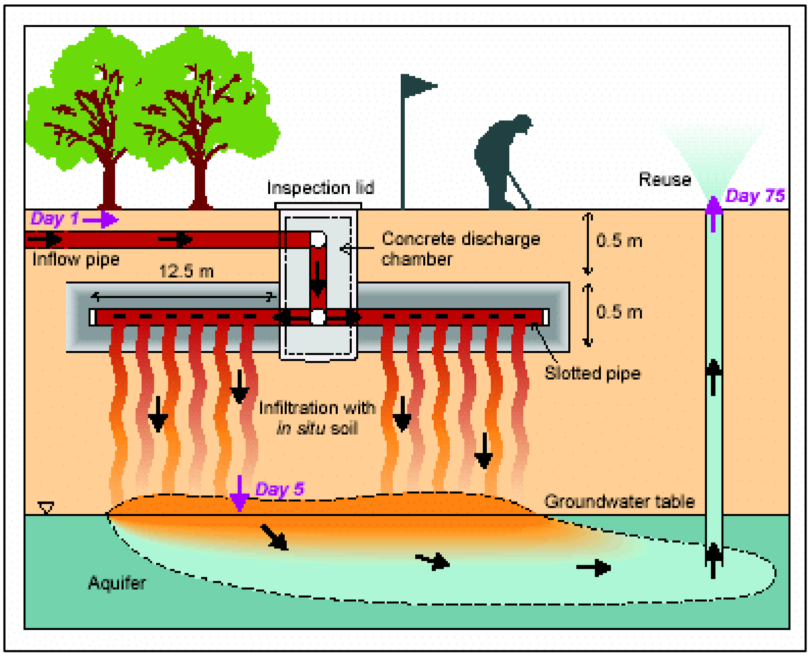


Figure 4.6: Cross-section of an Infiltration gallery

Household Filters

Conventional Households Filter (CHF or Pitcher Filter)

At the household level, this filter is made or pitchers. This is made by stacking a number of pitchers. As shown in Fig. 5.8, one above the other contains different filter media. The top pot receives raw water, while the bottom one receives filled water. Water is primarily clarified in this process through mechanical straining and adsorption, depending on the type of filter media used. Arsenic may not be removed by a standard pitcher. Because it draws arsenic-free water from surface water sources, the treated water is arsenic-free.

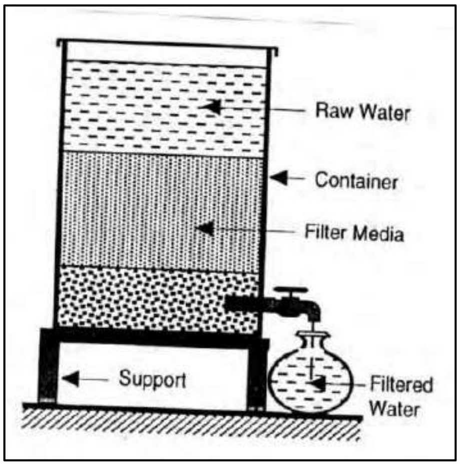


Figure 4.7: Pitcher Filter

Figure 4.8: Small Household Sand Filter

Small Sand Filter (SSF)

It will be built by laying a layer of well-graded sand 300–450 mm thick on a 150–225 mm thick base. As seen in Fig. 5.7, a cylindrical container is filled with coarse aggregates. Filtered water is collected from the bottom after the soil has been filled with water. It is necessary to prevent the filter bed from drying out. If the media are kept submerged in water at all times, full efficacy or at least filtration is achieved. Arsenic itself is not present in the SSF unit. Because it draws arsenic-free water from surface water sources, the treated water is arsenic-free.

Solar Disinfection

One approach for treating surface water with solar energy is solar disinfection. Pathogenic microorganisms that are present in the water are inactivated and eliminated by solar light. The core functions is placing water-filled transparent containers in direct sunlight for approximately five hours. Small amounts of water used for consumption have been shown to be satisfactorily disinfected using this method.

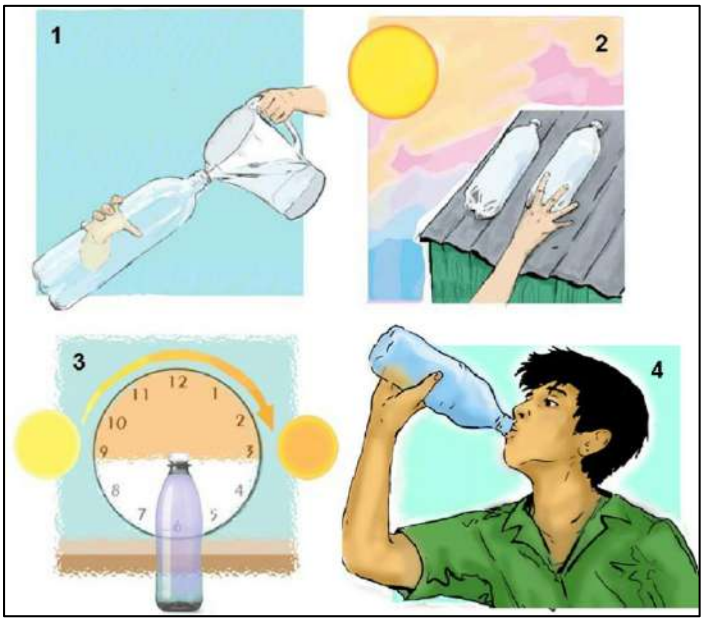


Figure 4.9: A graphical description on the solar disinfection (SODIS) household

Any water with a low turbidity level can be disinfected using solar radiation. With compared to pond water, SODIS (SOlar DISinfection) produced better outcomes for dug well water contains less organic and bacterial contamination than pond water. The WATSAN collaboration program is putting the SODIS intervention method into practice in several Bangladeshi districts.

Water Treatment Plant

In the context of prevalence of high concentrations of arsenic in tubewell water, wide range technologies have been tried for the removal of arsenic in water treatment plant from drinking water. The most common arsenic removal technologies include oxidation, co-precipitation and adsorption onto coagulated flocs, adsorption onto sorptive media, ion exchange and membrane techniques. The conventional technologies have been scaled down to meet the requirements of households and communities and suit the rural environment. This section provides a review of the arsenic removal technologies that have been used or are being used in Bangladesh. This review is primarily based on the papers presented at the UNU-BUET Workshop on Arsenic Removal Technologies from Drinking Water, held in May 2001, especially the paper by Ahmed (2001).

Oxidation

Arsenic is present in groundwater in different proportions as As (III) and As (V). Most treatment methods are effective at removing As(V), so an oxidation step is included as a pretreatment step to convert arsenite to arsenate. Arsenite can be oxidized by oxygen, ozone, free chlorine, hypochlorite, permanganate, hydrogen peroxide, and Fulton's reagent. However, in Bangladesh, atmospheric oxygen, hypochlorite, and permanganate are commonly used for oxidation.

$H_3As0_3 + {}^1/_2O_2 = H_2AsO^-{}_4 + 2H^+$

$H_3As0_3 + HCIO = HaAsO^-{}_4 + Cl^- + 3H^+$

$3\ H_3As0_3 + 2KMnO_4 = 3HaAsO^-{}_4 + 2MnO/ + 2K^+ + 4H^+ + H_2O$

1. Passive Sedimentation

Passive sedimentation received considerable attention because of rural people's habit of drinking stored water from pitchers. Oxidation of water during collection and subsequent storage in houses may cause a reduction in arsenic concentration in stored water (Bashi pani). Experiments conducted in Bangladesh showed zero to high reduction in arsenic content by passive sedimentation. Arsenic reduction by plain sedimentation appears to be dependent on water quality particularly the presence of iron in water. Ahmed et al. (2000) showed that more than 50% reduction in arsenic content is possible by sedimentation of tubewell water containing 380-480 mg/L of alkalinity as $CaCO_3$, and 8-12 mg/L of iron but cannot be relied to reduce arsenic to desired level. Most studies showed a reduction of zero to 25% of the initial concentration of arsenic in groundwater. In rapid assessment of technologies passive sedimentation failed to reduce arsenic to the desired level of 50 μg/L in any well (BAMWSP, DFID, Water Aid, 2001).

2. In-situ Oxidation

In- situ oxidation of arsenic and iron in the aquifer has been tried under DPHE-Danida Arsenic Mitigation Pilot Project. The aerated tubewell water is stored in a tank and released back into the aquifers through the tubewell by opening a valve in a pipe connecting the water tank to the tubewell pipe under the pump head. The dissolved oxygen in' water oxidizes arsenite to less mobile arsenate and also the ferrous iron in the aquifer to ferric iron, resulting a reduction in arsenic content in tubewell water.

3. Solar Oxidation

SORAS is a simple method of solar oxidation of arsenic in transparent bottles to reduce arsenic content of drinking water (Wegelin et al., 2000). Ultraviolet radiation can catalyze the process of oxidation of arsenite in presence of other oxidants like oxygen (Young, 1996). Experiments in Bangladesh show that, the process on average can reduce arsenic content of water to about one- third.

Co-precipitation and Adsorption processes

These processes are based on coagulation and flocculation followed by sedimentation. Aluminium salt and ferric salts are used as coagulants (alum. ferric chloride ferric sulphate). In all the processes, As (V), can be more effectively removed than trivalent arsenic. As (III). In these processes, coagulants are added and dissolved in water under efficient stirring for few minutes. Micro-flocs are formed rapidly and the water is then gently stirred for few minutes for agglomeration of micro-flocs into larger settleable flocs. Arsenic is primarily removed by adsorption onto the coagulated flocs and co-precipitation. Potassium permanganate (or bleaching powder) is added as an oxidizing agent to convert As (III) to As (V). A filter media (e.g., a sand filter) may be provided for complete removal of flocs. Some co-precipitation and processes are:

1. Bucket Treatment Unit
2. Stevens Institute Technology
3. BCSIR Filter Unit
4. Fill and Draw Units
5. Arsenic Iron Removal Plant (AIRP)
6. Chemical Package

Sorptive Filtration Processes

Several sorptive media have been reported to remove arsenic from water. These arc activated alumina, activated carbon, iron and manganese coated sand, kaolinite clay, hydrated ferric oxide, activated bauxite, titanium oxide, silicium oxide and many natural and synthetic media. The main problem in all sorptive techniques is the inefficient removal of arsenic (III). Significant fraction of the arsenic in Bangladesh groundwater is present as arsenic (III); as (lll) can vary from 10-90% of total arsenic. Another major problem with all filtration processes is the clogging of the filter bed with iron present in water. To be effective, any filtration device therefore needs a pre-treatment system for removal of excess iron. Some Sorptive Filtration Processes are:

1. Activated Alumina
2. Iron Coated Sand
3. Indigenous Filters
4. Cartridge Filters
5. Granular Ferric Hydroxide

Rain Water Harvesting System (RWHS)

Rainwater harvesting is a technology to collect rainwater for its use in drinking purposes. About 203 cm rainfall occurs annually in Bangladesh. The rainwater is safe if it maintained hygienically. The main limitation of this option is non-availability of rainwater round the year. However, it can be widely used as supplementary source. As per "National Policy for Arsenic Mitigation 2004 & Implementation Plan for Arsenic Mitigation in Bangladesh," the government's role is mainly to conduct promotional activities for RWH. The rainwater has virtually no bacterial or arsenic

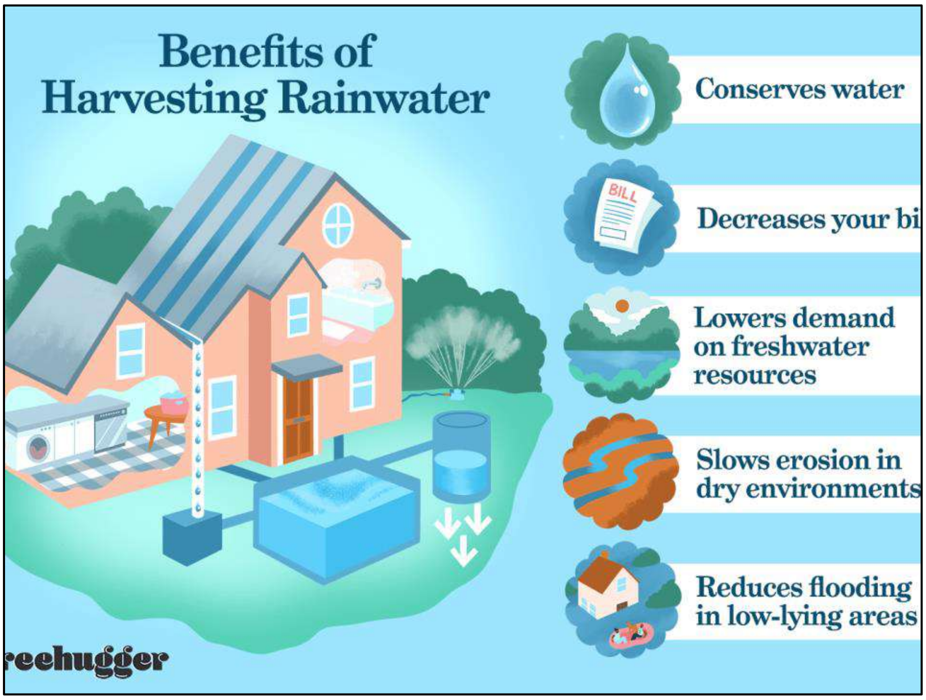


Figure 4.10: Rainwater Harvesting System (RWHS)

Content. However. in using rainwater for drinking water supplies, it is not so much the quality of rainwater itself that is important, but rather the quality of the water as drawn from the storage tank in which the water is collected and stored for later consumption. The issues with water in storage are related to the bacteriological quality, not with the arsenic content. The stored rainwater is free from arsenic contamination.

Based on the seven (7) criteria as in: Physiology of the villages, Hydrology, Hydrogeology, Disaster, Hard to Reach area, Water quality, Development, Expert opinion & consultation with local DPHE officials and local community, the following interventions are suggested by our experts to lessen the sufferings of those villagers of selected 15 pilot villages. Table 16 depicts the interventions related to water supply and sanitation.

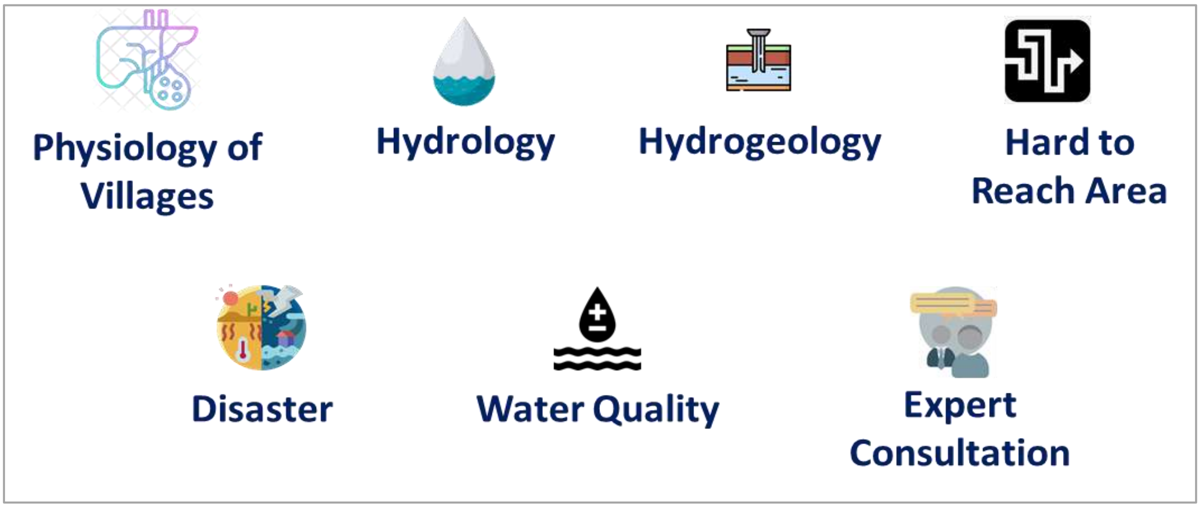


Figure 4.11: Considered Criteria for Selection of Interventions

Table 4.1: Technological Solutions related to water Supply for Arsenic Contaminated Areas

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
Saikchail, Bipulasar, Manoharganj, Cumilla.	Arsenic free tubewell Region based deep tubewells Pipe Water supply	Mini Piped Water Supply Submersible Tubewell Dug Well Pond Sand Filter (PSF) Infiltration gallery/Well Arsenic Iron Removal Plant (AIRP)	Mini piped Water supply Submersible tubewell
Tipna, Kharnia, Dumuria, Khulna	Region based deep Tubewells Pipe Water supply Arsenic free tubewell	Submersible Tubewell Deep tubewell Solar Disinfection (SODIS)	Submersible tubewell
Datinakhali, Labsa, Shyamnagar, Satkhira	Pipe Water supply Region based deep tubewells Govt., non-Govt. water supply during disaster	Rain Water Harvesting System (RWHS) Pond Sand Filter (PSF) Reverse Osmosis (RO) plant Water Treatment Plant Household Filters Solar Disinfection (SODIS)	Rainwater harvesting Pond with sand filter Water treatment plant
Shimulbank, Shimulbank, Shantiganj, Sunamganj	Arsenic free tubewell Elevated installation of tubewell Pipe water supply	Rural Piped water supply Deep Tubewell Dug Well	Rural piped Water supply

Sanitation

Sanitation Technologies

The sustainability of a sanitation system is usually the most important consideration when selecting a specific technology option for a community. Sustainability refers not only to measures to minimize breakdowns and costs in the operation of a scheme, but also refers to measures.

The following sections briefly outline some of the key requirements for promoting sustainability of sanitation systems and their relationship to choose the technology.

User education and participation in technology choice	It is imperative that representatives of the community for whom the sanitation project is to benefit be consulted and fully informed of the sanitation technology options that could be considered. The representatives must be part of the decision-making process, and should in turn inform the residents of the options and choice. As a general rule, the greater the household/community responsibility for operation and maintenance of the system, the more extensive must be the program of user education, and the lower the tariffs and municipal O&M costs. Conversely the greater the institutional responsibility for O&M, the greater the need for system monitoring by the local authority and effective cost-recovery from the users to provide the necessary resources for O&M.
Health and hygiene promotion	It is the responsibility of the local authority to ensure that a project implementation health awareness program followed by an ongoing program of health and hygiene promotion is established. Any program must focus on the

	particular needs of different communities, in line with the level of service to be developed.
Operation and maintenance tasks and plant & equipment availability	Households are responsible for the operation and maintenance of the sanitation system components located on their own erf, but the municipality may provide support for undertaking bigger tasks such as pit or septic tank emptying, moving top structures, or unblocking sewers. It is the responsibility of the local authority to ensure that all transport, treatment and disposal facilities and equipment for handling sanitation wastes are appropriate to local conditions and of sufficient capacity to deal with the wastes associated with the level of service to be provided. The operation and maintenance requirements of the transport, treatment and disposal facilities and equipment and all their associated costs must be planned for. Back-up/emergency procedures are the responsibility of the local authority and must be addressed as part of the ongoing O&M requirements.
Cost recovery	It is the responsibility of the local authority to ensure that the recurrent costs of the level of service to be developed are identified in full during the planning stage. Along with any user education program, issues around cost recovery awareness and the implications of non-payment must be addressed on an ongoing basis; this in itself constitutes an O&M cost.

The following are the general requirements for operation and maintenance of the various sanitation options. These should be fully assessed and detailed during the design stage of the specific projects:

Sanitation Scheme	O & M Tasks	Skills Level	Time Requirement	Equipment and Materials	Comments
All latrines	Maintaining structure & pedestal	Maintenance skills	± 1 day per year	Some cement, paint, wood	May be done by home owner or small contractor
VIP Latrines	Cleaning vent pipe	None	½ hour per month		Undertaken by home owner
	Emptying pit	Brief Training	1 day in 5 to 10 years	Vacuum tanker or hand equipment + roughage for composting sludge + safety clothing	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
UDS latrines	Emptying pit	None	½ day each year	None	Most activities can be undertaken by home owner
Aquaprivy	Removing sludge from tank	Brief training	± 1/4 day every 3 months	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for Aquaprivy lowering costs and creating jobs
	Maintaining soak pit	Brief training	Monthly for grease trap	None	Soak pit may need to be unblocked or moved every 5 to 10 years in some soils
Flush toilet with septic	Repairs to pipes	Pipe Skills	± 1 day every 5 years	Pipes and joints	May be done by home owner or small contractor

Sanitation Scheme	O & M Tasks	Skills Level	Time Requirement	Equipment and Materials	Comments
tank and adsorption trench	Removing sludge from septic tank	Brief Training	± 1/4 day every 3 years	Vaccum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining soil adsorption trench	Brief Training	Monthly for grease trap	None	Soak pit may need to be unblocked or moved every 5 to 10 years in some soils
Flush toilet with septic tank, solids free sewer and pond treatment	Repairs to pipes	Pipe Skills	± 1 day every 6 years	Pipes and joints	May be done by home owner or small contractor
	Removing sludge from septic tanks	Brief Training	± 1/4 day every 3 years per household	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining stabilization pond	Brief Training	Daily	Minor tools	This can provide permanent job positions for 2 to 5 people
Full waterborne sanitation	Repairs to pipes	Pipe skills	± 1 day every 6 months	Pipes and joints	May be done by home owner or small contractor (if on-site) or municipality (if off-site).
	Sewe blockages	Minor training	± 1 day per week	Rodding equipment + transport	May be done by municipality or small contractor
	Operating and maintaining wastewater treatment works	Full training to diploma level	Daily	Monitoring equipment +tools	Municipal responsibility providing permanent job Positions for 4 to 10 people.
Sewage pump stations	Maintaining pumps, clearing screens and grit channels	Full training to certificate level	± 4 hours per week	Pump maintenance tools, safety clothing	Municipal responsibility but pump maintenance may be contracted in.

Sanitation Technology Choice

<u>Options Recommended</u>

Dry on-plot systems	• Ventilated Improved Pit (VIP) toilet • Ventilated Improved Double Pit (VIDP) toilet • Composting or desiccating (e.g. urine diversion system-UDS) toilets
Wet on- or off-plot systems	• Septic tank and soak-away
Wet off-plot systems	• Small bore solids-free sewer • Full or conventional waterborne sewerage • Conventional waterborne system with shallow sewerage

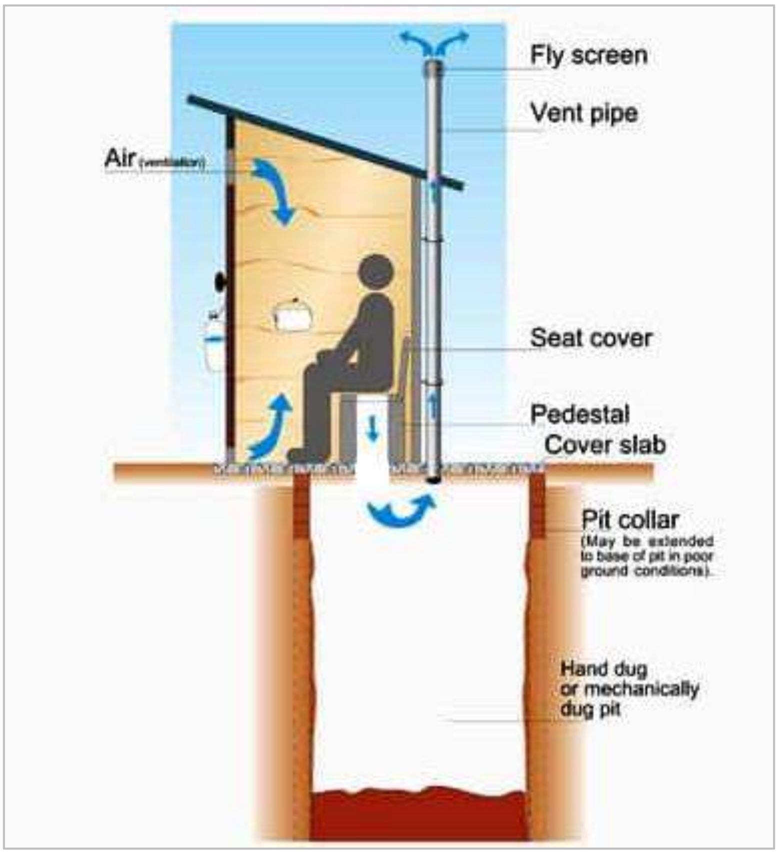


Figure 4.12: Ventilated Improved Pit (VIP) toilet.

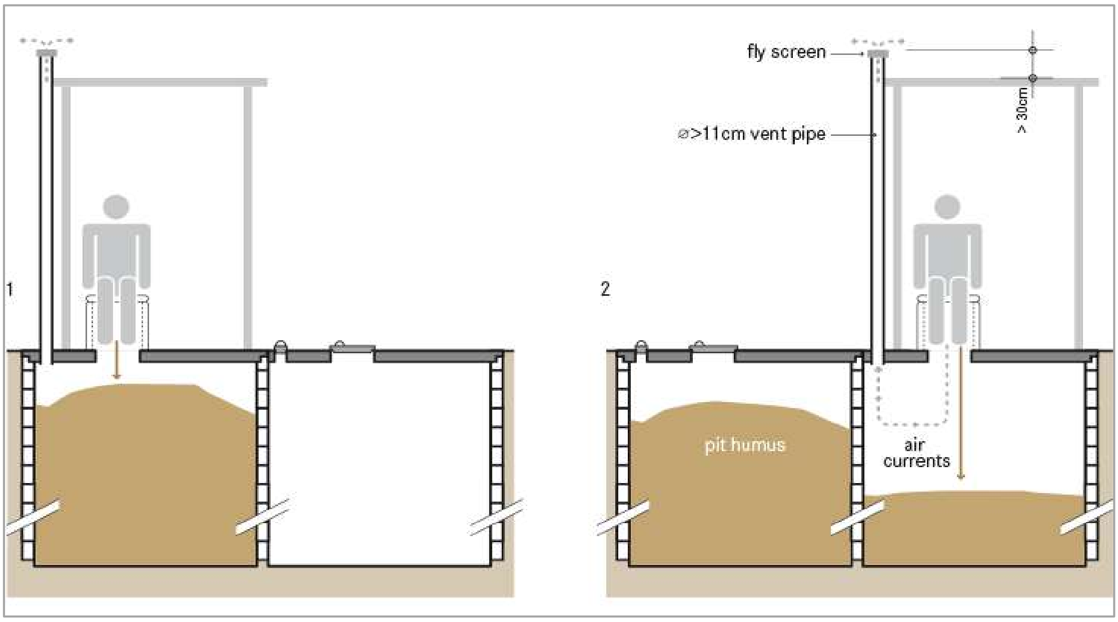


Figure 4.13: Ventilated Improved Double Pit (VIDP) toilet.

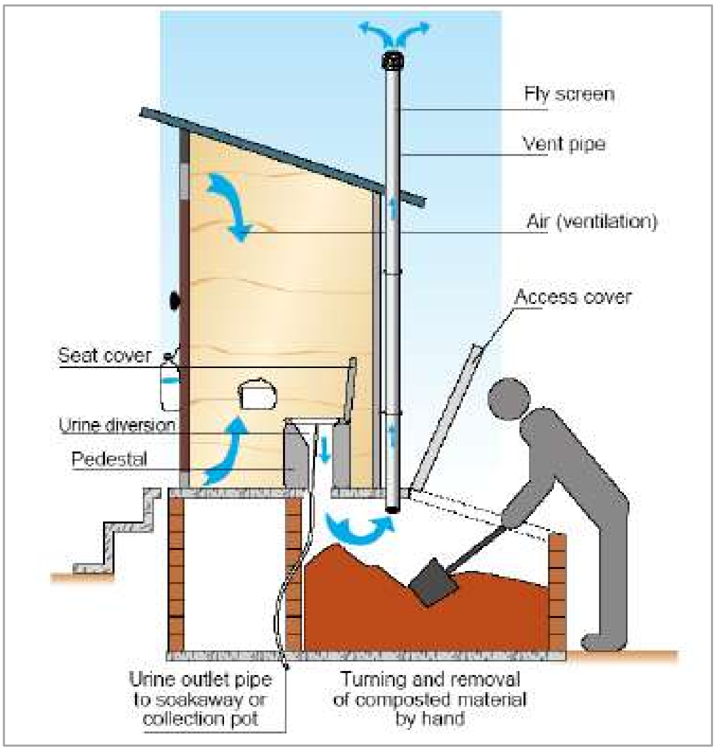


Figure 4.14: Composting or desiccating (e.g. urine diversion system - UDS) toilets.

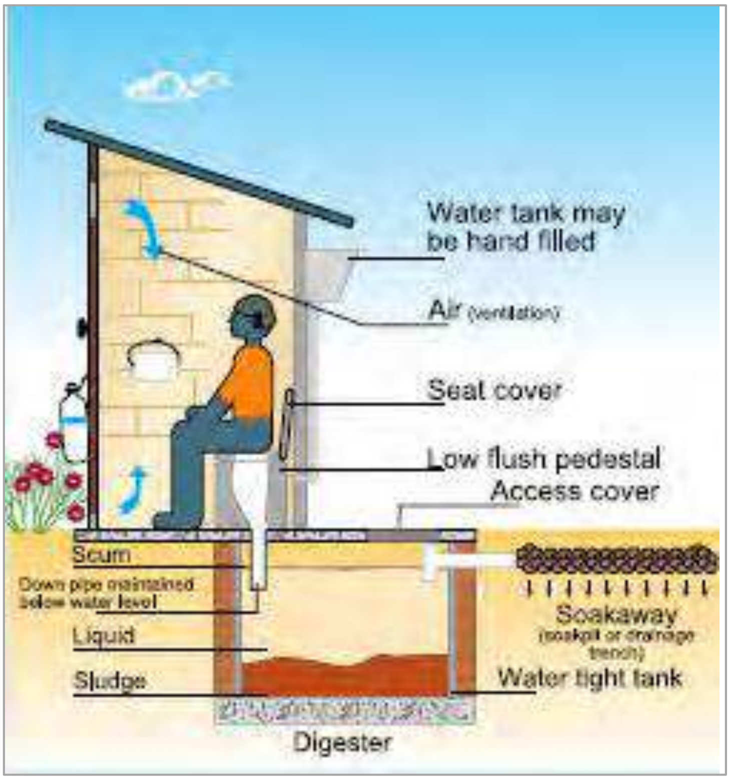


Figure 4.15: Wet on-plot system (Loflos or aquaprivy toilet with soakaway).

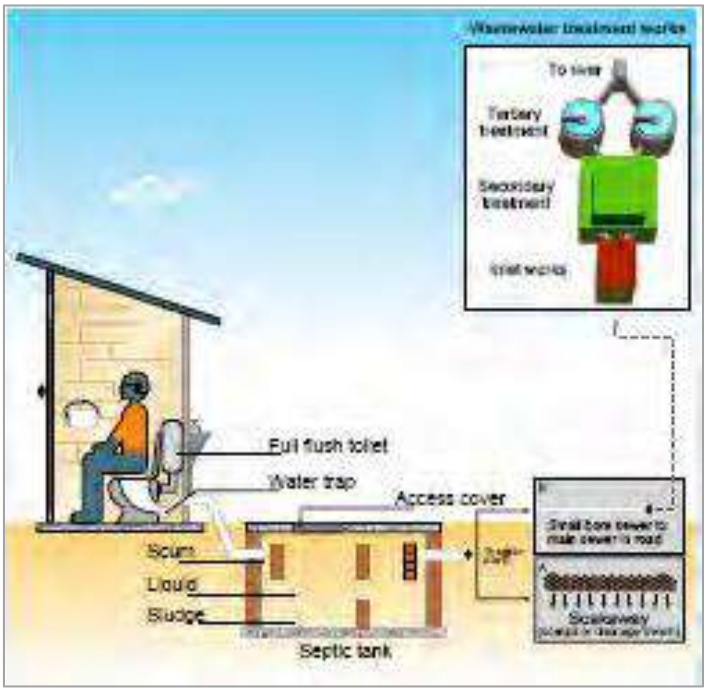


Figure 4.16: Wet on- or off-plot systems (Septic tank and soak-away).

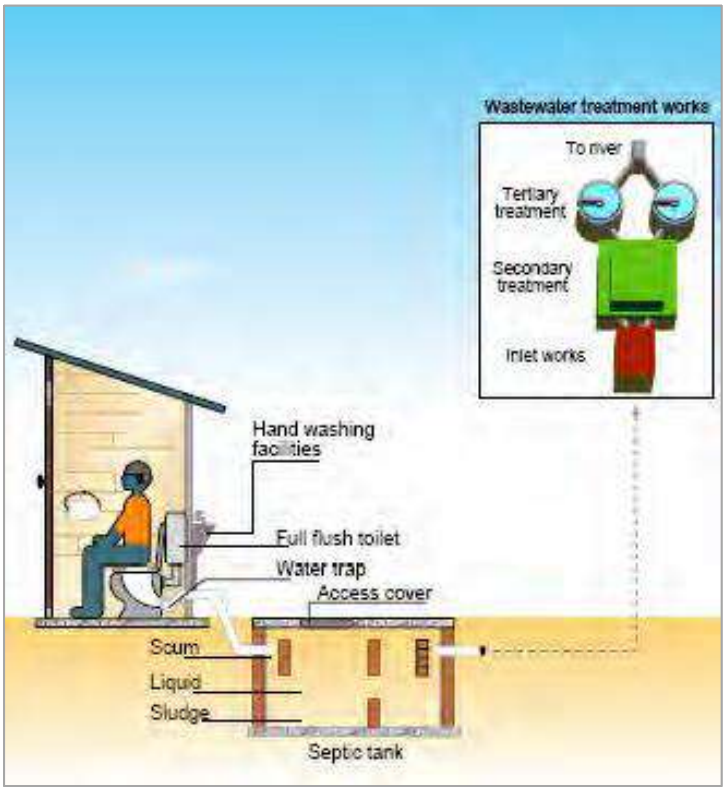


Figure 4.17: Wet off-plot systems (Small bore solids-free sewer).

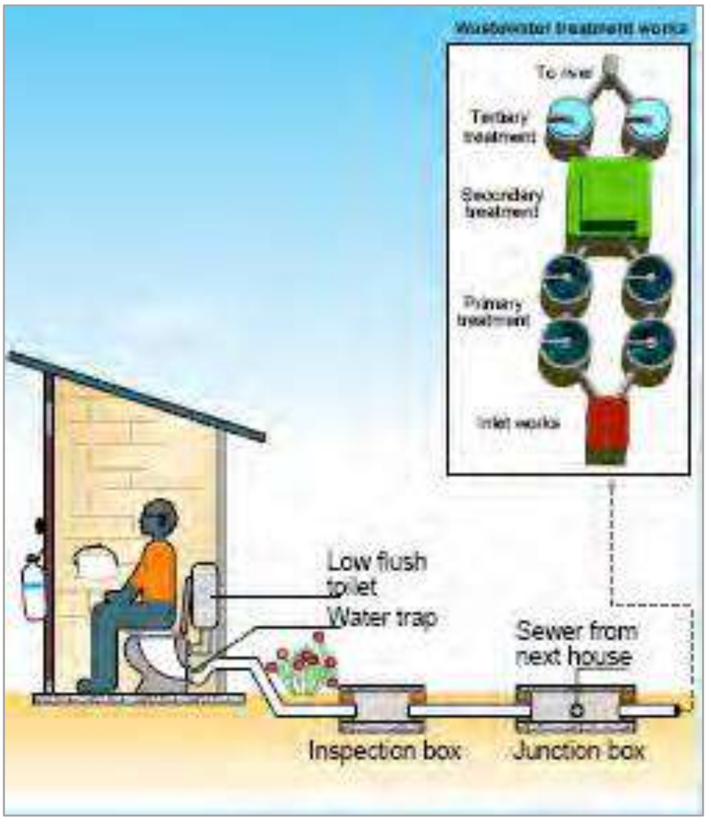


Figure 4.18: Wet off-plot system (Conventional waterborne system with shallow sewerage).

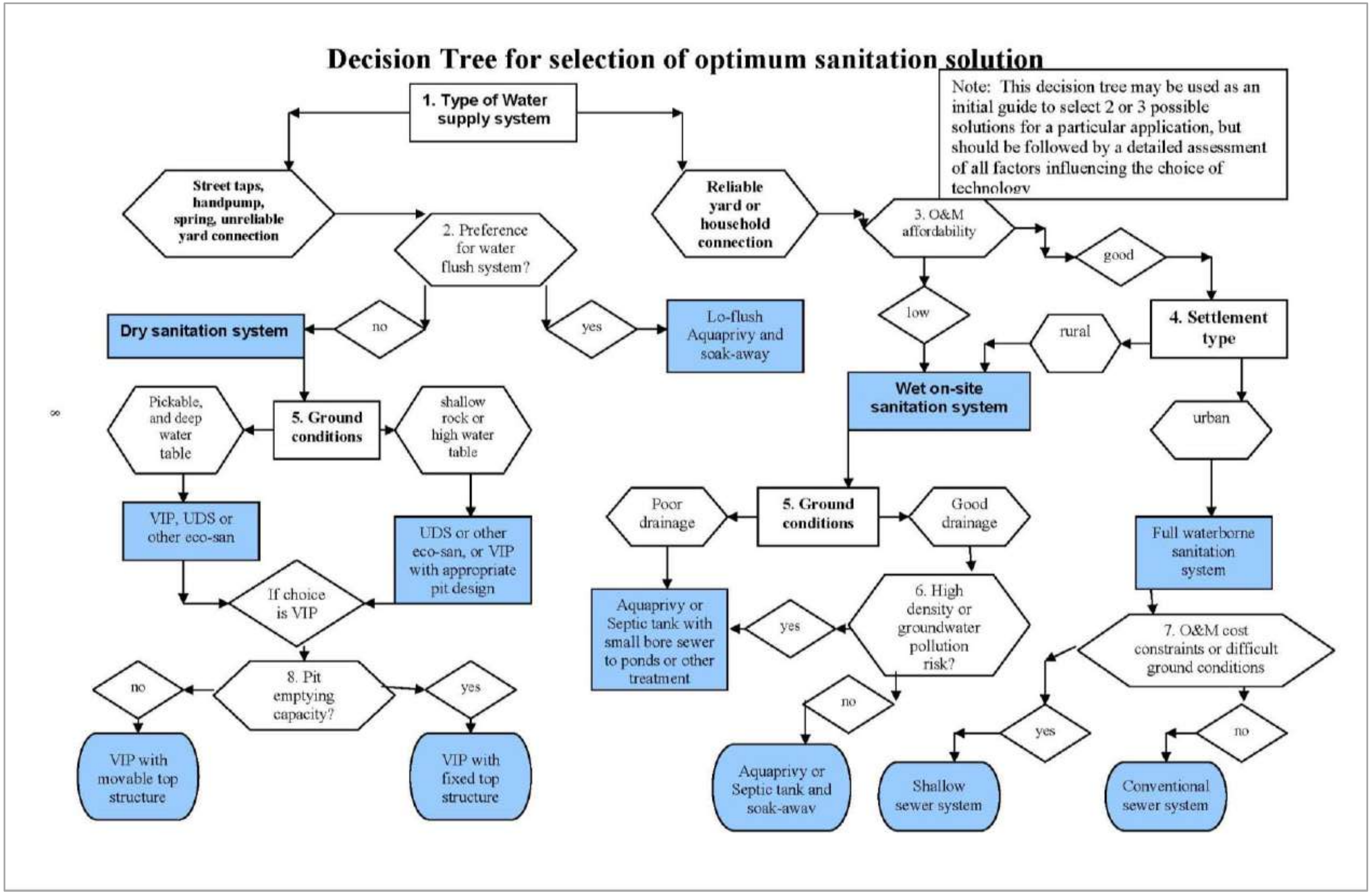


Figure 4.19: Decision Tree for Selection of Optimum Sanitation Solution.

Conversion of Single Pit Latrine into Twin Pit Latrine

Single pit latrine is not fully sanitary latrine a there is highly potentiality of fly breeding. In addition to this, there is much possibility of risk about falling into the latrine and ground water pollution as well. Furthermore, desludging is necessary in every 3-5 years which is omitted sometimes due to lack of hygiene knowledge and others. In these backdrop, technical team has planned to conversion of 250 single pit latrine into twin pit latrine

Construction of Twin Pit Latrine

Twin-pit latrines are improved pit latrines, which allow on-site treatment and transformation of fecal sludge into a hygienized soil amendment. They have been constructed over the past 30 years mainly in India, Bangladesh and Nepal. They basically consist of two pits (similar in design to soak pits), which are linked, using a Y-junction, to a single pour-flush toilet. Twin pit latrine is a complete disposal system which is capable of fulfilling all sanitary requirement. In other word, twin pit latrine provides continuous operation with minimal effort. The content of the pit filled with organic humus and safe for manual cleaning in about two years. After considering its advantageous aspect, technical team has planned to construction of 400 twin pit latrine throughout the village.

Table 4.2: Technological Solutions related to Sanitation for Arsenic Contaminated Areas

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
Saikchail, Bipulasar, Manoharganj, Cumilla.	1. Pit Latrine 2. VIP Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine 3. Flash Latrine 4. Septic tank flash Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine
Tipna, Kharnia, Dumuria, Khulna	1. Pit Latrine 2. Septic tank Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine 3. Flash Latrine 4. Septic tank flash Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine
Datinakhali, Labsa, Shyamnagar, Satkhira	1. Pit Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine 3. Flash Latrine 4. Septic tank flash Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine
Shimulbank, Shimulbank, Shantiganj, Sunamganj	1. Pit Latrine 2. Septic tank Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine 3. Flash Latrine 4. Septic tank flash Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine

4.2 Guideline for Proposed Intervention

Technical guidelines for the proposed interventions about water supply are tabulated below:

Sl.	Intervention	Technical Guidelines
1.	Submersible Tubewell	• Topping up the motor: The submersible motor is supplied pre-filled with a mixture of clear cold drinking water and anti-corrosive liquid. The following steps are executed prior to installation: • Position the motor vertically on its base. • Check if all fasteners are tight. Tighten if required. • The two threaded plugs provided at the top/circumference of the cable box are removed. • Check the motor and if required, top up the motor with clear cold drinking water. • Air bubbles, if any, are removed by gently rocking the motor to and fro. • Check water level in the motor and if required, top up with cold clear water. • The two threaded plugs are then re-assembled, ensuring the motor is encapsulated. • Dry the exterior of the motor and check thoroughly for water leakage. • If there is no leakage, the motor is now ready for coupling with the pump and then installation.
2.	Pond Sand Filter (PSF)	• The filter bed must be permanently submerged and a minimum flow of the water must be maintained to provide the microorganisms in the filter bed with a stable flow of nutrients and oxygen. Users must pump into the unit in order to draw from the outlet. • The inspection cover has to be closed at all times except during the cleaning of the PSF. • The raw water quality and the treated water quality must be monitored, especially for bacteriological quality, on regular basis. • The main maintenance activity of the PSF is the cleaning of the filter when the filtration rate falls below the tolerable rate. • The cleaning of PSF mainly comprises scraping off 3 inches of sand from the top of the filter and replacing with clean sand. The scraped sand is washed, dried in sun and stored for future use. • The users of the system can normally execute all operation and maintenance specifically cleaning is simple but should be given much attention. • PSF is proposed for the village Datinakhali where Groundwater supply from tubewells is not a reliable and sustainable for this area and therefore, test well drilling is not required for this area.

Sl.	Intervention	Technical Guidelines
3.	Water Treatment Plant: Arsenic Iron Removal Plant (AIRP)	• AIRPs are simple treatment units consisting of two cement tanks that utilize the principles of oxidation and co-precipitation of iron to remove arsenic. • Groundwater moves up through a hand pump from a tube-well and over a perforated plate, called an aeration tray, and down into the first cement tank, called the aeration tank. Ferrous iron, naturally present in the groundwater of Bangladesh, is oxidized by the introduction of oxygen through the aeration tray and iron oxides are subsequently formed. The newly formed iron oxides act as a strong sorbent for arsenic species, causing co-precipitation. • The arsenic removal capabilities of the AIRP require regular maintenance. Cleaning is recommended to occur every 3–4 weeks; this period comprises what is known as a 'cleaning cycle'. • Regular cleaning requires that both tanks are emptied and the filter materials are removed for external cleaning. • Immediately after cleaning, the efficiency of the AIRP is low due to an insufficient residence time of water, since upon filling, water moves rapidly though the AIRP. Ten to 20 hours are needed for adequate settling of iron-oxide precipitates, and thereby arsenic removal. • Optimal efficiency of the AIRP is achieved mid-cleaning cycle. • AIRP is thought to be introduced in Datinakhali village where surface water treatment is necessary to drink arsenic & iron free water.
4.	Reverse Osmosis Plant (RO)	• Reverse osmosis is a filtration method, used to remove the particles including ions from the water, contains a semi-permeable membrane that allows the water passing and rejects the contaminants. • RO system removes the salts, sugars, proteins, dyes, bacteria and other particles having a molecular weight greater than 250 daltons even viruses. • Pump creates pressures to pass the water through membrane for separating water from contaminants. • Generally, the RO system recovers 70-80% of feed water and the efficiency depends on the using frequency of membrane. • The membranes are commonly made of cellulose acetate having a very small pore size ranging from 0.01µ to 0.0001µ. RO membranes are used having the pore size of 0.0003µ. • No microorganism can pass through this membrane. • This membrane is fitted in a hollow tube where the water is passed from outside to the inner side of the rube through the membrane. The filtered water is collected from the hollow tubing and the remaining water containing water contaminants is collected separately. • RO plant is proposed for the village Datinakhali, as the area is both arsenic and saline prone.
5.	Rainwater harvesting Plant	• Feasible where average rainfall is 1600 mm per annum. • There should have required catchment area for rainwater harvesting. • Surface run-off rainwater harvesting is appropriate for the location. • Both storage and storage with GW recharge collection system can are suitable for Datinakhali.

Sl.	Intervention	Technical Guidelines
6.	Mini Piped Water Supply	• Community that has clustered housing. • Serving more than 10-15 families at a time • Have Electrical Connection • Source water must satisfy the recommended drinking water quality standards. • Regular maintenance needs to be ensured. • Requires larger space than regular Tubewell.
7.	Rural piped water supply	• Suitability and modality of the scheme is to be thoroughly investigated. • User Group should demand the facility and are prepared to pay tariff. • A significant amount of land is required. • Primary Survey of the proposed area is required. • Water Quality will confirm the need for treatment Plant.

Technical guidelines for the proposed interventions about Sanitation are tabulated below:

Sl	Intervention	Technical Guidelines
1	Twin Pit Latrine	• The pits should be of an adequate size to accommodate a volume of waste generated over one or two years • For a family of 5 members, a pit about 1 m deep and 1 m around should be enough for three years (HESPERIAN FOUNDATION 2004) • Toilet will be located directly over the pits or at a distance from them • Toilets can also be constructed inside the house, while the pits can be situated outside the house • Pits should not be situated in drainage lines, the paths of storm water drains or in depressions where water is likely to collect in order to prevent water from entering the pit which can cause groundwater pollution or destabilize the constructions • The pit shape can be circular or rectangular, but circular pits are more stable and cost less (ROY et al. 1984) • It is recommended that the twin pits be constructed 1 m apart from each other to minimize cross-contamination between the maturing pit and the one in use. If the spacing between the two pits has to be reduced, an impervious barrier should be provided between them • It is also recommended that the pits be constructed over 1 m from any structural foundation as leachate can negatively impact structural supports.
2.	Single pit to twin pit latrine	• Single Pit Latrine that in being converted to Twin Pit Latrine must be in operational. • Water for washing should be adequate. • For Conversion Single Pit must be offset from latrine super structure. • For Proper Handling of the feces to pits, a Y shaped inspection Pit is required. • The Toilet should be in usable form. Otherwise latrine repair cost is to be added with the estimated cost.

4.3 Guideline for Existing Intervention

The guideline of the water supply about existing intervention by DPHE:

- Participation of users in planning, development, operation and maintenance through local government and community-based organizations of the stakeholders;
- Development of water supply through local bodies, public-private sector, NGOs, CBOs and women groups involving local women particularly elected members (of the local bodies in the sector development activities).;
- Close linkages between research organizations and extension agents/implementing agencies;
- Social mobilization through publicity campaign and motivational activities using mass media among other means to ensure behavioral development and change in safe water using practice and hygiene;
- Capacity building at the local/community level to deal effectively with local water problems;
- Mobilization of resources from users, GOB and development partners for implementation of activities of the sector in a coordinated manner based on targeted plan of action;
- Regular qualitative and quantitative monitoring and evaluation to review progress of activities and revision of the strategy based on experiences;
- Wherever feasible safe water from surface water sources shall be given precedence over other sources; and
- With a view to controlling and preventing contamination of drinking water, regular and coordinated water quality surveillance by Department of Public Health Engineering (DPHE),
- National Institute for Preventive & Social Medicine (NIPSOM), Atomic Energy Commission and Department of Environment (DOE) need to be involved and random testing of quality of drinking water (including bottled water) by DPHE, Bangladesh Standard Testing Institute (BSTI) and DOE to determine the level of contamination;

The guideline of the sanitation about existing intervention by DPHE:

- Development of sanitation sector through local bodies, public-private sector, NGOs, CBOs and women groups involving local women particularly elected members (of the local bodies in the sector development activities)
- Adoption of water supply and sanitation technology options appropriate to specific regions, geological situations and social groups
- Improved understanding of sanitation is mandate issue, as once the people realize the bad consequences of improper sanitation, and the benefit of improved sanitation, they would spontaneously be interested to participate in any sanitation program. Training at community level, local level workshops, video films, group discussions etc. are very effective media to increase the knowledge of people of water supply, sanitation and their implications with health and environment
- After having the knowledge on health and sanitation, people should know the ways and means to face the sanitation problems. Specially, the concerned groups of people including members of local authorities, VSC, NGOs and CBOs should know the technology of low cost sanitation options particularly for hilly areas

- Providing sanitation facilities to the poor at free of charge and a tax concession to the well to do people is a good strategy to increase sanitation coverage
- For the community latrine, it is essential to appoint someone to look into the managerial aspects of the communal latrine
- Motivation is required to improve unhygienic sanitation practices
    - More local and mobile Village Sanitation Centre (VSC) should be established to make people feel inspired when see a mason producing ring-slab at their local market and others from the neighborhood also buying those.
    - To make clear about the benefit of having a hygienic sanitation facility to the people, motivation of the people about using sanitary latrine need to be conducted continuously.
    - To make people understand about the importance of improved sanitation facilities and turn them interested to take it, repeated stimulation can put contribution.
    - Awareness of health and hygiene can be raised for a successful sanitation program. Posters, leaflets, and video films can be used to raise the level of awareness at the local level. Among all communication materials, video film is very attractive and effective as well in motivating people
- An integrated approach combining water, sanitation, and hygiene education for achieving overall success in the improvement of general health, the quality of life, and the environment
- Capacity building of the local authority, as well as the CBOs towards the sustainable development of the overall sanitation program, should be strengthened

4.4 Perception on Proposed WASH Interventions

The four pilot villages in arsenic contaminated area have faced water scarcity and sanitation problem. So, some interventions have been proposed for the area through assessment and based on people's opinion. People believe that the discussed interventions in chapter 5 will mitigate the crisis regarding water supply & sanitation, they are facing now. Having latrines was associated with hygiene and a desire to live in a clean environment in the population studied, and was regarded as a basic need. The heads of household interviewed mentioned no stigma or cultural prohibitions to the use of latrines or the practice of open defecation. On the other hand, they believed that owning a latrine increased one's prestige or social standing in the community. The perceived benefits of the interventions on the health and well-being of the population support their continued use. Individuals expressed a preference for improved water sources and latrines. When the systems were built, having water at home was considered a "blessing" that outweighed budgetary constraints or time spent performing economic activities. Lack of knowledge about disease pathways, a lack of funds, and prioritization of other activities were major limiting factors for those without access to sanitation and water services. Concern for children's health and knowledge of disease pathways appear to be important factors in adopting and maintaining preventive behaviours. This emphasizes the importance of continuing to educate women and caregivers about the microbiological and chemical causes of disease in order to ensure long-term use of improved water and sanitation. Time spent on water treatment reflects concern about water safety and illness transmission. Though household heads may be discouraged from using point-of-source chlorination due to perceptions of bad taste or danger, education in household water treatment must be reinforced by emphasizing the use of alternative techniques such as filtration or solar disinfection or elucidating the benefits of chlorination prior to financial feasibility.

In participant interviews, comparisons between communities were frequently observed. According to research, users' perceptions of satisfaction are higher when they believe they have better services than their peers. Interviewees intend to compare their communities to others in order to express satisfaction or dissatisfaction with the interventions received. As a result, perceptions of inequality regarding the quality of services and infrastructure received, as well as opportunities for support and participation, were raised. These findings emphasize the importance of understanding the factors that promote similar levels of participation and the provision of WASH infrastructure within and across neighboring communities in order to improve perceptions of equity, particularly during post-disaster events.

4.5 Socio-Economic Impacts of the Proposed Interventions

Social and economic beneficiary are the main priority whenever we implement an intervention. Intervention may have positive or negative impacts to the environment. The project will get acceptance if it has more positive impacts than negative impacts. Economic condition is also a parameter to successfully implement the project.

Positive socio-economic impacts of the proposed interventions are-

- Water availability will be ensured throughout the year. So, water crisis will mitigate;
- Ensure safe drinking water;
- Water & excreta diseases is the main cause of mortality and morbidity in Bangladesh. Providing safe drinking water and proper sanitation will help them to overcome it;
- It will mitigate the time duration for the collection of water;
- People don’t need to purify water;
- For drinking water purpose, people need to use many types of pot for boiling; Implementation of the project will reduce the cost in this regard;
- Many people purchase water for drinking purpose. Thus, people will be benefited financially.
- Open defecation and poorly managed latrines affect the environment. So the proposed intervention will mitigate this problem too.
- Sufficient water will help to irrigate crop. Thus, it will increase the production. More income source will be created.

Negative socio-economic impacts of the proposed interventions are-

- As there are no maintenance group, there will be a huge gathering of people. As a result, social confliction may rise related to distribution;
- Land requisition confliction may occur;

If waste disposal does not dismantle properly, it will generate odour and unhygienic condition.

4.6 Issues and Challenges

The sustainability of human health, particularly among children, highly depends on access to safe drinking water and minimal sanitary conditions. The most frequent cause of illness and death among the underprivileged in developing nations is water-related disorders. So, safe drinking water and sanitation is a basic needs of human rights.

People of those surveyed villages are unprivileged and also illiterate. The do not aware of the safe drinking water. Therefore, it is the responsibility of government to ensure them a safe drinking water and proper sanitation. However, there are some issues and challenges arise following the conditions. In terms of modernizing both water supply and sanitation aspects, some issues and challenges arise. The following issues and challenges have been discussed below.

Tipna

The village is covered with deep tubewells in which 50.78% is govt. deep tubewell, 23.06% people use neighbor's tubewells and 18.68% personal tubewell. The water availability prevails in around 90.54% tubewells but remaining tubewells experience scarcity of water due to lowering down of water level from the month March to May. The water quality of 0.78% household is bad and the main reason behind it is presence of iron (Fe). The main challenge of this village is to face the salinity and iron (Fe) problem. Deep tubewell over 700ft from the ground level is giving good service showing no arsenic and salinity. People demanded to build water reservoir in this village. The sanitation condition is good showing 75.5% houses have toilets although a few people still have no toilets. So, for those people community toilets can be built in nearby local markets and highways.

Datinakhali

Datinakhali is not a successful region for tubewells. The tubewells contain between 3500 and 4500 PPM of saline. Due to the Iron's (Fe) presence, the water quality is poor in 19.6% households. 52.3% of tubewells have an arsenic issue. Pond sand filters and rainwater collection are the main sources of drinking water. Around 32.5% households meet up their water demand by collecting rainwater in monsoon. Other times of the year, water is collected from the three PSF in the studied village. Actually, water availability depends on the frequency of raining, there is a problem getting water to the house if the rain is not adequate. Two or three times a year, the village protection embankment breaks, allowing floodwater to surge through, flooding the PFS ponds during emergencies. There is prominent scarcity of drinking water source due to Arsenic (As) & Iron (Fe). People have to buy water for drinking purpose with a high price from different NGO or running project. The installation of community-based RO plants is a feasible solution for the provision of drinking water in this area. Rainwater harvesting systems are another practical choice that the locals prefer. Here, the state of sanitation is poor stating that 66.8% houses have toilets in this village.

Saikchail

Hand tubewells are found in 51.27% households where 10.41% houses use their own pump tubewells. 25% people use neighbor's tubewell for collection of water. The water quality of 17.13% houses is below the average level just because of presence of Iron (Fe). Water availability throughout the year remains in 96.19% tubewells and the remaining tubewells face unavailability of water for lowering down the water level from the month March to April. The main challenge is tubewell water possesses Arsenic (As) & Iron (Fe) and the level of groundwater is declining. Again, the sanitation condition is not up to the mark as 65.7% houses have toilets only where only 6.5% are double pit latrines.

Shimulbank

At present, the village contains 31 Government Tubewell No.-6 deep tubewell which depth is averagely 650ft. The main problem is Arsenic (As) prevailing in shallow depth tubewell water but the village is successful deep tubewell area. But the sanitation quality is poor having only toilets in 59.64% houses.

4.7 Selected Option for Intervention

Final selected Interventions for Water Supply in arsenic contaminated area

Name	Final Selected Options
Saikchail, Bipulasar, Manoharganj, Cumilla.	Mini piped Water supply Submersible tubewell
Tipna, Kharnia, Dumuria, Khulna	Submersible tubewell
Datinakhali, Labsa, Shyamnagar, Satkhira	Rainwater harvesting Pond with sand filter Water treatment plant
Shimulbank, Shimulbank, Shantiganj, Sunamganj	Rural piped Water supply

Final selected Interventions for Sanitation in arsenic contaminated area

Name	Final Selected Options
Saikchail, Bipulasar, Manoharganj, Cumilla.	Conversion of single-pit latrine to twin pit latrine Complete twin-pit latrine
Tipna, Kharnia, Dumuria, Khulna	Conversion of single-pit latrine to twin pit latrine Complete twin-pit latrine
Datinakhali, Labsa, Shyamnagar, Satkhira	Conversion of single-pit latrine to twin pit latrine Complete twin-pit latrine
Shimulbank, Shimulbank, Shantiganj, Sunamganj	Conversion of single-pit latrine to twin pit latrine Complete twin-pit latrine

5. Design and Cost Estimation

5.1 Introduction

This section covers water availability, accessibility, water sources, water supply design, sanitation design, climate change risk assessment, water point maintenance, water quality, ownership of water source, and problem faced in access to and collection of water in the project areas and also different practices (collection of water, water use for different purposes, expenditure for water etc.) by the households. People's hygiene mostly depends on necessary supply of water for drinking, cooking, domestic work and personal hygiene.

5.2 Water Supply System Design

The water supply system design of the finally selected option of the four arsenic contaminated villages are given below:

Saikchail, Bipulasar, Manoharganj, Cumilla

The selected option for Saikchail village of Cumilla district is mini piped water supply and submersible tubewell. The detailed design of those interventions are given below:

Mini Piped Water Supply

Mini Piped water supply scheme consists of three parts. One tubewell with Submersible Pump, Raised Platform (typically 15 ft height) for food grade plastic water tank of capacity 3000 Litre, one valve distribution chamber and 10 nos (Typically) individual collection point for each user. Tubewell must be safe from arsenic and iron contamination for additional treatment unit will rise the cost of the scheme. Proper electrical and pump related maintenance is a must for this scheme to be successful. Generally, this scheme is mostly suitable for compacted settlements, where approximately 10-15 families stay together in a close proximity. Rather than providing individual tubewell for each family one large unit can ensure safe water supply to all. DPHE will be responsible for the design of the

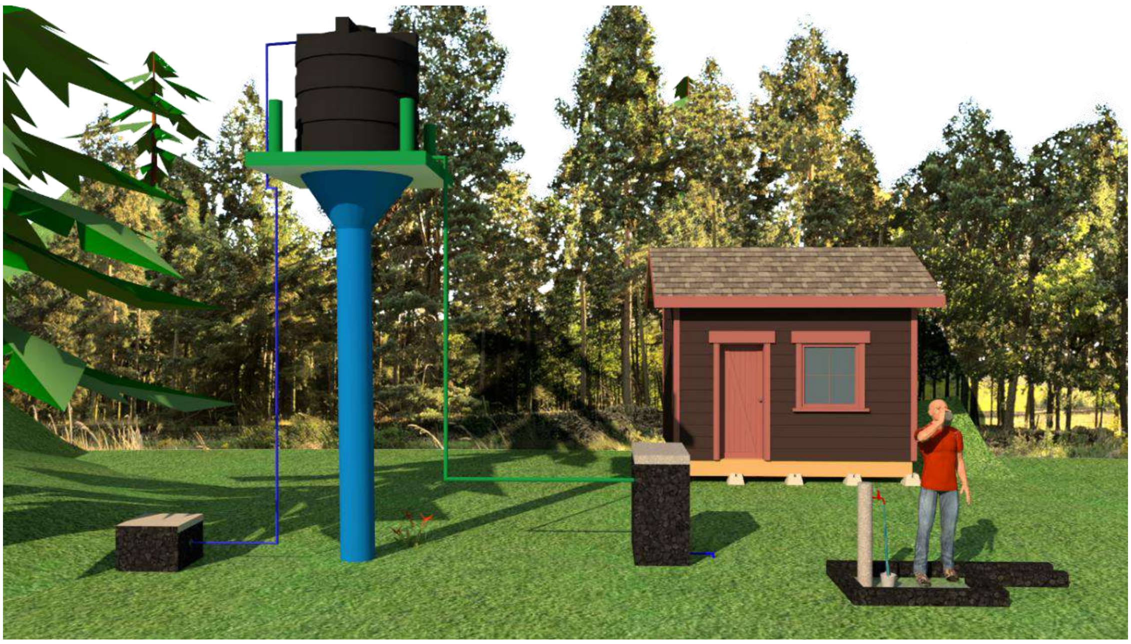


Figure 5.1: Schematic view of mini piped water Supply

tubewell and structure to be provided. Operation and Maintenance of the scheme is to be conducted by the user community.

Technical Guideline

This intervention is to be used where the following criteria match: -

- Community that has clustered housing.
- Must serving more than 10 families at a time
- Have electrical connection
- Where Water Quality is Significantly Better
- Regular maintenance is Ensured
- Requires Larger space than regular Tubewell

I. Area wise Technical Feasibility

Figure 5.2: Mini Piped Water Supply System

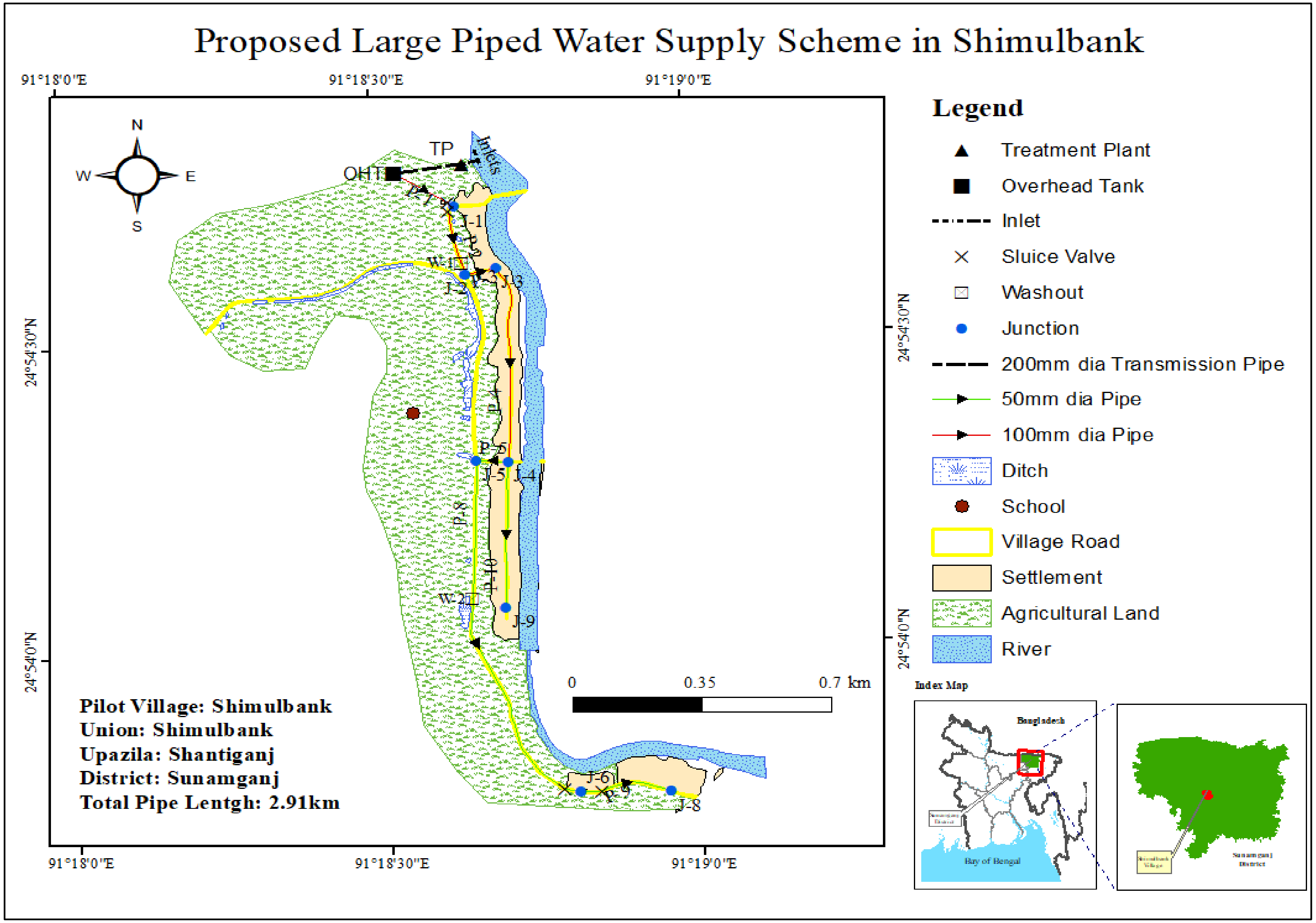


Figure 5.3: Proposed Large Piped Water Supply Scheme in Shimulbank

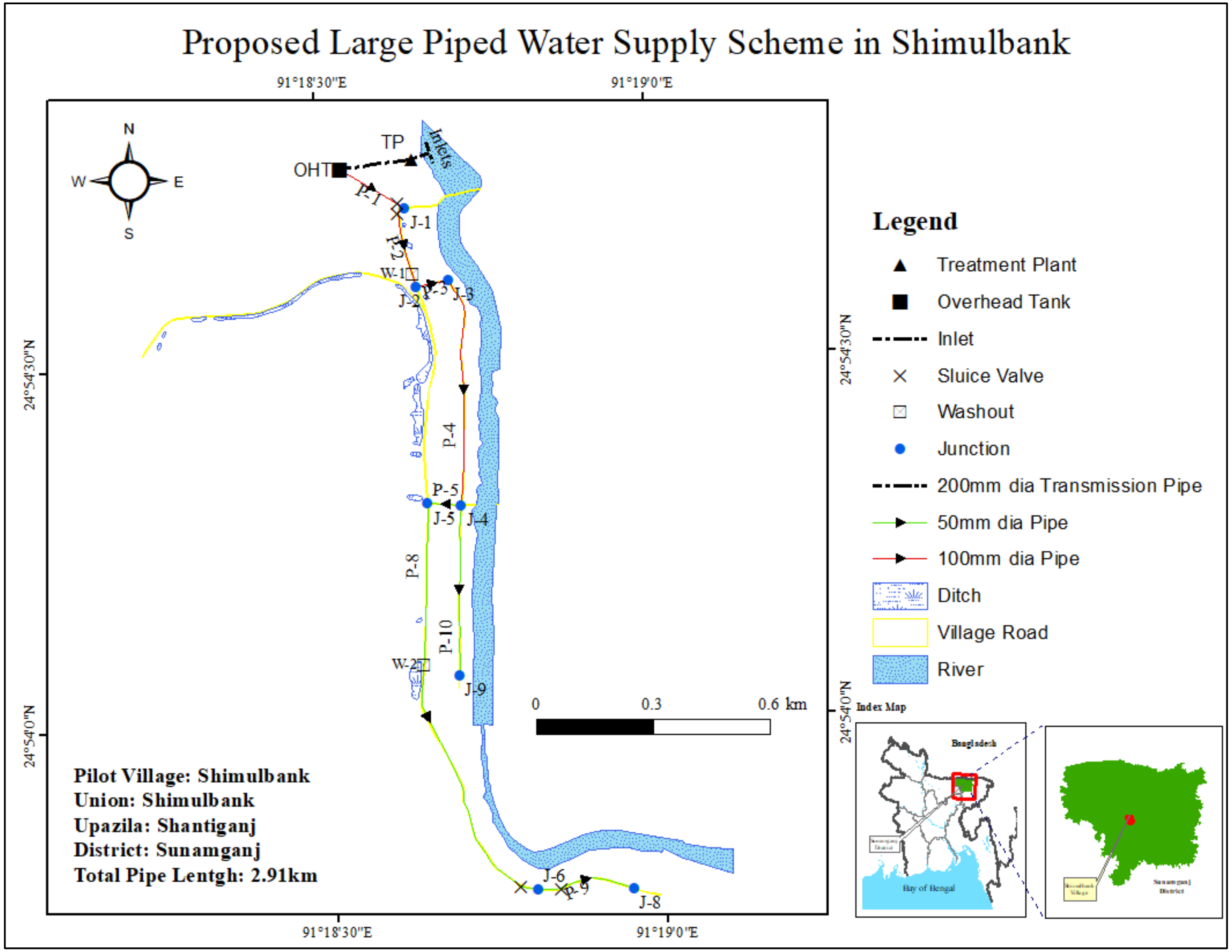


Figure 5.4: Detailed Pipe Network for Piped Water Supply Scheme in Shimulbank Village

The pipe schedule in different reaches/sections is given in Annex III.

Pipe Table

Pipe ID	Length (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Minor Loss Coefficient (Local)	Flow (L/Day)	Velocity (m/s)	Head loss Gradient (m/m)
P-1	39	T-1	J-1	100	uPVC	150	0	391,314	0.58	0.003
P-2	308	J-1	J-2	100	uPVC	150	0	362,937	0.53	0.003
P-3	84	J-2	J-3	100	uPVC	150	0	339,827	0.5	0.003
P-4	590	J-3	J-4	100	uPVC	150	0	291,389	0.43	0.002
P-5	85	J-4	J-5	50	uPVC	150	0	101,389	0.6	0.008
P-10	436	J-4	J-9	50	uPVC	150	0	90,000	0.53	0.006
P-8	1,107	J-5	J-6	50	uPVC	150	0	84,700	0.5	0.006
P-9	255	J-6	J-8	50	uPVC	150	0	53,156	0.31	0.002
Total Pipe Length	2904									

II. Discussion

The prime goal of the design of this water supply distribution system is to satisfy consumer needs providing with reliable, continuous and pressurized water supply system as well as minimizing cost for the implementation and operation of the system.

The piped network may get water supplies from several point sources of production wells as well in future. At meeting points of flows from various sources, the velocity in the water main may be low, but high pressure may exist. Therefore, the situation will not affect the flow leading to branch lines.

For obvious reason, pressure in pipes close to pump house would be high. Valve or fixture for reducing pressure may be adopted.

Figure 5.5:: Intake Pontoon Station

Operation and Maintenance

The project would be implemented by DPHE. Village authority would establish "Water Supply Section" and employ necessary manpower to ultimately takeover the water supply system from DPHE for its day-to-day operation and maintenance. During implementation, DPHE would provide necessary training to the relevant staff of the Water Supply Section. Village authority would be empowered to impose water tariff, collect the same and spend the money for O&M of the system.

5.3 Sanitation Design

The sanitation design of the finally selected option of the four arsenic contaminated villages are given below

Conversion of Single Pit to Twin Pit Latrine

Introduction

When single pit latrines fill, a new latrine should be built, or the pit emptied. Single pit latrine users must spend money to buy new latrine components or hire pit emptying workers. Manually emptying fresh excreta presents a number of health risks, including exposure to helminth eggs. The emptying process also has the potential to contaminate the household environment and surrounding areas where the fresh excreta are released.

Double pit latrine systems address many of the problems inherent in the single pit latrine design. When the first pit fills, users divert the waste stream to the second pit and allow the contents of the first pit to decompose. Users thus move the superstructure from one pit to another, or redirect the tube or pipe leading away from the toilet, from the full pit toward the empty pit. Pathogens, including helminth eggs, are greatly reduced in the decomposition process. After the excreta in the first pit decompose, the excreta can be safely emptied by household members and used as soil amendment in homestead gardening. The decomposition process usually takes 12–18 months, and during this time, household members use the second pit.

Given the limitations of single pit latrines and the health hazards associated with emptying fresh excreta, the converting single pit to double pit pour-flush latrine system may greatly improve sanitation in areas like Bangladesh. Householders may be less resistant to use latrines that offer a feasible solution (and a beneficial by product) to pit emptying. Despite these benefits, there are some barriers to scaling up double pit pour-flush latrines. These barriers may lead governments and NGOs to hesitate to invest in them.

Technical Guideline

First, they are more expensive than single pit latrines.

Second, they require sufficient space for the second pit, which is often unavailable in higher density settings even in rural villages.

An offset double pit latrine where the superstructure remains in place and the waste stream is diverted to the second pit also requires careful construction to ensure proper flow.

I. Area Wise Technical Feasibility

Single to Twin Pit Latrine Conversion Proposed						
SL	**District**	**Upazila**	**Union**	**Village**	**Household**	**Single Pit to Twin Pit Latrine Conversion**
1	Sunamganj	Santiganj	Shimulbank	Shimulbank	382.00	195.00
2	Satkhira	Shyamnagar	Burigoalini	Datinakhali	993.00	410.00
3	Cumilla	Monoharganj	Bipulshar	Saikchail	1164.00	390.00
4	Khulna	Dumuria	Khurnia	Tipna	624.00	300.00
				Total	**3163**	**1295**

II. Design Considerations

- Single Pit Latrine that in being converted to Twin Pit Latrine Must be in operational
- Water for washing should be adequate
- For Conversion Single Pit must be Offset from latrine super structure
- For Proper Handling of the feces to pits, an inspection Pit is required, it is a Y-shaped simple mechanism.
- The Toilet should be in usable form. Otherwise, latrine repair cost is to be added with the estimated cost.

III. Schematic Drawing

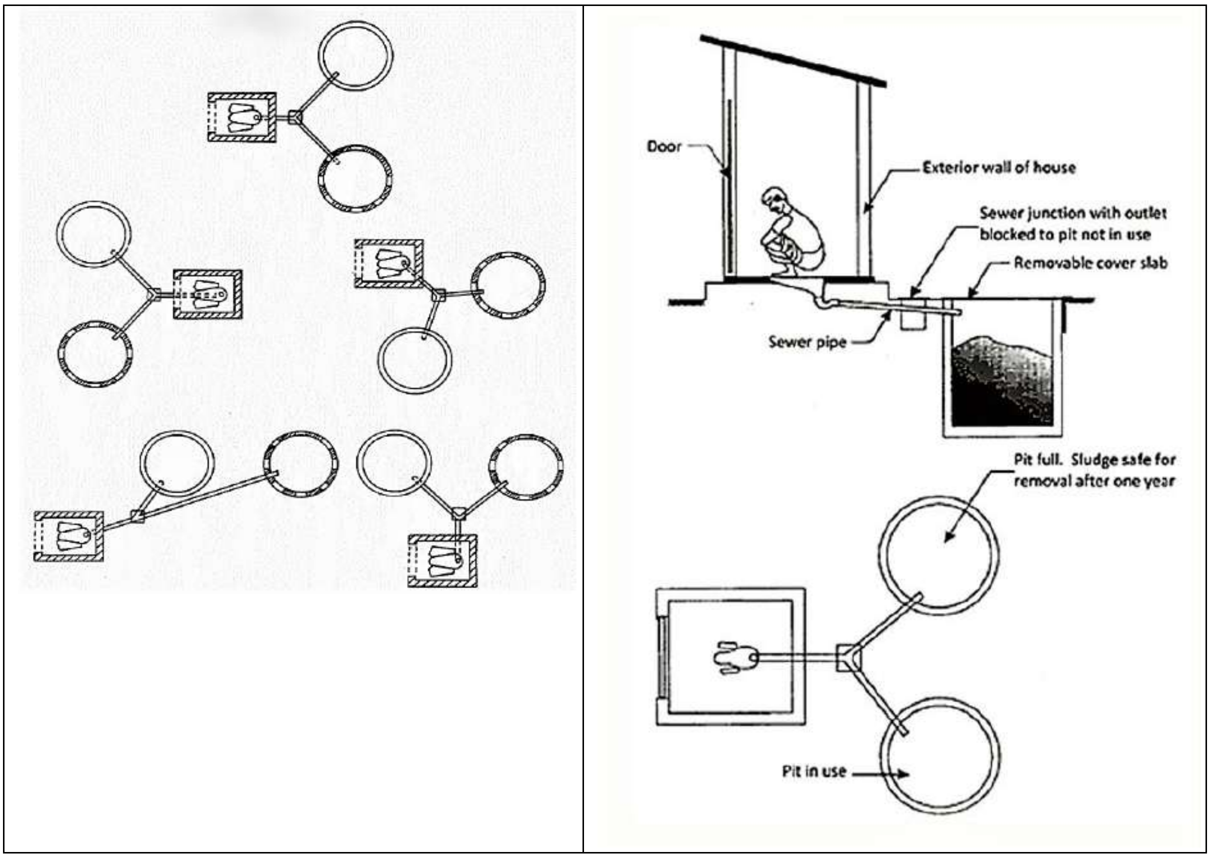


Figure 5.6:: Schematic diagram of conversion of single pit latrine to twin pit latrine.

Twin Pit Latrine

<u>Introduction</u>

When a single pit latrine becomes full, users must empty it themselves and risk exposure to fresh feces, pay an emptying service to remove pit contents or build a new latrine. Double pit pour-flush latrines may serve as a long-term sanitation option including high water table areas because the pits do not need to be emptied immediately and the excreta decomposes into reusable soil.

The rural households accepted the double pit pour-flush latrine model and considered it feasible to use and maintain. This latrine design increased accessibility of a sanitation facility for these low-income residents and provided privacy, convenience and comfort, compared to open defecation. Although a double pit latrine is costlier and requires more space than a single pit latrine the households perceived this sanitation system to save resources, because households did not need to hire service workers to empty pits or remove decomposed contents themselves. In addition, the excreta decomposition process produced a reusable soil product that some households used in homestead gardening. The durability of the latrine superstructures was a problem, as most of the bamboo-pole superstructure broke after 6–18 months of use. So, building with brickwork extends service life of latrine to 5-8 years.

<u>Technical Guideline</u>

Where water is accessible, adequate land area and resource are available, Offset Twin pit may be built.

The black water (and in some cases greywater) is collected in the pits and allowed to slowly infiltrate into the surrounding soil.

Over time, the solids are sufficiently dewatered and can be manually removed with a shovel and reused on-site, much like compost, to improve soil fertility and fertilize crops.

As the option takes care of sludge management, it is more appropriate where sewerage system will not be implemented in near future.

Efficient water seal/trap (75mm dia) may be used to avoid overflowing from a pit in soils of finer particles.

A latrine with six rings of 0.75 m dia may be filled up with sludge of a family of five members in about 2.5 years (sludge accumulation rate is 0.05 cum/per/year). When one pit is filled with sludge it is covered with soil or ash and kept in rest for at least one year to turn sludge into harmless humus which may be used in agriculture. The second pit is brought under use alternatively.

The alternate use of the pits continues for indefinite period.

Appropriately designed Twin Pit latrines may also be used as community latrine.

I. Area Wise Technical Feasibility

Twin Pit Latrine Proposed						
SL	**District**	**Upazila**	**Union**	**Village**	**Household**	**Twin Pit Latrine**
1	Sunamganj	Santiganj	Shimulbank	Shimulbank	382.00	105.00
2	Satkhira	Shyamnagar	Burigoalini	Datinakhali	993.00	198.00
3	Cumilla	Monoharganj	Bipulshar	Saikchail	1164.00	205.00
4	Khulna	Dumuria	Khurnia	Tipna	624.00	145.00
				Total	**3163**	**653**

II. Design Considerations

For Pit Size Calculation:

For design purposes, the sludge accumulation rate is:

=0.067 m^3 /p/yr (Under wet condition, i.e., where the groundwater table is above the pit bottom at any time of the year (Roy et al., 1982)

=0.045 m^3 /p/yr (Under dry condition, Roy et al., 1982)

=0.025~0.034 m^3 /p/yr (Under wet condition of pit with ablution water, Wagner and Lanoix, 1958, and Bhaskaran, 1962)

=0.09 m^3 /p/yr (where anal cleaning materials like stones, mud balls, corn-cobs and cement bags are used and which are not readily decomposed) ; and

Long Term Septage Acceptance Rate (LTAR) of soil **(Cairncross and Feachem, 1983)**

Soil	Infiltration Capacity/m2/day	
	Sewage	Sullage
Sand	50	200
Silts and Loam	30	100
Clay	10 or less	50 or less

III. Schematic Drawing

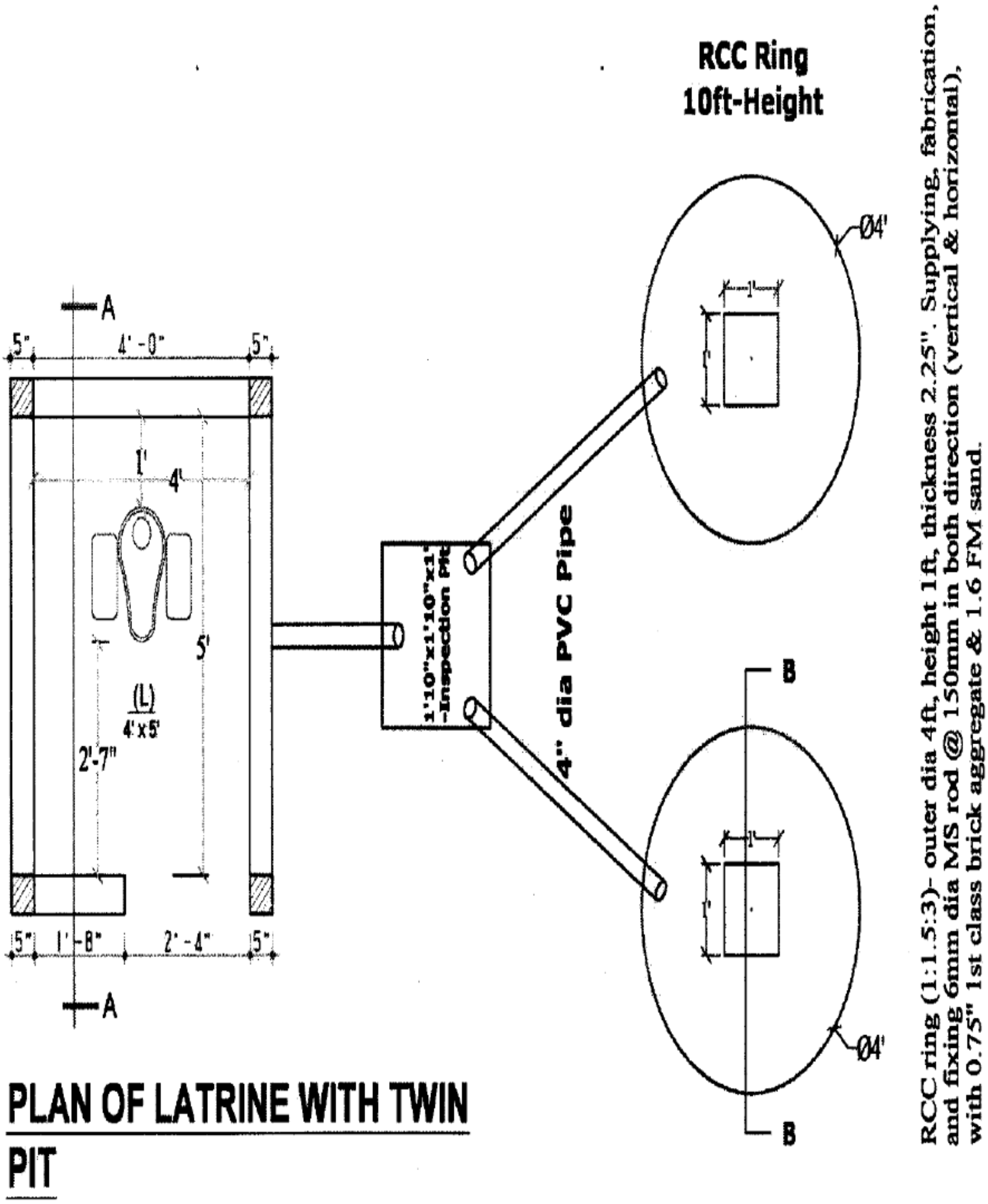


Figure 5.7: Plan View of Twin Pit Latrine.

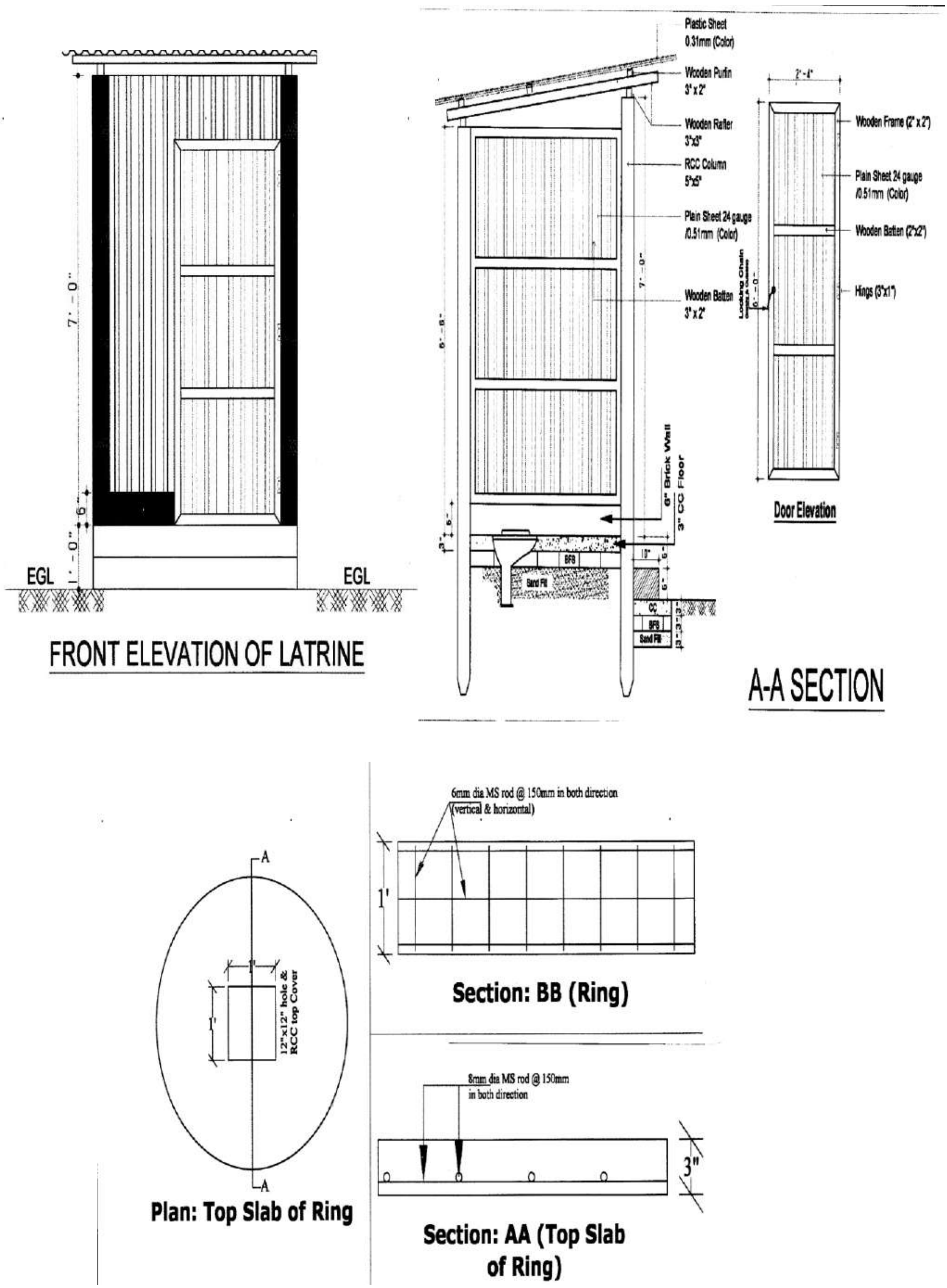


Figure 5.8: cross-section of Twin Pit Latrine

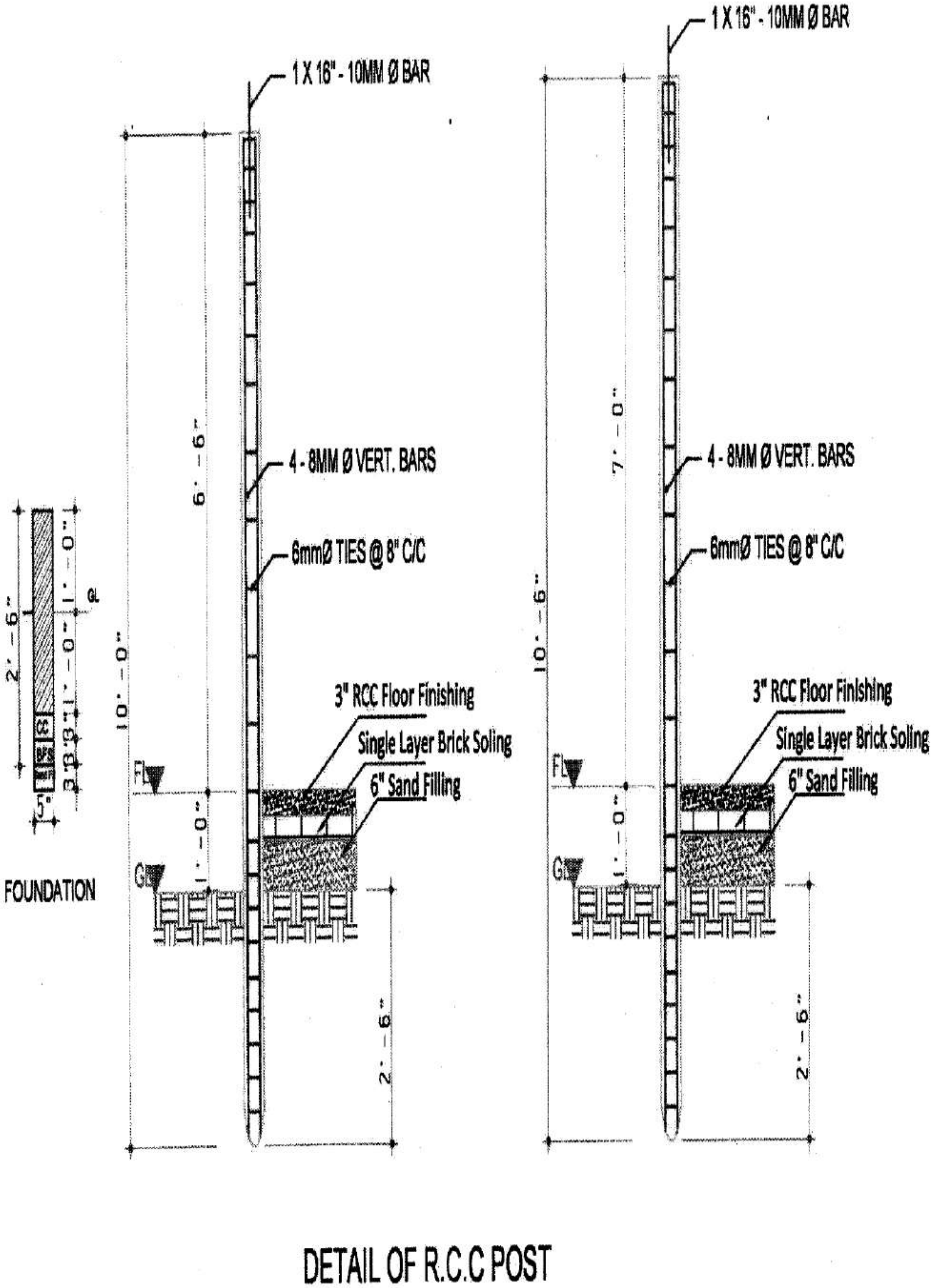


Figure 5.9:: Detail R.C.C design of Twin pit Latrine.

5.4 Cost Estimation

The cost estimation of the finally selected option for water supply system of the four arsenic contaminated villages are given below

Saikchail, Bipulasar, Manoharganj, Cumilla

The selected option for Saikchail village of Cumilla district is mini piped water supply and submersible tubewell. The detailed cost estimation of those interventions are given below

Mini Piped Water Supply

Tentative Cost Estimate

Tentative Estimate for Construction of Mini Piped Water Supply scheme by installing 100mm x 50mm dia tubewell with 1.5 hp Submersible Pump

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
Part-A	**Installation of 100mm dia Deep Tube well**	n/a	0.001	0.001	0.00
1	**Transportation**: Transportation of all kind of materials/equipment's to the site for installation of 100 mm x 50 mm dia tube well with supplying of casting pipe, boring pipe, construction of derrick and dismantling the same, cleaning the site after completion of work etc. all as per direction of the Engineer-in-Charge.	LS	1.00	5,000.00	5,000.00
2	**Boring & Drilling**: Boring to install 100mm x 50mm dia tube well by using 150/200 mm diameter cutter with 38 mm dia GI pipe and other equipment's capable of drilling up to required depth by water Jet method or any other method approved by the EIC through all sorts of strata, pea gravel interference, protection of caving in by supplying necessary MS casting pipe and use of bentonite slurry or similar, collection of soil samples at every 3 m interval in a white polyethene bag/wooden compartmental box and preserving them for analysis, withdrawal of boring pipes and casing pipes etc. complete lowering of pipes for installation of all tube well as per drawing, specification and direction of the EIC.	N/A	0.00	0.00	0.00
2.a	(a) 0.5 m 100mm dia 3.65mm thickness GI pipe	m	0.50	1,500.00	750.00
2.b	(b) From 0.5 m to 45.5 m (100 mm dia uPVC Pipe class `D')	m	45.00	850.00	38,250.00
2.c	(c) From 45.5 m to 90.5 m (50 mm dia uPVC Pipe class `D')	m	45.00	335.00	15,075.00
2.d	(d) From 90.5 m to 150.5 m (50 mm dia uPVC Pipe class `D')	m	60.00	360.00	21,600.00
2.e	(e) From 150.5 m to 210.5 m (50 mm dia uPVC Pipe class `D')	m	60.00	400.00	24,000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
2.f	(f) From 210.5 m to 267.5m (50 mm dia uPVC Pipe class `D')	m	57.50	440.00	25,300.00
2.g	(g) From 267.5 to 273.5 m (50 mm dia uPVC Class-E) strainer [Slot Opening 8-10]	m	6.00	600.00	3,600.00
2.h	(h) Sand trap (50 mm dia uPVC Pipe class `D') 273.5 m to 275.00 m 1.5 m long 50mm dia. including PVC end cap in one end and socket in another end with fitting and fixing in proper position etc. all complete as per specifications and direction of the Engineer in charge.	m	1.50	440.00	660.00
2.i	(i) 100X50 mm dia uPVC Reducer	nos.	1.00	300.00	300.00
3	**Gravel Pack, Clay Sealing & Local/bored Soil Filling**	n/a	0.00	0.001	0.00
3.a	Preparation and making of **gravel pack** 2-5 mm size with the supply of shrouding materials of recommended size, sieving for sorting & gradation, free of clay particles. All complete as per design, specification and instruction of Engineer in charge. (Up to 10m from top of the strainer)	cum	0.50	3,000.00	1,500.00
3.b	Clay Sealing: Filling up the 6 m annular space from the top of coarse sand with 3-5 mm diameter balls made of bentonite and local clay in a proportion of 1:1.	m	6.00	50.00	300.00
3.c	Local/bored Soil Filling: Filling the remaining bore hole spaces with bored soil preferably clay soil, all complete as per direction of EIC.	m	257.50	7.00	1,802.50
4	**Well Development:** Complete development of the tube well by using both manual and compressor pump by continuous pumping at least for 6-12 hours until water becomes sand and turbidity free and ensuring a satisfactory yield etc., all complete as per specifications and direction of the E/C.	Item	1.00	800.00	800.00
5	**Disinfection:** Disinfecting the well including supply of 50 gm of bleaching powder (33% strength), chlorinated water having 150 ppm available free chlorine complete as per standard specification etc. all complete as per specifications and direction of the EIC.	Item	1.00	250.00	250.00
Part-B	**Installation of Submersible Pump with Electric connection**	n/a	0.001	0.001	0.00
6	**Submersible Pump:** (Gazi/ RFL/ Partex/ Madina premium quality with two years guarantee, delivery 25 mm dia to draw water at roof tank from TW, minimum 1.5 HP motor, discharge 40-120 litter/min and minimum efficiency 40%. Head 40-85 m with required marine cables as per standard specification, carrying fitting and fixing (by 10 no GI wire)	item	1.00	25,000.00	25,000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	within TW and suction and delivery pipe commissioning etc. all complete as per specification and accepted by the Engineer in Charge.				
7.a	**Column Pipe:** Supplying, fitting and fixing special hard grade/thread pipe (class E) 38 mm as column pipe each 3.0 m long having one end socket and another threaded etc. using necessaries T's, bends, L-bows and sockets and fitted in position with all necessaries etc. all complete as per standard practice and accepted by the engineer in charge.	m	38.00	100.00	3,800.00
7.b	**SS Wire**	m	100.00	60.00	6,000.00
8	**Flange Plate:** Supplying and fitting, fixing a flange of 150 mm dia and 4 mm thick m.s plate having one hole for easy setting of 25 mm dia uPVC suction pipe and for pump cable and copper heavy wire etc. all complete as per requirement and accepted by the Engineer in Charge.	no(s)	1.00	700.00	700.00
9	**Electric Surface wiring:** for the following surface looping at the switch board with earth terminal including circuit wiring with 2c-1.5 sq.mm PVC insulated and sheathed cable (BYFYE) with PVC batten complete with 18 SWG GP Sheet Switch board with 3 mm thick ebonite sheet cover, 5 amps wall switch socket etc. including fixing materials, others accessories etc. all complete as per specifications and direction of the Engineer in Charge.	N/A	0.00	0.00	0.00
9.a	Supplying and installation of **Combined Socket**	no(s)	1.00	800.00	800.00
9.b	**Electric wire:** 2 Core (3/20 each core) electric wire (Eastern/ BRB/ Equivalent) for connection with electric service including protection of wire to ensure safety with 12 mm dia PVC pipe/ channel etc. All complete as per as per standard practice and accepted by the Engineer in charge.	m	25.00	80.00	2,000.00
9.c	Circuit breaker 5 amps	no(s)	1.00	400.00	400.00
9.d	**Single Phase electric meter** 2 wire, Accuracy Class: 1.0, Conformation with IS: 13779, Current: 5 – 30 Ampere, Reference voltage: 240 Volts, Reference frequency: 50 Hz. Export Quality with Multifunction Display: Digital LCD display with back-light. Displays various electrical parameters like electric consumption (Kwh), Voltage (V), Current (I), Power-factor (PF), Load (kw/kva), Frequency (Hz) on press of button.	no(s)	1.00	1,950.00	1,950.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	Copper connections Surge resistant and tamper proof with magnetic shielding Sustained accuracy over long period of time Low power consumption ·High insulation and dielectric strength ·Poly-carbonate enclosure which is UV protected, flame retardant				
Part-C	**Construction of Superstructure with platform; RCC Structure Height: 15ft with Platform: 5 ft by 4 ft**	n/a	0.00	0.00	0.00
10	**Earth work in excavation** in all kinds of soil for foundation trenches in/c layout, providing centre lines, bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and making layout with chalk powder providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking the excavated earth at a safe distance of up to 60 m lead, removing the spoils etc. all complete as direction of the Engineer in Charge.	cum	10.00	126.00	1,260.00
11	**Sand filling** in foundation trenches and plinth with sand having F.M.1.2 in 150 mm layers including levelling, watering and compaction to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level as per design supplied by the design office only etc. all complete and accepted by the Engineer in charge.	cum	0.75	635.00	476.25
12	**Single layer brick flat soling** with 1st class or picked jhama bricks, true to level, in/c carrying bricks, filling the interstices tightly with sand of minimum F.M 0.80 etc. all complete as per contract requirements and direction of the Engineer in Charge.	sqm	5.50	420.00	2,310.00
13	Mass concrete (1:2:4) in floor with cement, sand (F.M. 1.2) and picked jhama chips including breaking chips, screening, mixing, laying, compacting to levels an curing for at last 7 days in/c the supply of water, electricity and other charges an costs of tools and plants etc. All complete and accepted by the Engineer, (cement: CEM-ll-/A-M).	cum	0.40	7,643.00	3,057.20
14	**Backfilling with excavated earth** of the trench above pipe zone from 150 mm above the top of the pipe to road surface in/c watering and compacting in layers not exceeding 150 mm all complete as per direction of the Engineer in Charge.	cum	9.25	144.00	1,332.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
15	Reinforced cement concrete works using wooden shutter, with minimum cement content relates to mix ratio (1:2:4) having minimum f'cr=24 Mpa and satisfying specified compressive strength f'c=19 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM 7 cement conforming to BDS EN-197-1-CEM1, 52.5 N (52.5 MPa)/ASTM-C 150 type-I, best quality sand (50% quantity of best local sand (FM 1.2) and 50% quantity of Sylhet sand or coarse sand of equivalent F.M 2.2) and 20 mm down well graded picked jhama brick chips conforming ASTM C-33 including breaking chips and screening, making, placing shutter in position and maintaining true to plumb, making shutter water tight properly, placing reinforcement in position, mixing in standard mixture machine with hopper fed by standard measuring boxes, casting in forms, compacting adequately and properly by steel/wooden patta and curing for 28 days and removing cantering-shuttering after specified time approved, including cost of water, electricity, additional testing charges of materials and cylinders required by the engineer, other charges etc. All complete approved and accepted by the Engineer (Rate is excluding the cost of reinforcement and fabrications, binding, welding and placing).	n/a	0.00	0.00	0.00
15.a	Concrete	cum	3.50	8,414.00	29,449.00
15.b	Shuttering (Wooden)	sqm	22.00	354.00	7,788.00
16	Grade 400 (RB 300: complying BDS ISO 6935-2:2006) ribbed or **deformed bar** produced and marked according to Bangladesh Standard with minimum yield strength, fy (ReH) = 400 Mpa, fy not exceeding 450 MPa and minimum elongation after fracture and minimum total elongation at maximum force is 17% and 8% respectively up to the ground floor.	kg	580.00	82.00	47,560.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
17	**Paint:** Exterior premium acrylic emulsion paint of approved best quality and colour with high performance against dirt picking tendency and efflorescence resistance properties along with water resisting properties and resistance properties against fungi, fading and flaking from authorized local agent of the manufacturer (Berger weather coat anti-dirt long life/ Elite master coat/ Asian apex ultima or equivalent brand) in a sealed container; applying to exterior surface with surface preparation including cleaning drying, making free from dirt, grease, wax, removing all chalked and scaled materials, fungus, mending good the surface defects using sand paper and necessary scaffolding; applying 1 coat of exterior sealer of specified brand on prepared surface; then applying 1 coat of exterior putty of specified brand for levelling, spot filling, crack filling and cutting by sand paper/zero water paper; finally applying 2 coats of exterior emulsion paint by spreading with brush/roller/spray machine & necessary scaffolding etc. up to desired finishing, elapsing specified time for drying or recoating; all complete in all floors and accepted by the Engineer-in-charge.	sqm	12.00	261.00	3,132.00
18	Minimum 12mm thick **cement plaster** (1:4) with NCF having cement fineness min 2800 cm2/g, initial setting time min 45 minutes, final setting time max 375 minutes, gypsum <3% mixed with clinker, free from ash & any other foreign materials to give a minimum cylinder crushing strength of 19Mpa for 7 (seven) days concrete from a machine mixed typical batch with fresh cement (conforming to BDS 232) to dado and plinth wall up to 150mm below ground level with neat cement finishing in/c washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity & other charges etc. all complete in all respect as per drawing and direction of the Engineer in charge.	sqm	5.75	295.00	1,696.25
19	**125mm brick works** with first class bricks in cement sand (FM 1.8) mortar (1:4) and making bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer in charge.	sqm	2.50	948.00	2,370.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
20	**Distribution Chamber:** Construction of distribution chamber with 150 mm sand filling and 150 mm brick soling by supplying the necessary materials such as cement (3 bag), 1st class brick, 1st class khoa, reinforcement, coarse sand including labour charge, to serve the purpose including 12 mm thick plaster (1:4) with net cement finishing of the concrete surfaces ass per drawing. Which includes Grill at front, 100mm X 125mm beam and 100mm thickness RCC slab at top as per drawing. All complete and accepted by the Engineer in charge.	LS	1.00	20,000.00	20,000.00
21	**Platform Construction:** Construction of concrete (1:2:4) platform with 75 mm brick soling by supplying the necessary materials such as cement (3 bag), 1st class brick, 1st class khoa, reinforcement, coarse sand including labour charge, to serve the purpose including 12 mm thick plaster (1:4) with net cement finishing of the concrete surfaces. As per drawing and all complete and accepted by the Engineer in charge.	no(s)	10.00	6,400.00	64,000.00
22	**Protection** for submersible pump by making 2 ft 4 inch Outside Length) x 2ft 4 inch Outside Width x 1 ft 6 inch Height by making 125mm brick wall supported on single layer 250mm brick wall Constructed Masonry Box to be covered by 75mm RCC (with 10mm dia bar) slab on top Outside of the box requires to be plastered All complete as per instruction and direction of the Engineer in Charge.	no(s)	1.00	2,500.00	2,500.00
Part-D	**Intake and Distribution Pipeline network**	n/a	0.00	0.00	0.00
23	**Water Tank:** Supplying and fitting fixing plastic made water tank of 3000 L capacity made of 25 mm thick plastic composed sheet with plastic cover on top with locking arrangement providing inlet and out with flange, plug, jum nut, 40 mm dia ball cock, 12 mm dia over flow pipe with all other necessary fitting etc. all complete as per direction of Engineer in Charge.	no(s)	1.00	29,250.00	29,250.00
24	Making **Intake Plumbing line from column pipe to water tank** with special grade/thread uPVC pipe 'E' class including supplying necessary clamps, screw, royal plug, E1-bow, bends, Tees etc. all complete as per specifications and direction of the Engineer in Charge.	n/a	0.00	0.00	0.00
24.a	38 mm dia hard grade/thread pipe	m	12.00	186.00	2,232.00
24.b	38 mm dia elbow (uPVC)	no(s)	5.00	85.00	425.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
24.c	38 mm dia Union (uPVC)	no(s)	2.00	200.00	400.00
24.d	38 mm dia Tee (uPVC)	no(s)	1.00	150.00	150.00
24.e	38 mm dia Nipple (uPVC)	no(s)	5.00	50.00	250.00
24.f	Clamp with screw	Set	5.00	20.00	100.00
25	Making **Distribution Plumbing line from water tank to distribution chamber** with special grade/thread uPVC pipe 'E' class including supplying necessary clamps, screw, royal plug, E1-bow, bends, Tees etc. all complete as per specifications and direction of the Engineer in Charge.	n/a	0.00	0.00	0.00
25.a	50 mm dia hard grade/thread pipe	m	12.00	218.00	2,616.00
25.b	50 mm dia elbow (uPVC)	no(s)	5.00	100.00	500.00
25.c	50 mm dia Tee (uPVC)	no(s)	3.00	175.00	525.00
25.d	50 mm dia Union (uPVC)	no(s)	1.00	225.00	225.00
25.e	50 mm dia Nipple (uPVC)	no(s)	5.00	50.00	250.00
25.f	50 mm dia get valve (uPVC)	no(s)	1.00	350.00	350.00
25.g	50 mm by 12mm uPVC reducer	no(s)	1.00	100.00	100.00
25.h	Clamp with screw	Set	5.00	20.00	100.00
26	Making **Distribution Plumbing line inside the distribution chamber** with special grade/thread uPVC pipe 'E' class including supplying necessary clamps, screw, royal plug, E1-bow, bends, Tees etc. all complete as per specifications and direction of the Engineer in Charge.	n/a	0.00	0.00	0.00
26.a	25 mm dia hard grade/thread pipe	m	8.00	160.00	1,280.00
26.b	50 mm by 25 mm dia reducing Tee (uPVC)	no(s)	10.00	135.00	1,350.00
26.c	25 mm dia Nipple (uPVC)	no(s)	20.00	50.00	1,000.00
26.d	25 mm dia get valve (uPVC)	no(s)	10.00	300.00	3,000.00
26.e	Clamp with screw	Set	10.00	20.00	200.00
26.f	25 mm dia union	nos.	10.00	225.00	2,250.00
27	Making **Distribution Plumbing line from distribution chamber to platform** with special grade/thread uPVC pipe 'E' class including supplying necessary clamps, screw, royal plug, E1-bow, bends, Tees etc. all complete as per specifications and direction of the Engineer in Charge.	n/a	0.00	0.00	0.00
27.a	**HDPE (coil pipe):** Supply and installation of 25 mm HDPE (coil pipe) pipe for water supply including cutting trenches (150 x 600 mm) in all kinds of soil, pipes laying and back filling the trenches with excavated earth including levelling, dressing and removing excess earth	m	800.00	70.00	56,000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	in all respect as specification and of the E/C. 25 mm HDPE pipe.				
27.b	25 mm dia elbow (uPVC)	no(s)	10.00	50.00	500.00
28	**Piping Arrangement at Platform**	n/a	0.00	0.00	0.00
28.a	25 mm dia GI pipe	m	9.00	216.00	1,944.00
28.b	25 mm dia GI elbow	no(s)	8.00	125.00	1,000.00
28.c	25 mm by 12mm uPVC reducer	no(s)	9.00	75.00	675.00
28.d	**Bib Cock :** Supplying, fitting and fixing of best quality G.I. gate valve with sealant etc. complete approved and accepted by the Engineer- in- charge. **12 mm brass gate valve**	no(s)	11.00	409.00	4,499.00
Part-E	**Others**	n/a	0.00	0.00	0.00
29	Supply, fitting & fixing in position Marble stone **Name Plate** (size 1'-0" x 1'-0") in/c writing the name of project, implementation department and financial year.	no(s)	1.00	1,500.00	1,500.00
30	Supplying, fitting and fixing **lock** for distribution chamber grill of approved quality including all necessary tools and accessories etc. all complete approved and accepted by the Engineer-in-charge.	no(s)	1.00	350.00	350.00
31	**Collection of water sample and testing**: After ensuring proper well development, collect the water samples and sending the samples to the DPHE zonal laboratory for testing of Arsenic, iron parameters. The cost of sampling, carrying to the laboratory and testing by DPHE laboratory has to be borne by the contractor.	Per Test [Fixed rated]	3.00	600.00	1,800.00
32	Supply of best quality **instrument** including 12 inch sly-wrench (1 no.), 1 no. screw driver, 1 no. Tester as per instruction of Engineer-in-charge and hand over the tools, water quality test report & tube well to the school authority. (This item includes material cost, labour charge and carrying charge).	LS	1.00	1,000.00	1,000.00
33	**Operation and Maintenance**	n/a	0.00	0.00	0.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
33.a	Ladder for proper maintenance of the scheme to be handovered by the procuring entity to the caretaker Aluminium Ladder 18 feet long with 16 steps	nos.	1.00	10,000.00	10,000.00
Total Cost for 1 Nos					**492,589.20**
In Words: Taka Four Lac Seventy-Two Thousand Five Hundred Eighty-Nine and Twenty Paisa Only.					

Submersible Tubewell

<u>Tentative Cost Estimate</u>

Average Depth: 210 m

Technology: Deep Tube well (100*38) with Submersible Pump

PART-01(Tube-Well)

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
1	**(a) Transportation :** Transportation of all kinds of departmental and contractor's materials / equipments to the site for installation of Tube Well with supplying of casing pipe, boring pipe, restore the unused departmental materials to the departmental store etc. All complete as per direction of the Engineer-in-Charge.	1	LS	1,000.00	1,000.00
	(b) Construction of derrick and dismantling the same, cleaning the site after completion of the work etc. all complete as per direction of the Engineer-in-Charge.	1	LS	1000.00	1,000.00

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
2	**Drilling & Installation:** Boring by using 200 &100 mm diameter cutter with 38 mm dia GI pipe, required housing pipes and other equipments capable of drilling up to required depth by water jet method or any other method approved by the E/C through all sorts of strata, pea gravel interference, protection of caving in by supplying necessary MS casing pipe and use of bentonite slurry or similar, collection the soil samples in boxes at every 3 m interval and at every change of strata and preserving them for analysis, withdrawal of boring pipes and casing pipes etc. complete lowering of pipes for installation of all tubewells as per drawing, specification and direction of the E/C. (Material test fee is included in rate, Lapping will not be including in measurement of depth)				-
	Drilling & Materials including fitting & Fixing:				-
	i) 100mm dia 3.65mm thickness GI pipe	0.5	m	770.00	385.00
	ii) 0-30 m -100 mm dia uPVC (Class-D) Upper well casing	30	m	585.00	17,550.00
	iii) 30-80 m -38 mm dia uPVC (Class-D) Pipe.	50	m	194.00	9,700.00
	iv) 80-145 m -38 mm dia uPVC (Class-D) Pipe.	65	m	199.00	12,935.00
	v) 145-202.48 m -38 mm dia uPVC (Class-D) Pipe.	57.48	m	200.00	11,496.00
	vi) 202.48-208.48 m-38 mm dia uPVC Filter (Slot opening 8-10) (E'-Class)	6	m	250.00	1,500.00
	vii) 208.48 m -210m38 mm dia uPVC sand trap with end cap (D'-Class)	3	m	210.00	630.00
	viii) solvent cement (100gm Tube)	3	P/Tube	180.00	540.00
	ix) 100X38 mm dia uPVC Reducer (D'-Class)	1	no	300.00	300.00
3	**Clay Sealing, Sand Filling and Local/bored Soil Filling**				
	a) Sand Filling: Filling up of the annular space between bore hole & strainer with coarse sand (FM - 2.5) from end cap up to a level 10 m above the strainer (19 m).	19	m	50.00	950.00
	b) **Clay Sealing:** Filling up the 6 m annular space from the top of coarse sand with 3-5 mm diameter balls made of bentonite and local clay in a proportion of 1:1.(6m)	6	m	60.00	360.00

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
	c) Local/bored Soil Filling: Filling the remaining bore hole spaces with bored soil prefreably clay soil, all complete as per direction of EIC.(195m)	185	m	5.00	925.00
4	**Well Development:** Complete development of the tube well by using both manual and compressor pump by continuous pumping at least for 6-12 hours untill water becomes sand and turbidity free and ensuring a satisfactory yield etc, all complete as per specifications and direction of the E/C.	1	Item	500.00	500.00
5	**Disinfection:** Disinfecting the well including supply of 50 gm of bleaching powder (33% strength), chlorinated water having 150 ppm available free chlorine complete as per standard specification etc. all complete as per specifications and direction of the EIC.	1	Item	500.00	500.00
6	**Collection of water sample and testing :** After ensuring proper well development, collect the water samples and sending the samples to the DPHE Zonal Laboratory for testing of **Arsenic, Iron, Chloride** parameters which will be tested at the laboratory. The cost of sampling, carrying to the laboratory and testing by DPHE laboratory has to be done by the contractor.	3	P/Test	600.00	1,800.00
Sub Total Part 01 (Tube well) BDT					**62,071.00**
Part 02 - (Superstructure)					
Construction of Superstructure (250mm circular 42 inch outside diameter brickwork with platform LXB=5'-0" X 4'-0")					
7	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer-in-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer‟s approval shall not relieve the contractor of his responsibilities and obligations under the contract.				

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
	Earthwork in excavation in foundation trenches up to 1.5 m depth and maximum 10 m lead: in soft clayey soil / loose sand / silt	0.41	m^3	88.000	36.08
8	Supplying and laying of single layer polythene sheet weighing one kilogram per 6.5 square meter in all respect as per direction of the Engineer in charge.	3.39	m^2	42.000	142.38
9	One layer brick flat soling in foundation or in floor with first class/picked jhama bricks including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-charge	3.39	m^2	420.000	1,423.80
10	Mass concrete (1:3:6) in foundation or in floor with cement, sand (F.M. 1.2) and picked jhama brick chips including breaking of chips, screening, mixing, laying, compacting to required level and curing for at least 7 days including the supply of water, electricity, costs of tools & plants and other charges etc. all complete and accepted by the Engineer-incharge.(Cement: CEM-II/A-M)	0.26	m^3	6647.000	1,728.22
11	250 mm Brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:6) in foundation and plinth, filling the joints/interstices fully with mortar, racking out the joints, cleaning and soaking the bricks at least for 24 hours before use and curing at least for 7 days etc. all complete including cost of water, electricity and other charges and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M)	1.43	m^3	6040.000	8,637.20
12	125 mm brick work with first class bricks with cement sand (F.M. 1.2) mortar (1:6) and making bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand, curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) In ground floor	0.50	m^2	917.000	458.50
13	Minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to dado with cement (1:4) up to 150 mm including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity, scaffolding	5.48	m^2	295.000	1,616.60

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
	and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-incharge. (Cement: CEM-II/A-M) ground floor.				
14	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:2:4 having minimum f'cr = 24 MPa, satisfying a specified compressive strength f'c= 19 MPa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM, cement conforming to BDS EN-197-1-CEM-I, 52.5N (52.5 MPa) / ASTM-C 150 Type – I, best quality sand [50% quantity of best local sand (F.M. 1.2) and 50% quantity of Sylhet sand or coarse sand of equivalent F.M. 2.2] and 20 mm down well graded picked jhama brick chips conforming to ASTM C-33 including breaking chips and screening, making and placing shutter in position maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing in standard mixer machine with hopper fed by standard measuring boxes or mixing in batching plant, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders as required, other charges etc. all complete, approved and accepted by the Engineer-in-charge. (Rate is excluding the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering)				
15	Floor / roof slab, T-beam, L-beam and rectangular beam, tie beam, lintel, stair case slab and step etc. up to ground floor	0.13	m^3	7602.000	988.26
16	Grade 400 (RB 400 /RB 400W: complying BDS ISO 6935-2:2006) ribbed or deformed bar produced and marked according to Bangladesh sandard, with minimum yield strength, fy (ReH)= 400 MPa but fy not exceeding 450 MPa and whatever is the yield strength within allowable limit as per BNBC/ ACI 318, the ratio of ultimate tensile strength fu to yield strength fy, shall be at least 1.25 and minimum elongation after	22.00	kg	79.000	1,738.00

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
	fracture and minimum total elongation at maximum force is 16% and 8% respectively : up to ground floor				
Sub Total Part 02 (Superstructure) BDT					**16,769.04**
Part 03 - (Submersible Pump with plumbing works)					
18 (a)	Submersible Pump (Gazi/Partex/RFL / Equivalent quality with two years guarantee, delivery 25 mm dia.) to draw water at roof tank from TW, minimum **1.00 horse power** as per standard specification, carrying, fitting & fixing within TW and suction & delivery pipe, commissioning etc. 30 meter Electric wire without any joint must be used (3/20) (Estern/BRB/Equivalent) for connection with electric service from power supply to pump including trial operation etc. all complete as per specifications and direction of the Engineer in charge. (Discharge=60 L/m, Head meter-40m, Efficiency-40%)	1.00	Item	14,200.00	14,200.00
18 (b)	Protection for Submersible Pump by making 2 ft Length x 2ft Width x 1 ft 6 inch Height by making 125mm brick wall supported on single layer 250mm brick wall Constructed Masonry Box to be covered by 75mm slab on top Outside of the box requires to be plastered All complete as per instruction and direction of the Engineer in Charge	1.00	Item	1,200.00	1,200.00
18 (c)	Supplying, fitting and fixing Special hard grade/thread pipe (class 'E') 25 mm dia as column pipe each 3.0 m long having one end socket and another threaded etc. using necessary Tee's, bends, L-bows and sockets and fitted in position with all necessary accessories etc. all complete as per as per standard practice and accepted by the Engineer in charge.	35.00	m	110.00	3,850.00
18 (d)	S.S / Copper Wire- no 10, for hanging submersible pump in position of center of well, use 2ply wire (25mx2)	60.00	m	52.00	3,120.00
19	Supplying and fitting, fixing a flange of 100 mm dia. and 4 mm thick m.s plate having one hole for easy setting of 25 mm dia. uPVC suction pipe and for pump cable and copper heavy wire etc. all complete as per requirement and accepted by the Engineer in charge.	1.00	no.	200.00	200.00

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
20	Electric Surface wiring at the switch board with earth terminal including circuit wiring with 2c-1.5 sq.mm PVC insulated and sheathed cable (BYFYE) with PVC batten complete with 18 SWG GP Sheet switch board with 3 mm thick ebonite sheet cover, 5 amps. wall switch, socket etc. including fixing materials, others accessories etc as per direction of the Engineer in charge.				-
(a)	Supplying and installation of Combined Switch and socket	1.00	no.	800.00	800.00
(b)	Electric wire (3/20) (Eastern/BRB/Equivalent) for connection with electric service including trial operation including protection of wire to ensure safety with 10 mm dia PVC pipe/ channel etc. all complete as per as per standard practice and accepted by the Engineer in charge.	10.00	m	80.00	800.00
(c)	Circuit breaker 5 amps.	1.00	each	400.00	400.00
21	Supplying & fitting fixing plastic water tank of 1000 litre capacity (Gazi/RFL/Madina/N.Poly) made of 25 mm thick plastic composed sheet with plastic cover on top with locking arrangement providing inlet & out pipe with flange ,plug, jum nut , 25 mm dia over flow pipe with all other necessary fitting etc. All complete as per direction of E/C	1.00	no	11,000.00	11,000.00
	Making plumbing line Concealed) with special hard grade / thread pipe 'E' class including supplying necessary clamps, screws, royal plug ,El-bow, bends, Tees etc. all complete as per specifications and direction of the Engineer in charge.				-
	i. 25 mm dia pipe	1.50	m	110.00	165.00
	ii. 19 mm dia pipe	1.00	m	70.00	70.00
	iii. 25 mm dia gate valve (uPVC)	3.00	no	500.00	1,500.00
	iv. Clamp with screw	4.00	set	150.00	600.00
	v. 25mm Elbow (uPVC)	1.00	no	125.00	125.00
	vi. 25mm dia Tee (uPVC)	1.00	no	150.00	150.00
	vii. Supplying, fitting and fixing 12 mm Plastic bib cock.	2.00	no	150.00	300.00

Sl No	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
	viii. Thread Tap	3.00	no	35.00	105.00
	Sub Total Part 03 (Submersible Pump with plumbing works) BDT				**38,585.00**
	Total (Part 1, 2, 3) BDT				**117,425.04**

Capital Cost estimation for Saikchail Village

Village	Final Selected Intervention		Capital Cost (Tk.)
	Name	Number	
Saikchail, Cumilla	1. Mini piped Water Supply	20	9851784
	2. Submersible Tubewell (Deep)	30	3522751

Tipna, Kharnia, Dumuria, Khulna

The selected option for Tipna village of Khulna district is deep submersible pump with tubewell. The detailed cost estimation of the intervention is given below

<u>Tentative Cost Estimate</u>

Technology : Deep Tube well (100*38) with Submersible Pump

Average Depth: 210 m

PART-01(Tube-Well)

Sl No.	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
1	**(a) Transportation :** Transportation of all kinds of departmental and contractor's materials / equipments to the site for installation of Tube Well with supplying of casing pipe, boring pipe, restore the unused departmental materials to the departmental store etc. All complete as per direction of the Engineer-in-Charge.	1	LS	1,000.00	1,000.00
	(b) Construction of derrick and dismantling the same, cleaning the site after completion of the work etc. all complete as per direction of the Engineer-in-Charge.	1	LS	1000.00	1,000.00

Sl No.	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
2	**Drilling & Installation:** Boring by using 200 &100 mm diameter cutter with 38 mm dia GI pipe, required housing pipes and other equipments capable of drilling up to required depth by water jet method or any other method approved by the E/C through all sorts of strata, pea gravel interference, protection of caving in by supplying necessary MS casing pipe and use of bentonite slurry or similar, collection the soil samples in boxes at every 3 m interval and at every change of strata and preserving them for analysis, withdrawal of boring pipes and casing pipes etc. complete lowering of pipes for installation of all tubewells as per drawing, specification and direction of the E/C. (Material test fee is included in rate, Lapping will not be including in measurement of depth)				-
	Drilling & Materials including fitting & Fixing:				-
	i) 100mm dia 3.65mm thickness GI pipe	0.5	m	770.00	385.00
	ii) 0-30 m -100 mm dia uPVC (Class-D) Upper well casing	30	m	585.00	17,550.00
	iii) 30-80 m -38 mm dia uPVC (Class-D) Pipe.	50	m	194.00	9,700.00
	iv) 80-145 m -38 mm dia uPVC (Class-D) Pipe.	65	m	199.00	12,935.00
	v) 145-202.48 m -38 mm dia uPVC (Class-D) Pipe.	57.48	m	200.00	11,496.00
	vi) 202.48-208.48 m-38 mm dia uPVC Filter (Slot opening 8-10) (E'-Class)	6	m	250.00	1,500.00
	vii) 208.48 m -210m38 mm dia uPVC sand trap with end cap (D'-Class)	3	m	210.00	630.00
	viii) solvent cement (100gm Tube)	3	P/Tube	180.00	540.00
	ix) 100X38 mm dia uPVC Reducer (D'-Class)	1	no	300.00	300.00
3	**Clay Sealing, Sand Filling and Local/bored Soil Filling**				
	a) Sand Filling: Filling up of the annular space between bore hole & strainer with coarse sand (FM - 2.5) from end cap up to a level 10 m above the strainer (19 m).	19	m	50.00	950.00
	b) **Clay Sealing:** Filling up the 6 m annular space from the top of coarse sand with 3-5 mm diameter balls made of bentonite and local clay in a proportion of 1:1.(6m)	6	m	60.00	360.00
	c) Local/bored Soil Filling: Filling the remaining bore hole spaces with bored soil prefreably clay soil, all complete as per direction of EIC.(195m)	185	m	5.00	925.00
4	**Well Development:** Complete development of the tube well by using both manual and compressor pump by continuous pumping at least for 6-12 hours untill water becomes sand and turbidity free and ensuring a satisfactory yield etc, all complete as per specifications and direction of the E/C.	1	Item	500.00	500.00

Sl No.	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
5	**Disinfection:** Disinfecting the well including supply of 50 gm of bleaching powder (33% strength), chlorinated water having 150 ppm available free chlorine complete as per standard specification etc. all complete as per specifications and direction of the EIC.	1	Item	500.00	500.00
6	**Collection of water sample and testing :** After ensuring proper well development, collect the water samples and sending the samples to the DPHE Zonal Laboratory for testing of **Arsenic, Iron, Chloride** parameters which will be tested at the laboratory. The cost of sampling, carrying to the laboratory and testing by DPHE laboratory has to be done by the contractor.	3	P/Test	600.00	1,800.00
Sub Total Part 01 (Tube well) BDT					**62,071.00**
Part 02 - (Superstructure)					
Construction of Superstructure (250mm circular 42 inch outside diameter brickwork with platform LXB=5'-0" X 4'-0")					
7	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer-in-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer‟s approval shall not relieve the contractor of his responsibilities and obligations under the contract.				
	Earthwork in excavation in foundation trenches up to 1.5 m depth and maximum 10 m lead: in soft clayey soil / loose sand / silt	0.41	m^3	88.000	36.08
8	Supplying and laying of single layer polythene sheet weighing one kilogram per 6.5 square meter in all respect as per direction of the Engineer in charge.	3.39	m^2	42.000	142.38
9	One layer brick flat soling in foundation or in floor with first class/picked jhama bricks including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-charge	3.39	m^2	420.000	1,423.80
10	Mass concrete (1:3:6) in foundation or in floor with cement, sand (F.M. 1.2) and picked jhama brick chips including breaking of chips, screening, mixing, laying, compacting to required level and curing for at least 7 days including the supply of water, electricity, costs of tools & plants and other charges etc. all complete and accepted by the Engineer-incharge.(Cement: CEM-II/A-M)	0.26	m^3	6647.000	1,728.22

Sl No.	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
11	250 mm Brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:6) in foundation and plinth, filling the joints/interstices fully with mortar, racking out the joints, cleaning and soaking the bricks at least for 24 hours before use and curing at least for 7 days etc. all complete including cost of water, electricity and other charges and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M)	1.43	m^3	6040.000	8,637.20
12	125 mm brick work with first class bricks with cement sand (F.M. 1.2) mortar (1:6) and making bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand, curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) In ground floor	0.50	m^2	917.000	458.50
13	Minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to dado with cement (1:4) up to 150 mm including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-incharge. (Cement: CEM-II/A-M) ground floor.	5.48	m^2	295.000	1,616.60
14	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:2:4 having minimum f'cr = 24 MPa, satisfying a specified compressive strength f'c= 19 MPa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM, cement conforming to BDS EN-197-1-CEM-I, 52.5N (52.5 MPa) / ASTM-C 150 Type – I, best quality sand [50% quantity of best local sand (F.M. 1.2) and 50% quantity of Sylhet sand or coarse sand of equivalent F.M. 2.2] and 20 mm down well graded picked jhama brick chips conforming to ASTM C-33 including breaking chips and screening, making and placing shutter in position maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing in standard mixer machine with hopper fed by standard measuring boxes or mixing in batching plant, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders as required, other charges etc. all complete, approved and accepted by the Engineer-in-charge. (Rate is excluding the cost of reinforcement and its fabrication, placing, binding etc. and the cost of shuttering & centering)				

Sl No.	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
15	Floor / roof slab, T-beam, L-beam and rectangular beam, tie beam, lintel, stair case slab and step etc. up to ground floor	0.13	m^3	7602.000	988.26
16	Grade 400 (RB 400 /RB 400W: complying BDS ISO 6935-2:2006) ribbed or deformed bar produced and marked according to Bangladesh sandard, with minimum yield strength, fy (ReH)= 400 MPa but fy not exceeding 450 MPa and whatever is the yield strength within allowable limit as per BNBC/ ACI 318, the ratio of ultimate tensile strength fu to yield strength fy, shall be at least 1.25 and minimum elongation after fracture and minimum total elongation at maximum force is 16% and 8% respectively : up to ground floor	22.00	kg	79.000	1,738.00
Sub Total Part 02 (Superstructure) BDT					**16,769.04**
Part 03 - (Submersible Pump with plumbing works)					
18 (a)	Submersible Pump (Gazi/Partex/RFL / Equivalent quality with two years guarantee, delivery 25 mm dia.) to draw water at roof tank from TW, minimum **1.00 horse power** as per standard specification, carrying, fitting & fixing within TW and suction & delivery pipe, commissioning etc. 30 meter Electric wire without any joint must be used(3/20) (Estern/BRB/Equivalent) for connection with electric service from power supply to pump including trial operation etc. all complete as per specifications and direction of the Engineer in charge. (Discharge=60 L/m, Head meter-40m, Efficiency-40%)	1.00	Item	14,200.00	14,200.00
18 (b)	Protection for Submersible Pump by making 2 ft Length x 2ft Width x 1 ft 6 inch Height by making 125mm brick wall supported on single layer 250mm brick wall Constructed Masonry Box to be covered by 75mm slab on top Outside of the box requires to be plastered All complete as per instruction and direction of the Engineer in Charge	1.00	Item	1,200.00	1,200.00
18 (c)	Supplying, fitting and fixing Special hard grade/thread pipe (class 'E') 25 mm dia as column pipe each 3.0 m long having one end socket and another threaded etc. using necessary Tee's, bends, L-bows and sockets and fitted in position with all necessary accessories etc. all complete as per as per standard practice and accepted by the Engineer in charge.	35.00	m	110.00	3,850.00
18 (d)	S.S / Copper Wire- no 10, for hanging submersible pump in position of center of well, use 2ply wire (25mx2)	60.00	m	52.00	3,120.00
19	Supplying and fitting, fixing a flange of 100 mm dia. and 4 mm thick m.s plate having one hole for easy setting of 25 mm dia. uPVC suction pipe and for pump cable and copper heavy wire etc. all complete as per requirement and accepted by the Engineer in charge.	1.00	no.	200.00	200.00

Sl No.	Item of Works	Quantity	Unit	Unit Rate (BDT)	Total (BDT)
20	Electric Surface wiring at the switch board with earth terminal including circuit wiring with 2c-1.5 sq.mm PVC insulated and sheathed cable (BYFYE) with PVC batten complete with 18 SWG GP Sheet switch board with 3 mm thick ebonite sheet cover, 5 amps. wall switch, socket etc. including fixing materials, others accessories etc as per direction of the Engineer in charge.				-
(a)	Supplying and installation of Combined Switch and socket	1.00	no.	800.00	800.00
(b)	Electric wire (3/20) (Eastern/BRB/Equivalent) for connection with electric service including trial operation including protection of wire to ensure safety with 10 mm dia PVC pipe/ channel etc. all complete as per as per standard practice and accepted by the Engineer in charge.	10.00	m	80.00	800.00
(c)	Circuit breaker 5 amps.	1.00	each	400.00	400.00
21	Supplying & fitting fixing plastic water tank of 1000 litre capacity (Gazi/RFL/Madina/N.Poly) made of 25 mm thick plastic composed sheet with plastic cover on top with locking arrangement providing inlet & out pipe with flange ,plug, jum nut , 25 mm dia over flow pipe with all other necessary fitting etc. All complete as per direction of E/C	1.00	no	11,000.00	11,000.00
	Making plumbing line Concealed) with special hard grade / thread pipe 'E' class including supplying necessary clamps, screws, royal plug ,El-bow, bends, Tees etc. all complete as per specifications and direction of the Engineer in charge.				-
	i. 25 mm dia pipe	1.50	m	110.00	165.00
	ii. 19 mm dia pipe	1.00	m	70.00	70.00
	iii. 25 mm dia gate valve (uPVC)	3.00	no	500.00	1,500.00
	iv. Clamp with screw	4.00	set	150.00	600.00
	v. 25mm Elbow (uPVC)	1.00	no	125.00	125.00
	vi. 25mm dia Tee (uPVC)	1.00	no	150.00	150.00
	vii. Supplying, fitting and fixing 12 mm Plastic bib cock.	2.00	no	150.00	300.00
	viii. Thread Tap	3.00	no	35.00	105.00
	Sub Total Part 03 (Submersible Pump with plumbing works) BDT				**38,585.00**
	Total (Part 1, 2, 3) BDT				**117,425.04**

Capital Cost estimation for Tipna Village

Village	Final Selected Intervention		Capital Cost (Tk.)
	Name	Number	
Tipna, Khulna	1. Submersible Tubewell (Deep)	14	1643951

Datinakhali, Labsa, Shyamnagar, Satkhira

The selected option for Datinakhali village of Satkhira district is Rainwater harvesting, Pond with sand filter and Water treatment plant. The detailed cost estimation of those interventions are given below:

Rain Water Harvesting

Detail Estimate

Technology : Rain Water Harvesting System

Sl. No.	Item of Works	Unit	Quantity	Unit Rate (BDT)	Total (BDT)
1	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer-in-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer's approval shall not relieve the contractor of his responsibilities and obligations under the contract. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Base of Tank)	L.S.	1.00	150.00	150.00
2	Sand filling in foundation trenches and plinth with coarse sand having min. F.M. 0.5 to 0.8 in 150mm in layers including levelling, watering and compaction to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming Each layer up to finished level as per design supplied by the design office only etc. all complete and accepted by the Engineer-in-charge. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Base of Tank)	m^3	0.34	602.00	204.68
3	One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer-in-Charge. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Base of Tank and Platform)	m^2	0.85	390.00	331.50
4	Mass concrete (1:2:4) in foundation or floor with cement, sand (F.M. 1.6) and picked jhama chips including breaking chips, screening, mixing, laying, compacting to levels and curing for at least 7 days including the supply of water, electricity and other charges and costs of tools and plants etc. all complete and accepted by the E/C. (Cement: CEM-II/A-M) (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Base of Tank and Platform)	m^3	0.28	7481.00	2,094.68

Sl. No.	Item of Works	Unit	Quantity	Unit Rate (BDT)	Total (BDT)
5	250 mm brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:4) in exterior walls including filling the interstices with mortar, raking out joints, cleaning and socking the bricks at least for 24 hours before use and washing of sand, necessary scaffolding, curing at least for 7 days etc. all complete including cost of water, electricity and other charges (measurement to given as 250 mm width for one brick length and 375 mm for one brick and a half brick length) accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) In ground floor (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Base of tank)	m^3	0.62	6013.00	3,728.06
6	125 mm brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:4) and making bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand, curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) In ground floor. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). . (Platform)	m^2	0.20	837.00	167.40
7	Minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to plinth wall (1:4) with cement up to 150 mm below ground level with neat cement finishing including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity and other charges etc. all complete in all respect as per drawing and accepted by the E/C. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Cement: CEM-II/A-M) (Base of Tank and Platform)	m^2	5.85	246.00	1,439.10
8	Supplying of different components and fittings of approved quality for installation of Rain Water Harvester including fabrication, carrying, screening, washing, placing, jointing, making all joints leak proof using thread seal/Teflon/cement mortar/solvent cement as applicable as per drawing and direction of the Engineer -in -charge.				
	i) 100 mm dia PVC gutter with flat bar hangers (600 mm x25 mm x 6 mm @2 m) (B- Class)	m	10.00	650.00	6,500.00
	ii) 100mm x 38mm uPVC reducer Elbow, good quality (D class)	No.	1.00	300.00	300.00
	iii) 38mm dia uPVC pipe (down pipe/inlet pipe) (D class)	m	6.00	82.00	492.00
	iv) PVC gate valve (38mm dia)	No.	2.00	411.00	822.00

Sl. No.	Item of Works	Unit	Quantity	Unit Rate (BDT)	Total (BDT)
	v) PVC Tee (38mm X 38mm X 38mm) (D class)	No.	2.00	95.00	190.00
	vi) 38mm elbow (90°) (D class)	No.	2.00	92.00	184.00
	vii) 100mm elbow (90°) (B- Class)	No.	1.00	400.00	400.00
	viii) 100mm dia end cap (B- Class)	No.	1.00	100.00	100.00
	ix) 38 mm PVC Union with Nylon wire net (E class)	No.	1.00	50.00	50.00
	x) 38mm dia PVC V-socket (E class)	No.	6.00	40.00	240.00
	xi) 1/2" Brass bibcock with PVC thread pipe as per requirement	No.	1.00	250.00	250.00
	xii) 18 Nos G.I wire, good quality	No.	1.00	86.00	86.00
9	Supplying & fitting fixing plastic water tank of 3000 litre capacity (Gazi/ RFL/ Madina/ N.Poly) made of plastic composed sheet with plastic cover on top with locking arrangement providing inlet & out pipe with flange ,plug, jum nut , 25 mm dia over flow pipe with all other necessary fitting etc. All complete as per direction of E/C. **Wall/Top/Bottom thickness of plastic composed Sheet:** Total Sheet Thickness = 7-8 mm Outer layer Thickness (LLDPE) = 3-4 mm Inner layer Thickness (Food grade LLDPE) = 4-5 mm **Temperature resist capacity:** Minimum 70°C **Outer Layer materials:** LLDPE with U.V stabilized Layer **Inner Layer:** a. Food graded plastic b. Anti-bacterial inner layer for preventing bacterial growth inside the tank **Cover (diameter: 400-420mm):** Dust proof and insect proof threaded type lid **Material** 100% virgin materials (not to be use recycled materials) **Dimension:** Diameter = 1450-1550 mm Height ≥ [5326-(2.33 x Diameter)] mm **Weight (kg)** = 70-75 Kg **Shape:** Round **Warranty Period:** 20 year replacement Warranty	No.	1.00	29940.00	29,940.00
10	Collection of water sample and testing: After storage of rain water in the water tank, The Laboratory Staff will collect the water sample in auto clave bottle & preserved in ice box. Then, the sample send to the DPHE Zonal Laboratory for testing three parameters, i.e. Fecal Coliform (FC), Total Dissolved Solid (TDS) & PH for test on the same day. The sample should be sent with duly signed by concern SAE/AE for each water points. The whole work has to be done as per specification, drawing and direction of the EIC.	P/Test (Fixed Item)	3.00	600	1,800.00

Sl. No.	Item of Works	Unit	Quantity	Unit Rate (BDT)	Total (BDT)
11	GEO-Code Plate: Supplying & Fixation of GEO-Code Plate (Marble/Stone Plate-300X150X12.50 mm)on the vertical/inclined surface of the cc block (block size 300mmX300mmX450mm)The project name implementing agency/date of installation and well id no has to be engraved on the ID Plate with indelible ink. Geo-Code Plate shall install during construction of platform. The whole work has to be done as per specification, drawing and direction of the E/C.	1.00	1.00	1000	1,000.00
12	Trial Run, Commissioning and Handover the water point to the caretaker in fornt of concern DPHE Personnel (AE/SAE). A certificate in laminated form A4 size paper containing the well description, water quality test report in a prescribed format duly signed by concerned excutive engineer must be provided to the caretaker of the water point Handover certificate shall duly sign by the authorized caretaker and return to the excutive engineer .The whole work has to be done as per specification, drawing and direction of the E/C.	L.S.	1.00	500	500.00
Total Cost for 1 No. RWH :					**50,969.42**
In word: Fifty Thousand Nine Hundred Sixty Nine Point Four Two Tk					

Pond Sand Filter (PSF)

Cost Estima **Technology: Solar Operated Pond Sand Filter**
Unit Estimate for 10,000 Liter/D Capacity Solar Operated Pond Sand Filter (PSF)

Part-A: Construction work of PSF

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
1	Mobilization of all construction materials, equipment and manpower, preparetion and dressing of the site before and after construction, demobilization etc. all complete as per direction of the Engineer-in-charge.	L.S.	1.00	10000.00	10000.00
2	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer-in-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer's approval shall not relieve the contractor of his responsibilities and obligations under the contract. (This item includes	m^3	7.39	129.00	953.52

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). Earthwork in excavation in foundation trenches up to 1.5 m depth and maximum 10 m lead: in medium stiff clayey soil.				
3	Sand filling in foundation trenches and plinth with coarse sand having min. F.M. 1.2 in 25 mm in layers including leveling, watering and compaction to achieve minimum dry density of 95% with optimum moisture content (Modified proctor test) by ramming Each layer up to finished level as per design supplied by the design office only etc. all complete and accepted by the Engineer-in-charge. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit).	m^3	1.77	1043.00	1846.94
4	One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-Charge. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit).	m^2	20.35	454.00	9239.51
5	CC work (1:2:4) in floor and foundation with good quality Portland cement, sand (1.6 FM) and Khoa (19 mm) down graded) including supply and underlaying polythene and compecting properly and all works have to be completed using sweet water as per drawing and direction of the Engineer-in-charge	m^3	1.78	8557.00	15249.30
6	Brick works with first class bricks with cement sand (F.M. 1.2) mortar (1:4) in exterior walls including filling the interstices with mortar, raking out joints, cleaning and socking the bricks at least for 24 hours before use and washing of sand, necessary scaffolding, curing at least for 7 days etc. all complete including cost of water, electricity and other charges (measurement to given as 250 mm width for one brick length and 375 mm for one brick and a half brick length) accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) In ground floor (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit).	m^3	12.87	7728.00	99429.88

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
7	125 mm brick work with first class bricks with cement sand (F.M. 1.2) mortar (1:6) and making bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand, curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) In ground floor. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit).	m^2	18.79	976.00	18336.74
8	**a)** 12 mm plaster without Pudlo: Minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to plinth wall (1:4) with cement up to 150 mm below ground level with neat cement finishing including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity and other charges etc. all complete in all respect as per drawing and accepted by the E/C. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Cement: CEM-II/A-M) Ground floor.	m^2	66.72	311.00	20751.27
	b) 12 mm plaster with Pudlo: Minimum 12 mm thick cement sand (F.M-1.2) water proof, damp proof, dry and breathable plaster (1:4) with water proof Izonil Cement (STN-EN -1015-11 , Compressive Strength 34 MPa ,Max depth of water penetration into hardened plaster is <1 mm) or equivalent compound to wall surface, finishing the corner and edges including washing of sand, cleaning the surface, scaffolding and curing at least for 3 days, cost of water, electricity and other charges etc. all complete in all respect as per drawing and accepted by the Engineer–in-charge. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Izonil Cement/equivalent compound: water proof, damp proof, dry and breathable cement).	m^2	75.17	499.00	37509.16

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
9	Reinforced cement concrete works using wooden shutter, with minimum cement content relates to mix ratio 1:2:4 having minimum f'cr = 24 Mpa, and satisfying a specified compressive strength f'c= 19 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM & Cement OPC (CEM-1,52.5N (52.5MPa)/ ASTM C -150 Type -1, 50kg bag, Type – I, best quality sand [50% quantity of best local sand (F.M. 1.2) and 50% quantity of Sylhet sand or coarse sand of equivalent F.M. 2.2] and 20 mm down well graded bricks chips conforming ASTM C-33 including breaking chips and screening, making, placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing in standard mixer machine with hoper fed by standard measuring boxes, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering including cost of water, electricity, testing and other charges etc. all complete approved and accepted by the Engineer-in-charge. (Rate is excluding the cost of reinforcement and its fabrication, placing and binding) (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). Floor / roof slab, T-beam, L-beam and rectangular beam, tie beam, lintel, stair case slab and step etc. up to ground floor.	m^3	2.22	8429.00	18733.30
10	Supply, fitting and fixing country made mirror polish homogeneous floor tiles irrespective of color &/and design, with cement sand (F.M 1.2) mortar (1:4) base raking out the joints with white cement including cutting and laying the tiles in proper way and finishing with care etc. all complete and accepted by the Engineer. (Cement: CEM-II/A-M). (Mirror Polish 300 x 300 mm floor tiles)	m^2	10.85	1674.00	18166.22
11	Supplying, fitting and fixing country made-glazed wall tiles complying BDS ISO 13006: 2015, irrespective of color & or degign, with 20 mm thick cement sand (F.M-1.2) mortar (1:3) base and raking out the joints with white cement including cutting and laying the tiles in proper way and finishing with care etc. all complete and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M), (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). Wall tiles less than, equal or equivalent to 250 mm x 330 mm in sizes	m^2	4.71	1332.00	6273.05

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
12	Supplying, fitting and fixing of 16 gauge GI sheet Roofing over three filter unit (two Sand and one gravel) having one end hinged and opening with locking system arrangement at the other end, fitted and fixed on 40mmx40mmx6mm size M.S. angle outer frame member arrangement and inner members of the frame would be made of 20mmx20mmx5mm size M.S. angle having @ 412mm C/C, etc. all completed as per direction of the Engineer-in-charge.	m^2	6.21	2400.00	14915.48
13	Supplying, fitting and fixing of 16 gauge GI sheet Roofing over Raw Water Chamber fixed on 40mmx40mmx6mm size M.S. angle outer frame member arrangement and inner members of the frame would be made of 20mmx20mmx5mm size M.S. angle having @ 412mm C/C, etc. all completed as per direction of the Engineer-in-charge.	m^2	6.98	2200.00	15351.05
14	Supply of different components and fittings of approved quality for construction of PSF including fabrication, carrying, screening, washing, placing, jointing, making all joints leak proof using thread seal/taflon / cement mortar /solvent cement as applicable as per drawing and direction of the Engineer-in-charge. GI pipes and fittings shall be of national tubes and or karims pipes or equivelent.				
	a) 12 mm MS rod for RCC slab	kg	265.00	96.00	25440.00
	b) 5 - 8mm gravel (crushed)	m^3	2.27	8500.00	19314.16
	c) 15 -18mm gravel (crushed)	m^3	0.84	8500.00	7123.30
	d) Kustia Sand having property F.M.=1.8 to 2.0, D10= 0.20 to 0.21 and U= 2.1 to 2.5	m^3	3.00	2650.00	7950.00
	e) Researve/ Spare Kustia Sand having property F.M.=1.8 to 2.0, D10= 0.20 to 0.21 and U= 2.1 to 2.5 for future necessity of filter bed. Sand will be stored in weather coated bag as per the direction of engineer in charge.	m^3	1.28	2650.00	3378.75
	f) PVC/Cloth Separation Net (For filter bed)	sqm	2.00	175.00	350.00
	g) 38mm uPVC strainer	Nos.	1.00	135.00	135.00
	h) 38mm uPVC pipe (Thread Pipe)	m	12.20	72.44	883.41
	i) 38mm uPVC Elbow	Nos.	2.00	22.00	44.00
	j) 38mm GI pipe (NTL or equivelent)	m	4.57	535.00	2446.65
	k) 38mm GI Elbow	Nos.	10.00	82.00	820.00
	l) 25mm GI Elbow	Nos.	2.00	49.00	98.00
	m) 25mm GI pipe	m	3.00	218.00	654.00
	n) Plastic Bib cock	Nos.	4.00	246.00	984.00
	o) 38mm PVC Gate Valve	Nos.	5.00	350.00	1750.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	p) 38mm GI Socket	Nos.	4.00	135.00	540.00
	q) 25 mm dia Transparent pipe	m	1.50	230.00	345.00
	r) 450mm dia cast iron Manhole cover	Nos.	1.00	1700.00	1700.00
	s) 100 mm dia PVC Pipe	m	10.00	512.00	5120.00
	t) 25 mm dia uPVC Pipe	m	1.00	164.00	164.00
	u) 50 mm uPVC Elbow	Nos.	1.00	85.00	85.00
	v) 38 mm uPVC Tee	Nos.	2.00	22.50	45.00
	w) 15/38 mm uPVC reducer	Nos.	4.00	380.00	1520.00
	x) 38mm GI end plug(for Wash out pipe)	Nos.	10.00	110.00	1100.00
	y) 25 mm GI union socket	Nos.	1.00	110.00	110.00
	aa) 25 mm GI Gate Valve	Nos.	1.00	440.00	440.00
	ab) Gum	pot	1.00	660.68	660.68
	ac) Threat tape	Nos.	12.00	35.00	420.00
	ad) Nut bolt	Nos.	4.00	35.00	140.00
	ae) Clamp 6" dia	Nos.	3.00	45.00	135.00
	af) Clamp 1.5" dia	Nos.	3.00	35.00	105.00
	ag) Earth filling	m^3	0.25	622.00	155.50
	ah) Centering/Shuttering rent for wood	LS	1.00	2000.00	2000.00
15	Disinfection of PSF Water with mixing of 2Kg bleaching powder in water and discharging all water after one day	LS	1.00	500.00	500.00
16	Collection of PSF Treated water samples and sending the semples to the nearest DPHE zonal lab/any recognised public laboratory for bacteriological test (Fecal Coliform) etc. all complete as per direction of engineer in charge (The cost of sampling, carring to the laboratory and test fee has to be done by the contractor)	LS	1.00	700.00	700.00
17	Providing barbed wire fencing with R.C.C (1:2:4) pillars @ 2.43 m c/c. and of section 100 mm x 100 mm at top and 150 mm x 150 mm at bottom of 2.13 m total height (1.37 m above G.L. and 0.76 m below G.L.) including 150 mm thick, 450 mm square spread footings (pillars reinforced with 4 Nos. 10 mm dia main rod and 6 mm dia stir rups @ 150 mm c/c, footing reinforced with 5 Nos. 10 mm dia rod both ways) supplying, fitting and fixing 8 lines of barbed wire horizontally (fixed with the post through 6 mm dia rods embedded in to the post) and 2 lines diagonally from post to post with 12 BWG 2 ply barbed wire, with 4 points barbs @ at least 112 mm c/c including 6 mm thick (1:4) cement plaster up to 1500 mm length of the pillars etc. complete and accepted by the Engineer-in-charge. (Rate is excluding the cost of	sqm	20.00	190.00	3800.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	concrete and reinforcement which is to be paid as per corresponding items in the schedule) (This item includes Labour charge, carrying charge with VAT, Income Tax & Profit).				
	A.Total of construction cost				**377911.89**
Part-B : Fixed items including solar pump system					
18	Supplying, fitting and fixing of Heavy duty force/ lift pump set including all necessary accessories as per specification and drawing provided with tender doccuments. Brand: Aqua or equivalent, Material Mild Steel/Cast Iron, Inside Material Stainless Steel (Liner), Water supply 35-40 l/m, Height with Handle 32 Inches, Handle Length 33.5 Inches, Pump Weight 24 Kg, System: Water lifting technology, Check valve: Cast iron, Per stork 2 liter, Ingress 1.5 inch, Height without Handle 26.5 inches, Outlate lifting (1.5/1), etc. all complete as per direction of the engineer in charge with 5 years warrenty.	Each	1	10500.00	10500.00
19	Arrange local level meeting/ program for user/beneficiaries for the committee formation, handover & tarrif arrangement and operation and maintenance of the PSF and also supply the operation and maintenance manual (minimum 2 copies), all complete as per direction of engineer in charge.	LS	1	3000.00	3000.00
20	Supply tool box including belcha, wrench, tester, tape, pliers, 2 nos of bucket (25lit capasity), sand screener, etc. as per direction of engineer in charge.	L.S.	1	5000.00	5000.00
21	Supply of MS Scraper (having 12mm dia 1050mm long handle and 450mm long scraper portion) and algae removal net with handle (having 12mm dia 1050mm long handle and 150mm dia net supporting portion fitted with ss net) as per drawing and design supplied with tender documents.	L.S.	1	1000.00	1000.00
22	Exterior standard acrylic emulsion paint of approved best quality and color having water resisting properties and resistance properties against fungi, fading & flaking delivered from authorized local agent of the manufacturer (Berger weather coat smooth/ Elite smooth exterior/ Asian apex weather coat or equivalent brand) in a sealed container; applying to exterior surface with surface preparation including cleaning, drying, making free from dirt, grease, wax, removing all chalked and scaled materials,	Item	40.45	265.00	10719.33

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	fungus, mending good the surface defects using sand paper and necessary scaffolding; applying 1 coat of exterior sealer of specified brand on prepared surface; then applying 1 coat of exterior putty of specified brand for levelling, spot filling, crack filling and cutting by sand paper/zero water paper; finally applying 2 coats of exterior emulsion paint spreading by brush/roller/spray & necessary scaffolding etc. upto desired finishing, elapsing specified time for drying or recoating; all complete in all floors and accepted by the Engineer-incharge. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Berger Smart Blue (RO) or code no- 5T1101 Open Sky)				
23	Wall Painting over $9m^2$ area of PSF outer wall surface (weather coat) with picture drawing and massage including base coats painting as per given drawing/design as illustrated in manual and all complete as per direction of engineer in charge.	Item	1	14500.00	14500.00
24	**Submersible Pump with solar system for lifting water from Pond**				
	a) Supply, Installation and commissioning of 0.40 HP/0.30kw DC Solar Submersible Pumping System with 550Wp Solar Panel for daily average discharge of minimum 10,000 Liters at 15 M TDH. **Brand of origin must be European.** Including solar panel, centerfigul pump with Asynchronous brushless DC submersile motor and MPPT motor controller unit, cable accessoriess, lightining arrestor, Earthing, pump down and setting, water lifting, the pump should be UL, CE and ISO Certified the pump motor controller and **penel shall be same brand for better output**. Motor speed: 900-3300 rpm and Pump system (Motor, Pump and Controller) combined efficiency must be between 45-55% and Controller Enclosure class IP68. The pumping system would be given with necessary safety system (sensor) including dry run protection and overflow sensor.**Manufacturer Warranty period 5 years** and service period 10 years (1st 5years service considering product terms & condition with free of cost and next 5years service with service charge). all complete as per the instruction of the Engineer-in-Charge. (This item including all cost with testing fees, Vat, Tax & Profit). Must enclose the below documents while supply: i) 5 Years Manufacturer's Warranty. ii) Certificate of Brand Origin. iii) Factory test report.	Set	1	200000.00	200000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	iv) Manufacturer Authorization Certificate. v) Operational manual in Bangla.				
	b) Supply and install module mounting structure according to the detailed drawing provided and approved by the Engineer. Fixed Panel Structure mounting on pole with 23 degree south facing. Rate should include Aluminum anodized /HD galvanized angle structure of 50mm x 50mm x 3mm and the pole is 20 feet length 75mm dia GI supports, plates & screw, bracing and angles for dividers etc to complete the structure. Rate shall include excavation, concentrating and fixing of structure. all complete as per direction of the engineer in charge.	Set	1	40000.00	40000.00
25	For floting supply and fiting fixing 450mm x 450mm x 900mm size 4nos plastic zerican with bending 2nos 50mm x 2mm x 3mm flat bar and tied with 38mm 6m vertical PVC pipe. PVC pipe driving vertically in the pond up to required depth. Suppling and fitting fixing a flunge of 100mm dia 4mm thick M.S. plate between four zerican having one hole and 100mm 3m or as per required length D-grade PVC filter (slot of filter as per required) install through the hole up to above the ground level of pond and this distance maintain minimum 1feet between ground level and filter. Submersible pump set up into 100mm filter pipe and fitting with floating arrangement. supply of straight and strong bamboo posts of minimum 75mm dia and driving vertically in the pond upto required depth for support the post (Nos of post as per required). all complete as per direction of the engineer in charge.	Set	1	9500.00	9500.00
26	Supply, installation of 100Wp of solar module/panel for LED light and UV system with necessary electrical cables to the safety box according to the drawing and engineer instruction and approval. all complete as per direction of the engineer in charge. Warranty : 5 Years warranty for complete system	Item	1	7000.00	7000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
27	Supply and installation of Solar Powered UV System: a) 1 set 25 watt water sterilizer UV Lamp set with stainless steel body (Length: 24 inch, Dia 2.5 inch, water inlet and outlet pipe 3/4inch, water flow capacity: 12 ltr/m), clear quartz sleeve, international reputed brand UV lamp (**Brand of Origin Must be European**) (UV- C Type) of minimum 9000 hr lamp life (UV light wavelength 254-265 nm) with minimum 10 ltr/m water filtration capacity, Adapter with 3 years replacement warranty. b) International reputed brand 30 Amp 12v solar powered battery with 5 years replacement warranty c) 10A Charge Controller with 3 years replacement warranty. d) DC to AC Inverter with 3 years replacement warranty. e) UV light set Safety Box (Materials: 1mm MS sheet, Length: 28 inch, Height: 7 inch, Depth: 7 inch with powder coated color) with inside local door locking system, air ventilation system, water pipe connection system and water proof on/off switch. f) Battery, Controller and Inverter Safety Box (Materials: 1mm MS sheet, Height: 22 inch, width: 12 inch, depth: 8.5 inch with powder coated color) with inside local door locking system, air ventilation system and water proofing system. g) 2 nos collection bib cock. h) 1 nos 1.5 inch pvc T i) 1 nos 3/4 inch pvc T. j) 2 nos 3/4 inch elbow. k) 1 meter 3/4 uPVC pipe. l) 1 meter flexible pipe. m) 6 nos SS royal bolt	Set	1	35000.00	35000.00
28	Supply and installation of 5W LED light	nos.	2	529.00	1058.00
	B.Total of Fixed Item cost				**337277.33**
Part-C : Fixed items including solar pump Test					
1	Test must to be done by BUET/ RUET/ KUET/ CUET/ DUET/SUST/MIST or any other government authorized testing lab.The report must be informed to the PD & concern authority. all complete as per the instruction of the Engineer-in-Charge. (This item including all cost with testing fees, Vat, Tax & Profit).	Per Package	1	50,000.00	50,000.00
Part-D: Pond Excavation and Prevention of Water Inundation					

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
1	Pond is to be excavated as per the design approved by the project director's office & concern authority. all complete as per the instruction of the Engineer-in-Charge. (This item including all cost with testing fees, Vat, Tax & Profit).	LS	1	3,500,000.00	3,500,000.00
Grand Total in BDT including (Vat, IT & Profit) for one solar PSF (A+B+C+D) =					**4,265,189.22**
	Say : 42,66,000/=				
In Word: Forty Two Lakh Sixty Six Thousand Taka Only.					

Water Treatment Plant

Cost Estimate

Estimate for Saline Water Treatment Plant (Capacity 4000 LPH)

Item no.	Description of Item	Units	Quantity	Unit Price	Total Price
A	**Raw Water Section**				
1	**Raw Water Tank**: Supplying, fitting and fixing of 5000 liter capacity food grade HDPE water tank to preserve Feed water including all cost of materials, fittings labour etc. all complete as per direction of the Engineer-in- charge.	Nos	2	26,000.00	52,000.00
2	**Aeration System:** Aeration System with Color coated protective net.	Lot	1	16,000.00	16,000.00
	Capacity: 8000 LPH				
	MOC: PVC Pipe				
A	**Pre-Treatment**	No.	1	50,000.00	50,000.00
3	**Feed Pump:** Supply, fining, fixing and commissioning of Feed Pump of following specification:				
	1. Type: Centrifugal				
	2.Capacity: 4000 LPH				
	3. Pump Head: 30-40 m				
	4, Housing material: SS316				
	5. Impeller materials; SS316				
	6. Power: 220V, 50 Hz, 0.75KW/1 KW				
	7. Brand: Wil0/Dynamic/Grundfos/CNP or Equivalent				
	8. Country of origin: EU / China or equivalent.				
	All complete as per instruction of Engineer-in charge. (including cost of all materials labour and transportation, VAT and IT)				
4	**Multimedia Filter:**	No.	2	168,000.00	336,000.00
	Supply, fitting, fixing and commissioning of MMF filter of following				
	Specification:				

Item no.	Description of Item	Units	Quantity	Unit Price	Total Price
	1. Capacity: 4000 LPH				
	2. Dimension: 600 mm X 2400 mm (24"X72")				
	3. Operation: Continuous service with Manual Multiport backwash device				
	4. Sheet materials: FRP				
	5. Pipes and fittings: uPVC				
	6. Size of Inlet and Outlet pipes: 50mm (2.0 inch)				
	7. Media: Graded Sand/ Manganese				
	8. Pressure meter: 0-100 psi, 2.5 inch dial.				
	9. Operating Pressure: 100 - 150 psi, Testing Pressure: 200 - 300 psi, Cycle test: 100,000 cycles, Operating Temperature: 1 °C to 49 °C, Bursting Pressure: 750 -500				
	10. Brand: Gfiber/ Topklean				
	11. County of origin: USA/China or equivalent.				
	All complete as per instruction of Engineer-in				
	Charge. (including cost of all materials, labour and transportation, VAT and IT)				
5	**Iron Removal filter:**	No.	2	179,000.00	358,000.00
	Supply, fitting, fixing and commissioning of IRF filter of following:				
	Specification:				
	1. Capacity: 4000 LPH				
	2. Dimension: 600 mm X 2400 mm (24"X72")				
	3. Operation: Continuous service with Manual Multiport backwash device				
	4. Sheet materials: FRP				
	5. Pipes and fittings: uPVC				
	6. Size of Inlet and Outlet pipes: 50mm (2.0 inch)				
	7. Media: Sand/Gravel/ Birm				
	8. Pressure meter: 0-100 psi, 2.5 inch dial.				
	9. Operating Pressure: 100 - 150 psi, Testing Pressure: 200 - 300 psi, Cycle test: 100,000 cycles, Operating Temperature: 1 °C to 49 °C, Bursting Pressure: 750 -500				
	10. Brand: Gfiber/ Topklean				
	11. County of origin: USA/China or equivelent.				
	All complete as per instruction of Engineer-in				
	Charge. (including cost of all materials, labor and transportation, VAT and IT)				
6	**Activated Carbon filter:**	No.	2	171,000.00	342,000.00
	Supply, fitting, fixing and commissioning of ACF filter of following:				
	Specification:				
	1. Capacity: 4000 LPH				
	2. Dimension: 600 mm X 2400 mm (24"X72")				
	3. Operation: Continuous service with Manual Multiport backwash device				
	4. Sheet materials: FRP				

Item no.	Description of Item	Units	Quantity	Unit Price	Total Price
	5. Pipes and fittings: uPVC				
	6. Size of Inlet and Outlet pipes: 50mm (2.0 inch)				
	7. Media: Activated Carbon				
	8. Pressure meter: 0-100 psi, 2.5 inch dial.				
	9. Operating Pressure: 100 - 150 psi, Testing Pressure: 200 - 300 psi, Cycle test: 100,000 cycles, Operating Temperature: 1 °C to 49 °C, Bursting Pressure: 750 -500				
	10. Brand: Gfiber/ Topklean				
	11. County of origin: USA/China or equivelent.				
	All complete as per instruction of Engineer-in				
	Charge. (including cost of all materials, labor and transportation, VAT and IT)				
7	**Antiscalanat Dosing System**	No.	2	35,000.00	70,000.00
	Supply, fitting, fixing and commissioning of WS filter of following:				
	Pump Specification:				
	1. Capacity: 0.477 LPH				
	2. Max. pressure: 7 Bar				
	3. Type: Mechanical actuated diaphragm type with adjustable stroke.				
	4. Pipes and fittings: pneumatic.				
	5. Power requirement of motor: 220 volt. 50 Hz, 16W				
	6. Brand: Pulsafceder/seko				
	Country of manufacturing: USA/Italy or equivalent.				
	Tank Specification:				
	1. Capacity: 60 Ltr.				
	2. MOC: HDPE/PVC				
	3. Brand Gfiber/Pantair				
	4. Country of manufacturing: USA or equivelent.				
B	**Reverse Osmosis (RO) Unit**				
8	**Cartridge Filter:**	No.	2	25,000.00	50,000.00
	Supply, fitting, fixing and commissioning of Cartridge Filter of following specification:				
	1 .Capacity: 4000 LPH				
	2. Accuracy: 5 Micron				
	3. Housing materials: PVC				
	4. Filter Materials: PP				
	5. No. of filter: 05				
	6. Filter Size: Length- 500mm (20")				
	6. Filter Size: Diameter- 63 mm (2.5")				
	7. Brand: Gfiber/ Heron				
	8. County of origin: USA/China or equivelent.				
	All complete as per instruction of Engineer-in				
	Charge. (Including cost of all materials, labor				
	and transportation, VAT and IT)				
9	**High Pressure Pump:**	No.	2	220,000.00	440,000.00

Item no.	Description of Item	Units	Quantity	Unit Price	Total Price
	Supply, fitting, fixing and commissioning of High Pressure Pump of following specification:				
	1. Type: Vertical Multistage Centrifugal				
	2. Capacity :4000 LPH				
	3. Pump Head : 160 m				
	4. Housing Material : SS316				
	5. Impeller materials: SS316				
	6. Power: 220V, 50 Hz.				
	7. Brand: Wilo/Groundfos/CNP/Dynamic or Equivalent				
	8. County of origin: EU/China or equivelent.				
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, labor and transportation, VAT and IT)				
10	**RO Pressure Tube:**				
	Supply, fitting, fixing and commissioning of RO Pressure Tube of following specification:				
	1. Type: End Entry Design				
	2. Operating Pressure: 300psi				
	3. Materials: FRP				
	4. Size: 100mm X 1016 mm (4"X 40")	Pc.	16	25,000.00	400,000.00
	5. Brand: Code line/Gfiber				
	6. Country of origin: EU/ USA or equivalent.				
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, labour and transportation, VAT and IT)				
11	**RO membrane:**				
	Supply, fitting, fixing and commissioning of RO membrane of following specification:				
	l. Type: TFC (0.12 Micron)				
	2 Size: 100mm X 1016mm (4"X 40")				
	3.Brand: Filmteh/ Toray/GE/Membranium/Oltremare/Equivalent				
	Specification:				
	Performance:				
	Permeate Flow: 9.1 m3pd				
	Salt Rejection: Nominal 99.7%				
	Minimum 99.5%	Pc.	16	30,000.00	480,000.00
	Type:				
	Configuration: Spiral Wound				
	Membrane Polymer: Composite Polyamide				
	Active Area:78 sq. ft				
	Application Data:				
	Maximum Applied Pressure: 600 psi				
	Maximum Chlorine Concentration: <0.1 PPM				
	Maximum Operating Temperature:113 F (45 C)				
	Feed water pH Range: 3.0 ? 10.0				
	Maximum Feed Water Turbidity:1.0 NTU				
	Maximum Feed Water SDI (15 mins):5.0				

Item no.	Description of Item	Units	Quantity	Unit Price	Total Price
	Maximum Feed Flow: 1.6 GPM				
	Minimum Ratio of Concentrate to				
	Permeate Flow for any Element:5:1				
	Maximum Pressure Drop for each Element:10 psi				
	Test Conditions:				
	The stated performance is initial (data taken after 30 minutes of operation), based on the following conditions:				
	2000 PPM NaCl solution				
	150-225 psi (1.55 Mpa) Applied Pressure				
	77 F (25 C) Operating Pressures				
	15% Permeate Recovery				
	6.5 -7.0 pH Range				
	4.Counuy of origin: EU/USA/Japan/China/Equivelent				
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, laborand transportation, VAT and IT)				
12	**Pipe fittings with others accessories:**				
	Pipe and fittings: uPVC fittings, (Size: 1 inch)				
	Supply, fitting, and fixing of pipe and others fittings and pipes made of 40 Schedule.				
	Others accessories:				
	Inlet solenoid valve 1pc, automatic flush valve 1pc, flow meter 2pcs, pressure meter 4pcs, pressure switch 1 pc, etc.	Lot	1	50,000.00	50,000.00
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, labor and transportation, VAT and IT)				
13	**Electric Control Panel:**				
	Supply, fitting, fixing and commissioning of Electric Control Panel Box (MOC: SS304) including Circuit breaker, magnetic contact, thermal overload really, timer, digital Conductivity monitor, indicator lamp, selector switch and any other related accessories,	Set	1	50,000.00	50,000.00
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, labour and transportation, VAT and IT)				
	Brand : Schneider/Tokaimi/ABB/Simen/LS				
	Origin: USA/EU/Japan/China or equivalent.				
14	**Skid for Desalination plant:**				
	MOC: SS 304 hollow box (Thickness- 1.5mm)	No.	1	20,000.00	20,000.00
	Box Size: 1.5"X 1.5" inch				
C	**TREATED PURE WATER SECTION**				

Item no.	Description of Item	Units	Quantity	Unit Price	Total Price
15	Drinking Water Tank: Supply, fitting and fixing of food grade HDPE Capacity 2,000 liter to preserve pure drinking water including all cost of materials, fittings labour etc. all complete as direction of the Engineer-in-charge.	Set	2	20,000.00	40,000.00
16	Supply, fitting, fixing and commissioning of Water Level Controller with electric cable	Set	2	2,000.00	4,000.00
17	Drinking Water Quality Test water samples in a recognized public laboratory for Arsenic, Iron, TDS and Chloride including collection, transportation and submission of water sample as per direction of the Engineer-in-charge. (Including VAT & IT)	LS	1	5,000.00	5,000.00
D	**Consumables Item:**				
18	Antiscalanat	Kg	25	1,250.00	31,250.00
19	Cartridge Filter: 1 .Filter Size: Length.. 500mm (20"), Outer diameter 63 mm (2.5") 2.Brand : Any Brand 3. Country of Origin: EU/USA/China	Pc	25	550.00	13,750.00
	Total of Part A:-				2,808,000.00
Part-B:	Civil Work: Construction of Plant Room, Tank Base, Approach Road, Boundary Wall,	LS	1	800,000.00	800,000.00
Part-C:	Electrical Works of RO Plant with ATM System for the user group as per direction of engineer in charge	LS	1	250,000.00	250,000.00
Part-D:	Operation and Maintenance of Treatment Plant by contractor and Hand Over after contract period as per direction of the Engineer-in-charge	Month	12	50,000.00	600,000.00
Total Costing=					4,458,000.00

Capital Cost estimation for Saikchail Village

Village	Final Selected Intervention		Capital Cost (Tk.)
	Name	Number	
Datinakhali, Satkhira	1. Rain Water Harvesting	300	1,52,90,826
	2. Pond Sand Filter (PSF)	1	42,66,000
	3. Water Treatment Plant	1	4,458,000
Total Cost			24014826

Shimulbank, Shimulbank, Shantiganj, Sunamganj

The selected option for Shimulbank village of Sunamganj district is rural piped water supply. The detailed cost estimation of those interventions are given below:

PART A. Floating Intake Station & Pumping System					
SL No	**Description of Works**	**Qty**	**Unit**	**Rate**	**Amount**
1	Surface Water Intake Pump: Supply, testing (BUET/KUET /RUET/DUET /CUET/MIST etc.) of Supply of SS submersible water pump motor set for Turbid, Corrosive & Saline Raw Water Intake at Ambient temperature, Flow: 60-75 m3/h. Head: 30-25 m & RPM: To be mentioned, Brand: Apex/Wilo/Ebara/DESMI/ Grampus or Equivalent*. Country of manufacture: From the factory of original manufacturer company. Shaft seal-Flexible bellows mechanical seal with Carbon vv Silicon faces and Viton elastomers, max casing pressure-16 Bar, ISO 9001: 2000 standard stage casing-AISI 316/Duplex Stainless Steel/ Non Corrosive Alloy Steel suitable for saline water, impeller-AISI 316/Duplex Stainless Steel/ Non Corrosive Alloy Steel suitable for saline water, shaft made of AISI 316, Wearing Ring-AISI 316/Duplex Stainless Steel/ Non Corrosive Alloy Steel suitable for saline water, Electrical Connection: Induction Type, 415 ± 5% volt, 3-Phase, 50Hz. Pump overall efficiency not less than 48 %.	2	each	250000	500,000.00
2	Installation and commissioning of River Water Intake Pump: Installation & commissioning of Raw Water Intake Pump for intake Water from intake pump Station as per direction of engineer	2	each	42261	84,522.00
3	Fabrication & Construction Floating Intake Station using MS, SS, HDPE pipe etc.	1	job	200000	200,000.00
4	Supply of SS Strainer for intake pump	35	sqm	4200	147,000.00
5	Combination clam of HDPE Pipe using SS & MS Profile for Floating Structure.				
5.a	SS Belt, size: 35mm x5mmx 1m	20	Nos	1064	21,280.00
5.b	MS Angle , 50mmx 50mmx5mm	200	kg	80	16,000.00
5.c	Supplying of Corrosion, UV, Chemical Reistance High-Density Polyethylene (HDPE) Pipe with PN-10, SDR-17 to SDR-13.5. Diameter: 160 mm	12	m	2108	25,296.00

PART A. Floating Intake Station & Pumping System					
SL No	**Description of Works**	**Qty**	**Unit**	**Rate**	**Amount**
5.d	Supplying of Corrosion, UV, Chemical Reistance High-Density Polyethylene (HDPE) Pipe with PN-10, SDR-17 to SDR-13.5. Diameter: 300 mm	6	m	7579	45,474.00
6	Epoxy paint	4	set	12000	48,000.00
7	Seamless MS Pipes, 6 mm thikness (Full Length of each MS Pipe Shall be at least 6 metre and length of short piecs shall be as per drawing and field requirement)				
	i) 100 mm dia , Thickness 4.5 mm	60	m	4500	270,000.00
	ii) 150 mm dia , Thickness 5 mm	48	m	6500	312,000.00
8	MS bend , Diameter-150 mm, 5 mm thickness	2	Pc	5360	10,720.00
9	MS Tee, 6 mm thickness				-
	ii) 150mm x 150mmx150mm	1	Pc	8000	8,000.00
10	Sluice valves (PN 16) :				-
	i) 150 mm	2	Pc	14310	28,620.00
11	SS Non-Retun Valve (PN 10)				-
	i) 150mm	2	Pc	15500	31,000.00
12	Flexible Coupling (Rubber) with flange for following size of pipes				-
	i) 150 mm	2	Pc	10000	20,000.00
13	MS loose flange 12 mm thickness				-
	i) 100 mm	2	Pc	2500	5,000.00
	ii) 125 mm	2	Pc	2000	4,000.00
	iii) 150 mm	16	Pc	1500	24,000.00
14	MS Reducer/Enlarger, PN-10				-
	i) 150mm x 100 mm Reducer	2	Pc	8000	16,000.00
15	Flexible pipe, Constructed of neoprene rubber with neoprene impregnedted woven nylon with stain less steel reinforcing ring,both end flangeof following size,				-
	i) 150 mm diameter, PN-16	6	m	25000	150,000.00
16	Vertical Post driving with drop hammer and maintaining driving log in prescibed format Before commencing driving operation, contractor shall submit method statement for carrying out the driving operation including sequence of driving to the Engineer-in-charge for approval. However, Engineer‟s approval shall not relieve the contractor				-

PART A. Floating Intake Station & Pumping System					
SL No	**Description of Works**	**Qty**	**Unit**	**Rate**	**Amount**
	of his responsibilities and obligations under contract of following size,				
	i) 100 mm MS Pipe	10	Pc	4500	45,000.00
	i) 150 mm MS pipe	4	Pc	6500	26,000.00
17	0 to 150 psi Pressure gauge of approved brand.	1	Pc	3000	3,000.00
18	Nut Bolt				-
	a) MS Nut Bolt				-
	i) 16mm dia.	50	Pc	70	3,500.00
	b) SS Nut Bolt				-
	i) SS 16 mm dia	24	Pc	150	3,600.00
19	Rubber gaskets	10	Pc	100	1,000.00
20	Royal bolt	12	Pc	150	1,800.00
21	50 mm UPVC Electric Pipe	30	m	330	9,900.00
22	50 mm UPVC Electric bend	4	Pc	180	720.00
SUB TOTAL (A) =					**2,061,432.00**

Part B: Pump House

SL No	**Description of Works**	**Qty**	**Unit**	**Rate**	**Amount**
1	Earth Work in Excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, leveling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all completeand accepted by the E/C, subject to submit method statement of carrying out excavation work to the E/C for approval. However, E/C's approval shall not relieve the contractor of his responsibilities and obligations under the contract.	Cum	11.67	126.00	1,470.42
2	Single layer brick flat soling in foundation , floor,RCC road,boundary wall with first class bricks including preparation of bed and filling the interstices of sand (FM = 0.80),	Sqm	23.3	438.00	10,205.40

SL No	Description of Works	Qty	Unit	Rate	Amount
	leveling etc. complete and as per direction of the E/C.				
3	Mass concrete work 1:3:6 in foundation or floor with cement, sand (F.M. 1.2) and picked jhama chips including breaking chips, screening, mixing, laying, compacting to levels and curing at least 7 days including the supply of water, electricity and other charges and cost of tools and plants etc.all complete and accepted by as per direction of the E/C.	Cum	1.75	6,579.00	11,513.25
4	Grade 400 (RB 400/ 400 W: Complying BDS ISO 6935-2:2006) ribbed or deformed bar produced and marked according to Bangladesh Standard, with minimum yield strength, Fy (ReH)=400 Mpa but fy not exceeding 418 Mpa and whatever is the yield strength within allowable limit as per BNBC sec 8.3.3.5 / ACI 318-11 sec 21.1.5.2 the ratio ultimate tensile strength fu to yield strength fy, shall be at least 1.25 and minimum elongation after fracture and minimum total elongation at maximum force is 16% and 8% respectively:	Kg	2750	82.00	225,500.00
5	Reinforced cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 and 1:2:4 having minimum f'cr=30 Mpa & 24Mpa and satisfying a specified compressive strength f'c=25 Mpa & 19Mpa at 28 days on standard cylinders as per standard practice of Code ACI/ BNBC/ ASTM & Cement conforming to BDS EN-197-1-CEM 1 (52.5 N)/ ASTM-C 150 Type-I, best quality Sylhet sand or coarse sand of equivalent FM: 2.2 and 20 mm down well graded stone chips conforming to ASTM C-33, making, placing shutter in position and maintaining true to plumb, making shutter water-tight, properly placing reinforcement in position; mixing with standard mixer machine with hopper, fed by standard measuring boxes, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders, other charges etc. all complete approved and accepted by the the E/C. i) 1:1½:3 RCC (246 kg/cm2) for casting slab & walls with 19mm				

SL No	Description of Works	Qty	Unit	Rate	Amount
	down graded stone chips for water retaining structure/Water Reservoir with 1% Water reducing admixture of approved quality by weight of cement (0.5kg per 50kg of cement) except cost of reinforcement, etc. all complete as per drawing, specification and direction of the the E/C. a) All walls & water face column				
6	a) Foundation & Floor	Cum	2.85	12,154.00	34,638.90
7	b) All Column & Beam	Cum	3.75	12,367.00	46,376.25
8	c) All Slab, Sunshed etc.	Cum	2.6	12,240.00	31,824.00
9	Earth filling for foundation trenches & site development in 150 mm layer to achive minimum dry density of 90% with optimum moisture content (Modified Proctor Test) including carring, watering, leveling, dressing and compacting to a specified percentage Each layer up to finished level etc. all complete and accpted by the E/C.	Cum	7.25	149.00	1,080.25
10	250 mm thick brick works with 1st class bricks in cement sand (FM: 1.2) mortar (1:4) and bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hr. before used and washing of sand curing at least for 7 days in all complete including cost of water, clectricity and others charges etc. all complete as per drawing, specification and direction of the the E/C.	Cum	7.2	6,040.00	43,488.00
11	75mm thick DPC (1:1.5:3) mixed with cement, sand and picked jama bricks and stone chips screenung, centering , shuttering, castng, curing and coat of bitumen including the supply of water. All complete as per Engineer's in-charge	Sqm	4.75	1,330.00	6,317.50
12	Sand filling in foundation trenches and plinth with sand having FM: 0.5 to 0.8 in 150 mm layers including leveling, watering and compaction to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming Each layer up to finished level as per design supplied by the design office only etc. all complete and accepted by the the E/C.	Cum	18.25	635.00	11,588.75

SL No	Description of Works	Qty	Unit	Rate	Amount
13	Supply and use of accelerating chemical admixture in concrete, complying ASTM C-494 Type - C of approved brand/origin/manufacturer and supplied by only manufacturer's authorised dealer with certificate of origin. An admixture that is to accelerate the setting time and early strength gain of concrete.	Liter	20.2	151.00	3,050.20
14	Mininmum 6mm thick plaster cement sand (FM: 1.2) plaster (1:3) with fresh cement to cieling RCC columns, beams, surface of staircase, sunshades, cornices, railing, drop wall, louvers, fines & inner & outer surface, finishing the corner & edges including washing of sand cleaning the surface, sacffolding & curing at least for 7 days, cost of water & other charges etc. all complete in all respect as per drawing & accepted by the E/C.	Sqm	23.23	225.00	5,226.75
15	Minimum 12 mm thick cement sand (FM: 1.2) plaster (1:4) with fresh cement to wall both inner & outer surface, finishing the corner & edges including washing of sand cleaning the surface, sacffolding & curing at least for 7 days, cost of water, electricity & other charges etc all complete in all respect as per drawing & accepted by the E/C. i) 12 mm thick cement plaster (1:3) with neat cement finishing to inside wall & water face column of water retaining structure with 0.5% water reducing admixture of approved quality by weight of cement (0.25 kg per 50 kg of cement) including neat cement finishing etc.all complete as per direction of the E/C.	Sqm	26.28	295.00	7,752.60
16	ii) 12 mm plaster (1:4) to all outer sufaces of water retining structure & both side of brick wall.	Sqm	113.16	243.00	27,497.88
17	Supply and laying of single layer polythene sheet weighing one kilogram per 6.5 squre meter in floor or where below cement concrete complete in all respect and accepted by the E/C.	Sqm	17.8	42.00	747.60
18	Supplying fitting and fixing of Aluminum sliding window as per the U.S. Architectural Aluminum Manufacturer?s Association (A.AMA) standard specification having 1 .2 mm thick outer bottom (size 75.50 mm, 32mm), 1 .2 mm thick outer top (size 75.50	Sqm	4.05	3,563.00	14,430.15

SL No	Description of Works	Qty	Unit	Rate	Amount
	mm, 16.80 mm). 1.2 mm thick shutter top (size 33 mm.26.80. 22 mm). 1.2 mm thick shutter bottom (size 60mm, 24.40 mm),1.2 mm thick outer side (size 75.50 mm,19.90 mm). 1.2 mm thick sliding fixed side (size 31 mm, 26 mm),1.2 mm thick shutter lock (size 49.20 mm 26.20 mm) and 1.2 mm thick inter lock (size 34.40 mm, 32.10 mm) sections all aluminum members (total weight kg/sqm) will be anodized to aluminum bronze/silver colour with a coat not less than 15 micron in thickness and density of 4 mg per square cm etc. including all accessories like sliding door key lock, sliding door wheel, sliding door mohair, sliding door neoprene, bolts and nuts including sealants, keeping provision for fitting 5 mm thick glass including labour charge for fitting of accessories, making grooves and mending good damages, carriage, and electricity complete in all respect as per drawing and accepted by the E/C. Bronze Colour				
19	Supply, fitting & fixing window grill made of 12mm x 12mm M.S solid bar 100 mm c/c with outer frame of 38mm x 6mm F.I bar and painting two coats of enamel paint over a coat of anti corrosive priming etc. all complete as per direction of E/C.	Sqm	4.05	2,206.00	8,934.30
20	Supplying, fitting, fixing and installation of a functional MS gate (double leaf) of any design and shape with 38 x 38 x 6 mm MS angle box (made by welding 2 Nos. of 38 x 38 x 6 mm angle) outer frame having 25 x 50 x 25 x 5 mm MS channel (made by welding 2 Nos. of angle) placed part diagonally after cutting and shaping as per requirement part horizontally @ 75 mm c/c the two part of each leaf being separated by a vertical member of 38 x 38 x 6 MS box and welded the ends of diagonal and horizontal members properly with the box frame as per architectural drawing providing full locking arrangement on 3 mm thick MS plates providing 38 x 38 x 6 mm MS angle clamps, fitting fixing with the outer frame of the gate the clamp being embedded in RCC pillars with cement concrete (1:2:4) including cutting holes and mending good the damages, finishing, curing and where	Sqm	1.58	6,036.00	9,536.88

SL No	Description of Works	Qty	Unit	Rate	Amount
	necessary painting two coats with approved quality of synthetic enamel paint over a coat of priming of anticorrosive paint etc. all complete including making and providing 50 x 6 mm MS rail and 38 mm wheel for smooth movement of the gate etc. all complete as per drawing, design and accepted by the E/C.				
21	White washing by three coats, lime mixture prepared at least 12 hours before use, slacking stone lime, supplying of gums, blue, stirring thoroughly, removing the floating materials from the mixer, surface cleaning to free from all foreign materials before application of each coat, applying one vertical and one horizontal wash for each coat and successive coat is to be applied after drying up of previous coat including hair brass, providing necessary scaffolding and cleaning plinth, floors, doors, windows, portions and cost of water, electricity and other charges etc. complete in all respect in all floors and accepted by the Engineer-in-charge.	Sqm	66.45	22.00	1,461.90
22	Exterior standard acrylic emulsion paint of approved best quality and color having water resisting properties and resistance properties against fungi, fading & flaking delivered from authorized local agent of the manufacturer (Berger weather coat smooth/ Elite smooth exterior/ Asian apex weather coat or equivalent brand) in a sealed container; applying to exterior surface with surface preparation including cleaning, drying, making free from dirt, grease, wax, removing all chalked and scaled materials, fungus, mending good the surface defects using sand paper and necessary scaffolding; applying 1 coat of exterior sealer of specified brand on prepared surface; then applying 1 coat of exterior putty of specified brand for levelling, spot filling, crack filling and cutting by sand paper/zero water paper; finally applying 2 coats of exterior emulsion paint spreading by brush/roller/spray & necessary scaffolding etc. upto desired finishing, elapsing specified time for drying or recoating; all complete in all floors and accepted by the Engineer-incharge.	Sqm	62.3	238.00	14,827.40

SL No	Description of Works	Qty	Unit	Rate	Amount
23	Applying one coat exterior wall putty plaster serface proper scraping of RAK / Equivalent product as specified	Sqm	70.4	89.00	6,265.60
24	Standard synthetic enamel paint of approved best quality and colour delivered from authorized local agent of the manufacturer (Berger jhilik synthetic enamel/Elite quick drying/Asian decora synthetic enamel or equivalent brand) in a sealed container, havingvhigh water resistance, high bondibility, flexibility property; using specified brand thinner applying to metallic or wooden surface by brass/roller/spray in 2 coats over single coat anti-corrosive coating including cleaning, drying, making free from dirt, grease, wax, removing all chalked and scaled materials, all complete in all floors and accepted by the Engineer-in-charge.	Sqm	4.05	189.00	765.45
25	Supplying, fitting and fixing in Aluminium door frames, windows, partitions and curtain wall distortion free glass of approved quality and shade including cost of fitting fixing all necessary accessories etc. complete in all respect as per drawing and accepted by the Engineer-in-charge.	Sqm	3.65	1,352.00	4,934.80
SUB TOTAL (B) =					**529,434.23**

PART C. EXTERNAL & INTERNAL ELECTRICAL WORKS FOR INTAKE STATION (Floating Intake) :					
SL.	**Description**	**Unit**	**Quantity**	**Rate**	**Amount (BDT)**
	EXTERNAL ELECTRICAL WORKS FOR INTAKE STATION :				
1	10 KVA SINGLE PHASE TRANSFORMER Supply of following oil-immersed natural air cooled 1-phase 50 Hz 6.35 KV/0.24 KV outdoor type distribution transformer having percentage impedance 3-3.5% basic impulse insulation level (BIL) 75 KV HT & LV porcelain bushingstransformer tank oil inlet & outlet valves earthing terminalsdata plate etc.in/c painting suitable for connection with 11 KV line at 40 deg. C Ambient temperature with maximum temperature rise 60 deg. C locally manufactured and tested Bangladesh as per NEMA/VDE/IEC/BS standard. 1. Capacity 10 KVA 2. No load loss 70 watts (Maximum) 3. Full load loss 200 watts (Maximum)	Each	3	85,246.00	255,738.00
2	Installation testing and commissioning of following 6.35 KV/0.24 KV 10 KVA 1-phase transformer on prepared platform on pole with the help of necessary tools & plants as per direction of Engineer-in-charge.	per job	3	2,415.00	7,245.00
3	Supply and fixing of 11 kv drop out fuses complete with fixing arrangement on steel structure having capacity upto 100 amps (3Nos in a set)	Set	1	30,790.00	30,790.00
4	11 KV lighting arrestor complete with fixing arrangement as required but without earthing (earthing is to be paid seperatly) having maximum permissible stress 12.7 kilo volts	Set	1	15,093.00	15,093.00
5	Installation of HT drop outfuse/lighting arrester/ disconnection switch on prepared U-channel cross-arm on single or H-pole with necessary fixing material complete as per instruction of the Engineer-in-charge	N/A			-
a)	Drop out fuse	Set	3	724.00	2,172.00
b)	Lighting Arrester	Set	3	724.00	2,172.00

PART C. EXTERNAL & INTERNAL ELECTRICAL WORKS FOR INTAKE STATION (Floating Intake) :					
SL.	**Description**	**Unit**	**Quantity**	**Rate**	**Amount (BDT)**
6	Providing following GI pole fabricated with GI pipe completed with GI socket M.S base plate top cover necessary welding as required- Total 12192 mm (40-0) long having 152.4 mm (150mm) dia(3.4 mm) thickness 9144 mm (30) at the bottom and 101.60 mm (100 mm) dia (3.4 mm) thickness 3048 mm (10) at the top with 609 mm ×609 mm× 6.35 mm (2-0× 2-0× 0-0.25) size steel base plate.	Each	1	31,394.00	31,394.00
7	Erection of following tubular pole upto 1832.80 mm (6) depth by placing the pole base on one layer of 1st class brick flat soling over 76.2 mm (3) sand bedding and making 124 C.C work around the pole 304.8 mm (1-0) below GL & 304.8 mm (1 ft) above GL 12.5 mm(1/2) thick cement plaster with net cement finishing over concrete surface including proper curing excavation & refilling and ramming the loose soil etc. as required. 12192 mm (40) long MS/GS /Spun P.C pole with 457 mm×457mm (1.5×1.5) cc work.	Each	1	2,415.00	2,415.00
8	Providing and fixing following pole stay made of stranded G.I. wires complete with anchor plate of size 304.8 mm×304.8 mm× 6.35mm (1×1×1/4). 16 mm (5/8) dia stay rod of necessary length and frame bolts guy insulator nuts with necessary adjusting arrangement complete as required to be placed within 30°-45°angle with pole 8 SWG 7 stranderds etc	Each	1	1,630.00	1,630.00
9	Providing and fixing of 11 KV Porcelain Disc insulator in/c. Conductor clamps ball eye box Ball eye hook and pole attachment /supporting steel work and their installation at the pole top as per direction of E/C. (2 nos. in set)	Each	6	1,932.00	11,592.00
10	Providing and fixing 1524 mm (5-0) long cross arm fabricated 76 mmx76mm6.35mm thick (331/4thick) M.S Channel with necessary clamp brackets nut bolts etc completed (For H.T.line) in/c hot-deep galvanizing of the complete cross arm per direction of E/C.	Each	2	1,087.00	2,174.00
11	Providing and fixing clamp type side mounted bracket for fixing 11 KV pin insulator (with nut bolts) in/c. hot deep galvanizing complete as per direction of E/C.	Each	8	1,582.00	12,656.00

PART C. EXTERNAL & INTERNAL ELECTRICAL WORKS FOR INTAKE STATION (Floating Intake) :					
SL.	**Description**	**Unit**	**Quantity**	**Rate**	**Amount (BDT)**
12	Earthing the electrical installation with 40 mm. (1.5?) dia G.I. pipe (Earth electrode) having 6.35 mm. dia hole across the pipe at 305 mm. interval securedly bonded by soldering with 2 nos of No2 SWG HDBC earth leads with its protection by 20 mm. (3/4?) dia G.I. pipe up-to plinth level run at a depth of 609.6 mm. (2 ft) below G.L. up-to main board to be earthed including necessary connecting copper sockets bolts nuts etc. complete for maintaining earth resistance within 1 ohm. Depth of bottom of main electrode at 37536 mm. (122.5 ft) from GL & length of electrode 36576 mm. (120 ft).	Set	2	45,947.00	91,894.00
13	Construction of Earthing inspection pit inside measurement 600 mm × 600 mm with 250 mm thick brick in cement morter (1.4) with 100mm thick RCC top slab (124) with 1% re-inforcement 450 mm dia water sealed Ci man-hole cover with locking arrangements including necessary earth works site filling and one brick flat soling 75 mm thick (136) base concrete for making inlet channel & 12mm thick (12) cement plaster with neat finishing etc. all complete up to depth of 75 meter	Each	2	6,779.00	13,558.00
14	Overhead Line Construction	Per Span	1	150000	150,000.00
	INTERNAL ELECTRICAL WORKS FOR INTAKE STATION :				
15	L.T. PANELS Supply and fixing of 400/415 volt 3 phase 50 Hz indoor type low tension switchgear of following specification complete with multimeter phase indication lamps and following components (Such as TPMCCs shall be manucactured according to relevant NEMA/VDE/IEC/JIS/BS standards and shall have type test certificate according to relevant IEC Standard) foreign component but locally assembled in 14 SWG sheet steel metal clad dust & vermin proof free standing floor mounting epoxy resin powder coat painted cabinet as per relevant IEC standards and as per accepted /approved by the Engineer.	Each	1	163971.00	163,971.00

PART C. EXTERNAL & INTERNAL ELECTRICAL WORKS FOR INTAKE STATION (Floating Intake) :					
SL.	**Description**	**Unit**	**Quantity**	**Rate**	**Amount (BDT)**
	Incoming: 1 Set - 415 V 100 A TP&NE hard drawn electrolytic copper busbar. 1 no. - 415 V 160 A 25 KA Adjustable TP MCCB for main control with thermal overload and instanteous electric-magnetic short circuit release. 3 Nos. - 415 V 200/5 A ratio C.Ts with suitable accuracy & burden. Outgoing: 1 No. - 415 V 125 A 16 KA Adjustable TP MCCB for main control with thermal overload and instanteous electric-magnetic short circuit release (For Motor control Panel). 1 No. - 415 V 10 A 25 KA Adjustable TP MCCB for main control with thermal overload and instanteous electric-magnetic short circuit release (For PFI Plant). 1 Nos. - 415 V 63 A 16 KA Adjustable TP MCB for Internal Electrification.	N/A			-
16	18 KVAR PFI PLANT Supply of following 415 V 3-phase 50 Hz power factor improvement panel Capacity-18 KVAR complete with TP bushbars and earth block micro processor controlled auto power factor correction relay with digital PF reading display capacitor bank (except drectly connected one) etc.shall be manufactured & tested as per NEMA/VDE/IEC/JIS/BSS standards assembled locallyin 16 SWG sheet steel clad dust & vermin proof free standing floor mounting epoxy resin powdercoat painted cabinet as per relevent IEC standards and as per accepted/approved by the Engineer.	Each	1	148,057.00	148,057.00
	3 Nos.- 415V 100A hard drawn electrolytic copper busbar. 1 No.- 415 V 2.5 KVAR 50 Hz TP power capacitor bank with built in/separate discharge coil for connection directly with line through fuse. 1 No.- 415 V 2.5 KVAR 50 Hz TP power capacitor bank with built-in discharge resistor. 2 No.- 415 V 5KVAR 50 Hz TP power capacitor bank with built-in discharge resistor. 1 No.- 10A 415 V 50 Hz TP magnetic contact with AC3 duty. 4 No.- 30A 415 V 50 Hz TP magnetic contact with AC3 duty. 3 Nos.- 415 V 10A HRC Fuses with base. 12 Nos.- 415 V 20A HRC Fuses with base.	N/A			-

PART C. EXTERNAL & INTERNAL ELECTRICAL WORKS FOR INTAKE STATION (Floating Intake) :					
SL.	Description	Unit	Quantity	Rate	Amount (BDT)
4	Motor Control Panel (Intake Station): Supply and installation of metal clad surface mounting type, three phase 400 V, ±5% v, 50 Hz, Automatic starter i) 2 Nos. 18.5 kw starter ii) 2 Nos. 0.75 kw starter complete with contactor, phase failure, overload relay coil etc.) of the following range of rated current including supply of required fixing materials. Brand of major Component shall be SIEMENS/ABB/ Schenider as per direction of the Engineers.	Nos	1	155000	155000
1	Installation testing and commissioning of following 415V 3-phase 50 Hz indoor type LT switchgear/PFI plant/Motor control panel on prepared platform with the help of necessary tools & plants as per direction of Engineer-in-charge.	Per job	3	3000.00	9,000.00
SUB TOTAL (C) =					1,106,551.00

ITEM-02: Construction of 300 nos House connection (Rate included VAT,TAX etc)					
SL No.	Description of the work	Unit	Qty.	Unit Rate	Total Amount
1	Supplying different inside dia best quality uPVC pressure pipe for water supply having specific gravity 1.35- 1.45, and other physical, chemical, thermal, fire resistivity properties etc. as per BSTI approved manufacturer standards or ASTM, BS/ISO/IS standards fitted and fixed in position with sockets, bends, with all accessories such as Round grating/domed roof grating, bends, sockets etc. approved and accepting by the Engineer-in charge etc. including Testing of materials & installation.				
	a) 20 mm dia pipe wall thickness minimum 2.8 mm	rm	1500.00	190.00	285,000.00
	b) 25 mm dia pipe wall thickness minimum3.00 mm	rm	125.00	215.00	26,875.00
2	Supplying, fitting, fixing the following size GI pipe with all necessary fittings including cutting trenches where necessary, making hole in walls, correspondent mending good of the damages etc. all complete in all respects approved and accepted by the Engineer in charge. (Rate included Labour charge, carrying charge,Testing, VAT, Income Tax etc.).				
	a) 20 mm dia GI pipe, wall thickness minimum 2.65 mm, OD minimum 25.3 mm , weight 1.7 kg/m can withstand minimum 50 kg/cm2 Hydraulic Pressure.	rm	600.00	399.00	239,400.00
	b) 25 mm dia GI pipe, wall thickness minimu 3.35 mm, OD 31.7 mm minimum, weight 2.59 kg/m can withstand minimum 50kg/cm2 Hydraulic Pressure	rm	100.00	482.00	48,200.00

ITEM-02: Construction of 300 nos House connection (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
3	Supplying, fitting and fixing of GI. Union with sealant etc. complete in all respects approved and accepted by the Engineer-in-charge. (Rate included Labour charge, carrying charge, testing, VAT, Income Tax etc.).				
	a) 20 mm dia G.l. Union	Each	600.00	188.00	112,800.00
	b) 25 mm dia G.l. Union	Each	100.00	234.00	23,400.00
4	Supplying fitting and fixing of best quality **brass gate valve** with sealant etc. complete approved and accepted by the Engineer-in-charge.(Rate included Labour charge, carrying charge, testing, VAT, Income Tax etc.).				
	a) 20 mm brass gate valve	Each	300.00	523.00	156,900.00
	b) 25 mm brass gate valve	Each	50.00	712.00	35,600.00
5	Supplying the following GI L-Bow fittings & Fixing with the house Connections including others necessary fittings etc. all complete as per instructions, approved & accepted by the Engineer in Charge (Rate included Labour charge, carrying charge, testing, VAT, Income Tax etc.).				
	a) 20 mm dia	Each	600.00	200.00	120,000.00
	b) 25 mm dia	Each	50.00	250.00	12,500.00
6	Supplying of GI Nipple and fitting, fixing the following size GI nipple with necessary fittins as per drawing, design, specification and instruction of the Engineer in charge. the following fittings & Fixing with the house Connections including others necessary fittings etc. all complete as per instructions, approved & accepted by the Engineer in Charge(Rate included Labour charge, carrying charge, testing, VAT, Income Tax etc.).				
	a) 20 mm dia Nipple of wall thickness minimum 2.65 mm, minimum length 1.00 m, OD minimum 25.3 mm, weight 1.7 kg/m can withstand minimum 50kg/cm2 Hydraulic Pressure	Each	300.00	350.00	105,000.00
	b) 25 mm dia Nipple of wall thickness minimu 3.35 mm, minimum length 1.00 m, OD minimum 31.7 mm, weight 2.59 kg/m can withstand minimum 50 kg/cm2 Hydraulic Pressure	Each	50.00	550.00	27,500.00
7	Supplying of the following size PVC Saddle Clamp minimum thickness 10mm including all necessary fitting etc all Complete as per drawing, design specification and instruction accepted & approved by the Engineer in Charge.(Rate included Labour charge, carrying charge, testing, VAT, Income Tax etc.).				
	a) 110 mm X 20 mm	Each	300.00	550.00	165,000.00
	b) 110 mm X 25 mm	Each	50.00	600.00	30,000.00

ITEM-02: Construction of 300 nos House connection (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
8	**Meter:** Supplying the following Specified ISO -4064 standard,C-Class water Meter, Fitting the same with necessary fittings etc. all Complete as per Drawing, specification, direction, instruction, approved & accepted by the Engineer in charge. **General:** Reading with reed sensor, MID, ISO certified, Multijet principal assures a long service time, Suitable for potable water, Low Pressure loss, 360° rotating lid, High sensitivity in initial flow, Electrostatic painted body made of corrosion resistant brass, Protection against external magnetic fields, Body internally/externally e/p powder painted, with stainless steel register cups. Vaccum mechanism, frost free, clearly readable dial. Suitable for cold water up to 50°C, 3 Years Warranty, well packed, package quantity not more than 10 pcs etc. Service and spare parts to be available. DPHE-IDB must be written on the meter body. Also including 2 coupling tail pipes,2 coupling tail nuts,2 coupling gaskets. Manufacturer profiles ,Brochure, catalogue to be submitted before supplying of meter.Testing to be carried out one meter in one lot.(Rate included all VAT,TAX,Labour charge,Testing, carrying etc.)				
	(a) DN 25 mm dia, Dimension: Total overall meter height 124mm, Axis height 41.5 mm, Length 260mm, Width 92 mm, Length with connections 380mm, unit weight 1.87 kg (Minimum), conncting dia G11/4 Performance: Permanent Flowrate 6.3 (m3/h), Overload Flowrate 7.875 (m3/h), Transitional Flowrate 0.04032 (m3/h), Minimum Flowrate 0.0252 (m3/h), Initial Flowrate 7(I/h), Maximum Working Pressure 16 (bar), Maximum WorkingTemperature 50 (°C), Pressure Loss 0.63(bar), Q3/Q1 (R) ≤ 250, Maximum Registration Capacity 99999 (m3), Minimum Reading Resolution 0.00005(m3), Mounting on the network : Horizontal	Each	10.00	5355.00	53,550.00
	(b) DN 20 mm dia, Dimension: Total overall meter height 115mm, Axis height 31.5mm, Length 190mm, Width 92mm, Length with connections 270mm, unit weight 1.21 kg (Minimum), connecting dia G1. Performance: Permanent Flowrate 2.5 (m3/h), Overload Flowrate 3.125 (m3/h), Transitional Flowrate 0.02 (m3/h), Minimum Flowrate 0.0125 (m3/h), Initial Flowrate 5(I/h), Maximum Working Pressure 16 (bar), Maximum Working Temperature 50 (°C), Pressure Loss 0.63(bar), Q3/Q1 (R) ≤ 200, Maximum Registration Capacity 99999 (m3),	Each	25.00	3808.00	95,200.00

ITEM-02: Construction of 300 nos House connection (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
	Minimum Reading Resolution 0.00005(m3), Mounting on the network : Horizontal				
9	Meter Box: Manufacturing as per drawing & Specification & Supplying the water Meter Box of made with 16Gauge MS sheet with locking arrangement including lock, approved colour spray painting, fitting the Box on wall with supply of necessary fittings (Royal Bolt). Proper &Smooth welded throughly, well finishing, DPHE-IDB must be marked on meter box etc . All completed as per direction, instruction, approved & accepted by the Engineer in charge.(Rate included Labour charge, carrying charge, testing, VAT, Income Tax etc.).				
	a) Size 400 mm X 200mm X 150mm	Each	10.00	1550.00	15,500.00
	b) Size 350 mm X 200mmX 150mm	Each	25.00	1450.00	36,250.00
10	**Gate Valve Chamber:** Construction of 125 thick masonary Gate valve box,(inner size 300mm x500mm x550mm) With Supply of first Class bricks, Cement Sand moetar of ratio 1:4, 75mm thick cc base (1:2:4), 75mm thick Rcc Cover Slab (1:2:4) With Supply of best Quality Cement. Sond of FM-2, First Class Brick Chips, Plaster with NCF inner Side of the box, quring atteast 7 days, Screening of Chips etc all Complete as per direction, accepted & approved by the Engineer in Charge.(Rate included Labour charge, carrying charge, testing, VAT, Income Tax etc.).	Each	35.00	1900.00	66,500.00
Sub-Total Amount					**1,655,175.00**

ITEM-03: Construction of Pipe line (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
1	**Road pavement cutting:** Cutting and removing the following types of road pavements as per specification, drawings, site requirements (where applicable) for pipeline to a width of pipe diameter + 0.3 m including salvaging of materials, stacking the withdrawn materials at a safe place, complete as per direction of Engineer in charge.				
1a	Brick Flat Soling Road	m^2	65.00	29.00	1,885.00
1b	Bituminous carpeting	m^2	209.30	40.00	8,372.00
1c	CC road	m^2	32.50	401.00	13,032.50

ITEM-03: Construction of Pipe line (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
2	**Earth work in exavation of trench:** Earth work in excavation in trenches in all sorts of soil for pipeline, thrust block, fittings and s.v chamber, etc including removal of un-suitable materials, taking precautions necessary for protection of electric, telephone poles/cables, gas pipes or any other structures, bailing out water, soring etc for trenches of depth upto 1.15 m + pipe dia from road surface and a width of pipe dia + 0.3 m including trimming, dressing, levelling of trench bed and proper stacking of excavated earth by the side of trenches etc. all complete as per specification and direction of EIC.	cum	1,500.00	108.00	162,000.00
3	**Sand cousioning for pipes:** Making compacted sand cousioning around the pipes in trench in 150 mm thick pipe bedding and (a) for pipes in road verges to a height of 100mm above the top of pipe and (b) for pipes in road pavement, road crossing up to the bottom of the original road structure with supply of sand (FM 0.80) free from clay vegetation and other organic matter included compacting by sprinkling water in 150mm layer etc. all complete as per specification, drawing and direction of EIC. Dry density after compaction shall not be less than 95% of MDD(STD)	cum	426.64	690.00	294,379.88
4	**Backfilling of trench:** Back filling of trench with excavated earth above the sand cousion of pipes up to road surface for pipes in the road verse including watering and compacting in layers not exceeding 150mm layers up to finished level etc. all complete as per direction of EIC.	m^3	1,000.00	131.00	131,000.00
5	**Supply and laying of MS/GI Pressure Pipe:** Supplying, Laying, Fitting, Fixing and Jointing the following pipes including specials (API-5L, Grade B, Seamless pipe) including welding, cutting, shaping, 3mm thick rubber gaskets, painting with two coats of high class enamel paint over a coat of anticorrosive paint, nuts and bolts for each flanged joints etc. all complete as per direction of E/C.				

ITEM-03: Construction of Pipe line (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
5a	100 mm dia of thickness 4.50 mm,	rm	10.00	2350.00	23,500.00
6	**Supply and laying of HDPE Pressure Pipe:** Supply and laying of **HDPE pressure pipes** as per ISO 4427 of the following standard with any fusion joint including fitting fixing with fittings/specials as required using necessary equipments. This includes cleaning of pipes/specials/fittings both inside and outside with cutting pipes to required size,treming of ends etc. all complete as per specification and instruction of EIC.				
6b	110 mm nominal outside dia (PN 8)	rm	1100.00	1074.00	1,181,400.00
6d	50 mm nominal outside dia (PN 6)	rm	1900.00	528.00	1,003,200.00
7	**Supply and installation of MS flange adopter:** Supply and install the MS flange adopter(12.5mm thck flange and min 5mm thick drum) in pipe lines including cutting, welding, matching, where necessary and fitting, fixing with supply of required GI nuts and bolts, rubber, gaskets, etc. all complete as specification, drawing and instruction of EIC .				
7a	110 mm nominal dia	each	5.00	957.00	4,785.00
7b	50 mm nominal dia	each	5.00	820.00	4,100.00
8	**Supply and installation of MS/GI "S" bend:** Supply and install the G.I bend (B.S 1387-1985) - av. 1067 mm long size "S" bend in pipe lines in washout, culvert & Bridge crossing with required length of MS/GI pipe, welded flange (12.5mm thick), blind flange. GI nuts & bolts and the rubber Gaskets including cutting, matching, welding where necessary and fitting, fixing, painting (two coats of high class enamel painting over prime coat of red oxide) etc. all complete as per drawing, specifications & as per direction of Engineer in charge.				
8a	100 mm nominal dia 3.65 minimum thick	each	8.00	4311.00	34,488.00
9	**Supply and installation of C.I dresser coupling for MS/GI to MS/GI, HDPE:** Supply and install the size C.I dresser coupling in pipe lines for jointing MS/GI pipe with MS/GI pipe and uPVC/HDPE pipe of two different sizes including supply of necessary nut-bolts, washers, gasket,				

ITEM-03: Construction of Pipe line (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
	rubber rings etc. all complete as per drawing & instruction of Engineer in charge.				
9a	100 mm nominal dia (10 mm thick)	each	10.00	994.00	9,940.00
10	**Supply and fixing of MS loose flange:** Supply the size MS flange and welding with MS/GI pipe for bridge/culvert crossing including supply of necessary nut-bolts, washers, gasket, rubber rings etc all complete as per specification, drawing & instruction of Engineer in charge.				
10a	100 mm dia (10 mm thick)	each	10.00	620.00	6,200.00
11	**Supply and installation of HDPE fittings:** Supply and install the following HDPE Butt fusion jointing fittings (ISO as per ISO 4427 as per following standard) with butt fusion joint and fittings with Spigot/socket, cleaning the ends of pipes/ specials/fittings at inside and outside with acetone & clean with dry cloth, cutting the pipes, matching etc. all complete as per drawing, specifications and instruction of Engineer-in-Charge.				
11a	110 mm dia (PN10) HDPE End Cap	each	4.00	987.00	3,948.00
11b	110 mm dia 90 deg (PN10) HDPE Bend	each	10.00	3931.00	39,310.00
11c	110 mm dia 45 deg (PN10) HDPE Bend	each	10.00	3931.00	39,310.00
11d	110x110x110 mm dia (PN10) HDPE Tee	each	5.00	5579.00	27,895.00
11e	110x110x50 mm dia (PN10) HDPE Tee	each	5.00	7420.00	37,100.00
11f	110x50 mm dia (PN10) HDPE Reducer	each	2.00	5765.00	11,530.00
12	**Supply and installation of Sluice Valve/Gate Valve :** Supply and install the new sluice valves (according to DIN 3216 or equivalent) for distribution line and wash-out including supplying fittings and fixing of required no of C I flanged adopter with rubber ring, gasket, nut & bolts etc. all complete as per drawing, specifications and instruction of Engineer-in-Charge.				
12a	100 mm nominal dia	each	5.00	8700.00	43,500.00
14	**Construction of Sluice Valve Chamber:** Construction of new sluice valve chambers (900mm x 900mm x 1000mm) with kiln burnt 1st class bricks. Providing flat soling at the bottom of the chamber, filling the gaps with FM 0.1 sand and leveling, on	each	5.00	20000.00	100,000.00

ITEM-03: Construction of Pipe line (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
	which 75 mm C.C.(1:2:4) to be casted. 250 mm brick work with 1:4 mortar of approved cement & sand. 100 mm thick top RCC slab to be casted with a uplifting ring made by 12 mm dia rod at the center using coarse sand (FM = 2.2) as fine aggregate and nominal maximum (19mm) size downgraded brick chips as coarse aggregate with 12mm dia MS rod @ 150mm C/C in both the ways with Portland cement (1:2:4) as per drawing. 13mm thick (1:4) cement plastering both the inside and out side of the chambers (net cement finishing only inside of the chamber) with supplying of cement & sand of FM 1.5 and curing brick work, concrete & plastering works. as per drawing and direction of the Engineer.				
15	**Thrust Block in pipe line:** Construction of concrete thrust and anchor blocks in Tee, Bend, SV, WO (Tee: 0.60x0.60x0.45; Bend: 0.60x0.45x0.30; WO: 0.60x0.60x0.60; SV: 0.45x0.45x0.30) of pipe line with Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm down graded (LAA value not exceeding 40), including shuttering, mixing by concrete mixer machine, casting, laying compacting and curing for the requisite period breaking bricks into chips etc. all complete as specification, drawing and direction of E-I-C. (suggested mix proportion 1:2:4). Additional quantity of cement to be added if required to attain the strength at the contractors own cost.	cum	2.00	8330.00	16,660.00
16	**Air Rlease Valve (Itali/France/Taiwan):** Supplying, fitting and fixing 25mm dia manual air release valve, including 3mm thick MS steel protection box (size 250mm x 250mm x 300mm made of #6 MS bar 75mm c/c) and fixing the box with GI/MS pipe by gas welding, nipple and 19mm gate valve, 40mm padlock also be supplied along with other necessary fittings as per instruction of Engineer-in-Charge.(At bridge crossing) etc.	each	2.00	2209.00	4,418.00

ITEM-03: Construction of Pipe line (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
17	**Pressure Testing of pipe line:** Pressure testing of installed HDPE pipe lines for transmission and distribution at 6 bar kgf/cm2 with supply of required testing equipments and materrials & repairing of any types of defects detected during testing, replacement of damaged pipes/fittings at contractor's own cost untill satisfactory result is achieved etc. all complete as per specification and instruction of Engineer-in-Charge etc.	rm	3000.00	5.00	15,000.00
18	**Disinfection of pipe lines:** Disinfection of pipe lines by bleaching power (33% strength) including supply of sufficient quantity, making chlorinated water having 30 mg/l available free cholorine and applying to the pipe lines. After 24 hrs of retaintion, tube well water will be pumped out untill chlorine free water is reached etc all complete as per specification and direction of E-I-C.	rm	3000.00	4.00	12,000.00
19	Road Restoration: Restoration of the following types of road to original condition using suitable withdrawn material and with supply of required rest materials as per specification and direction of the complete as per direction of Engineer in charge.				
19a	Brick Flat Soling Road	m^2	65.00	447.00	29,055.00
19b	Bituminous carpeting	m^2	50.00	748.00	37,400.00
19c	CC road	m^2	20.00	9226.00	184,520.00
20	Materials Test : 160/110/50 mm dia HDPE Pipes test in any govt. laboratory including materials all complete as per direction of EIC.	Item	3.00	20000.00	60,000.00

ITEM-03: Construction of Pipe line (Rate included VAT,TAX etc)					
SL No.	**Description of the work**	**Unit**	**Qty.**	**Unit Rate**	**Total Amount**
	Commissioning, Testing and Operation & Maintenance (O&M) of the Production Tubewell, Over Head Tank, Pipeline Network upon completion of the construction works for a period of consecutive 24 (twenty four) months including supply of necessary tools, mechanical and electrical spare parts and accessories, raw water treatment and disinfecting chemicals like sodium hypochlorite solution/bleaching powder etc. and payment of all utility charges like oil-fuel, electricity, water, gas bills, and any other overhead expenses for smooth O&M of the pressure filter and testing of raw and treated water samples to ascertain dosing rate of the chemicals from time-to-time, as required, depute minimum 3 (three) Nos. of both technical & non-technical persons at the plant site on full-time basis to ensure proper O&M, organize and conduct on-the-job training to adequate number of DPHE/Pourashava staff in order to make them able to take over the O&M activities properly, and finally hand over to the Approved Authority through DPHE, all complete as per direction and satisfaction of the E/C.	Month	12	10,000.00	120,000.00
Sub-Total Amount					**3,659,928.38**

Name of work : Construction of R.C.C Over Head Water Tank for piped water supply scheme (Capacity =1,00,000 Liter)

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
1	Providing layout and carry over PWD bench-mark (BM) at site from nearby BM pillar, property lines, existing ground level (EGL), formation ground level (FGL), highest flood levels (HFL), plinth levels (PL), mean sea level (MSL), setting and marking all pillars, marker, pegs etc. showing and maintaining reduced levels (RL‟s) including locating, establishing, protecting all public utilities within the premise of work and finally all to be presented in black and white.	P/m2	81	24.00	1,944.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
2	Mobilization and cleaning site before commencing actual physical work and during contract period and demobilization after completion of the works under contract to be accepted by the Engineer-in-charge. This work shall also covers clayey cleaning and clearing, cutting or filling, dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer-in-charge, where, payments are to be based on ground area determined by the Engineer-in-charge and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer-in-charge.	P/m2	81	169.00	13,689.00
3	Providing and maintenance one project profile signboards of the size not exceeding 1 m x 2 m, to be placed at a suitable place of the site including submission of proposals for the materials of the signboards and text layout to the Engineer-in-charge for approval which will be positioned as directed by the Engineer-in-charge and removing the same on completion of the works or as instructed by the Engineer-in-charge.	P/m2	1.5	2,670.00	4,005.00
4	Testing the following test from BUET or any recognized Public University or government laboratory as per direction of E/C.				0.00
	a) Cement [Setting time, Compressive strength (3,7, 28 days, each set comprises with 3 cube)]	P/test	2	5500	11,000.00
	b) Sand (Sieve analysis of fine aggregate)	P/test	2	5000	10,000.00
	c) Stone chips (Batch consists of Sieve analysis, Loa Angles Abrasion)	P/test	2	6500	13,000.00
	d) Compressive strength test of concrete cylinder (100x200mm) for a set of 3 nos. of proportion 1:1.5:3 (7 and 28).	P/test	2	4000	8,000.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
	e) Tensile strength test including weight and elongation of MS Rod (10, 12, 16, 20 mm dia).	P/test	8	6500	52,000.00
5	Sub-soil investigation by 100 mm dia wash boring and / or by CPT, DCP etc. including collecting disturbed and undisturbed soil samples in numbers as required for classification of soil, conducting SPT, stratification of layers, analyzing physical parameters of soils like Atterberg limits, specific gravity, gain size distribution(by wet sieve, hydrometer if required) ,ground water table location, direct shear test, unconfined compression test, unit weight(dry/weight), natural moisture content ; c - ϕ values and other strength parameters to ascertain bearing capacity , skin friction, end bearings etc. at every 1.5m interval as per respective national/international standards and entering all these data & information in necessary tables & graphs and finally furnishing them in the form of standard sub-soil investigation report duly signed by competent engineer & exploratory office.(Bore hole depth from 0 to 20 m)	per borehole	2.00	26,528.00	53,056.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
6	Boring/drilling by wash or percussion method for cast in situ pile up to the required depth and diameter with minimum 6 m long temporary steel casing, true to vertical, providing bentonite slurry and maintaining water level in the hole, washing the hole for at least 30 minutes, cleaning the bore hole and making the bore hole ready for placing steel cage and concreting including hire charge of rig set with winch machine, tripod stand, tremie pipe, cost of fuel, lubricant, mobilization, demobilization, maintenance, spares, stand-byes, insurance coverage, water, electricity and other charges all compete, approved and accepted by the Engineer-in-charge. Before commencing boring operation, contractor shall submit the method statement of cast-in-situ pile work including sequence of boring and casting, disposal of spoils, test result of materials to the Engineer-in-charge for approval. However, Engineer's approval shall not relieve the contractor of his responsibilities and obligations under contract.(Boring and casting of RCC cast-in-situ pile-500 mm dia.)	P/m	250.80	794.00	199,135.20

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
7	Cast in situ pile with reinforced cement concrete works of high slump by adding high range water reducing admixture (ASTM C494 Type A or F) with minimum cement content relates to mix ratio 1 : 1.5 : 3 having minimum f'cr = 26 Mpa, and satisfying a specified compressive strength f'c = 21 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM & cement conforming to BDS EN-197-1-CEM -1,52.5 N / ASTM-C 150 Type – I, best quality coarse sand [Sylhet sand or coarse sand of equivalent F.M.2.2], 20 mm down well graded crushed stone chips conforming to ASTM C-33, including breaking chips, screening through proper sieves, making, placing re-bar cage in position, placing and removing tri-pod as per requirement, pouring the concrete in bore-hole with the help of a tremie pipe, maintaining the tremie pipe immersed in concrete by at least 1 meter throughout the period of concreting, maintaining required slump, etc. mixing the aggregates with standard mixer machine with hopper, casting in forms, all complete including water, electricity, testing of materials and concrete etc. and other charges as per design, drawing etc. all complete approved and accepted by the Engineering- charge. (Rate is excluding the cost of reinforcement and its fabrication, binding, welding, placing and admixture (approx. doses 150 to 250 ml per bag of cement which is to be fixed upon consultation with design office)	P/m3	49.26	13,463.00	663,187.38
8	Providing and making point welding at contact point of the spiral binders at reasonable intervals with the main reinforcements by electric arc welding for construction of cast in situ bored pile carefully with highly oxidized electrodes, making the points prominent and accepted by the Engineer-in-charge (Rate is inclusive of all materials labor, tools and plants, electricity and all equipment).	P/Point	2400	3.00	7,200.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
9	Providing and making welded splice over two sides of contact by welding of minimum 300 mm length at the lap of main reinforcement in re-bar cage to be placed in bore-hole where necessary by electric arc welding with highly oxidized electrodes making the joint prominent all complete and accepted by the Engineer-in-charge. (Rate is inclusive of all materials labor, tools and plants, electricity and all equipment).	P/m	28.8	570.00	16,416.00
10	Conducting Static Load Test as per ASTM D1143or equivalent standard for the cast in situ / pre-cast pile providing required scaffolding, bracing, jacks, pressure test gauge, loading unloading, kentledge and other plants and equipments including staging, mobilization, demobilization, hire charge, gunny bags, sand and filling sacs/gunny bags for loading, record readings and preparation of results in standard forms and other incidental charges per standard practice and procedures including submission of load test report, furnishing all graph and chart etc. complete in all respects approved and accepted by the engineer (minimum)two cyclic loading, one at service load and another cycle at double the load of service load then to continue loading till failure of the pile).Before commencing load test ,Contractor shall submit method statement for conducting load test to the Engineer for approval. However ,Engineer's approval shall not relieve the Contractor of his responsibilities and obligations under Contract. Load test and Report shall be conducted under the supervision of a professional geotechnical Engineer registered in BPERD or Geotechnical Firm registered in PWD. boring and Pouring logs / Driving Logs of Piles and Method statement shall be the part of load test report .(for 125 ton load for 1 no. of test)	each	1	148,097.00	148,097.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
11	Earth Work in excavation of foundation trenches up to required depth below ground level in all sorts of soil including uprooting trees, bailing out water, shoring etc. and spreading the soil in the premises of overhead tank all complete as per direction of the E/C (up to required depth and maximum 10 m lead: in very soft / saturated / organic clayey soil / soil of semi-liquid state.	P/m^3	46.73	217.00	10,140.41
12	Breaking the pile heads up to required level without damaging the structures, removing spoils, cleaning the reinforcement etc. as per direction of the Engineer.	P/m^3	1.59	4,673.00	7,430.07
13	Sand filling in foundation trenches and plinth with sand having F.M. 0.5 to 0.8 in 150 mm layers including leveling, watering and compaction to achieve minimum dry density of 95% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level as per design supplied by the design office only, all complete and accepted by the Engineer-in-charge	P/m3	37.28	635.00	23,672.80
14	Supplying and laying of single layer polythene sheet weighing one kilogram per 6.5 square meter in floor or any where below cement concrete complete in all respect and accepted by Engineer-in-charge.	P/m2	21.47	42.00	901.74
15	Mass concrete work in foundation of 75 mm thick, thrust block for delivery pipe, rising main, washout/overflow pipe etc. in (1:2:4) proportion with 19 mm down graded brick chips, medium sand (FM 1.60) and port land cement including breaking of bricks, mixing, laying compacting to levels and curing etc. all complete as per drawing and direction of the E/C.	P/m^3	1.87	7,643.00	14,292.41

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
16	Reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 MPa, satisfying a specified compressive strength f‶c = 25 MPa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM, Cement conforming to BDS EN-197-1-CEM-I, 52.5N (52.5 MPa) / ASTM-C 150 Type – I, best quality Sylhet sand or coarse sand of equivalent F.M. 2.2 and 20 mm down well graded stone chips conforming to ASTM C-33 (mixing water proofing chemical 2% by weight of cement for water retaining structures only) making and placing shutter in position and maintaining true to plumb, making shutter water-tight properly, placing reinforcement in position; mixing with standard mixer machine with hopper, fed by standard measuring boxes or mixing in batching plant, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders as required, other charges etc. all complete, approved and accepted by the Engineer-in-charge				0.00
	a) 1:1:5:3 Concert works in pile cap.	m^3	9.45	12,154.00	114,855.30
	b) 1:1.5:3 concrete works in column and bracing of OHT	m^3	34.77	12,475.00	433,755.75
	c) 1:1.5:3 Concrete works in water retaining structures such as cylindrical wall, bottom and top slab and circular beam of OHT	m^3	32.16	12,348.00	397,111.68
17	FORM WORK (Steel): Centering and shuttering, including strutting, propping etc. (The formwork must be rigid enough both in and out of plane, to make the concrete surface true to the designed shape and size by using necessary MS sheets of minimum 16 BWG, angles of minimum size 40 mm x 40 mm x 5 mm, flat bars etc.) and removal of form for:				0.00
	a) In Pile Cap and column below GL	m^2	29.16	438.00	12,772.08

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
	b) In Column (up to 3m)	m^2	52.47	408.00	21,407.76
	c) In Column (3m to above)		104.88	449.00	47,091.12
	d) In Bracing (up to 3m)	m^2	52.26	455.00	23,778.30
	e) In Bracing (3m to above)		84.88	496.00	42,100.48
	f) In bottom slab, roof slab and in side & out side of cylindrical wall of OHT	m^2	236.86	573.00	135,720.78
18	Supplying and placing properly in position of (250x9mm) approved quality PVC water stopper to ensure the structure water proof at each construction joints in water retaining portion only as directed by the Engineer in Charge.	Meter	60	1,017.00	61,020.00
19	Supplying, fabrication and fixing to detail as per design : ribbed or deformed bar reinforcement for Reinforced cement concrete, produced and marked in accordance with BDS ISO 6935 - 2: 2006 (or standard subsequently released from BSTI) including straightening and cleaning rust, if any, bending and binding in position with supply of G.I. wires, necessary laboratory tests (excluding splices or laps) etc. complete in all respect and accepted by the Engineer-in-charge (Measurement shall be recorded only on standard mass per unit length of bars, while dia of bars exceeds its standard) Grade 400 (RB 400 /RB 400W: complying BDS ISO 6935-2:2006) ribbed or deformed bar produced and marked according to Bangladesh standard, with minimum yield strength, fy (ReH)= 400 MPa but fy not exceeding 450 MPa and whatever is the yield strength within allowable limit as per BNBC/ ACI 318, the ratio of ultimate tensile strength fu to yield strength fy, shall be at least 1.25 and minimum elongation after fracture and minimum total elongation at maximum force is 16% and 8% respectively	Kg	16800	82.00	1,377,600.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
20	Supply and use of specified type chemical admixture delivered from an authorized local agent or manufacturer, complying with the ASTM C-494 requirements; conforming the current compliance of the admixture to specification requirements like physical properties, uniformity and equivalence in composition etc.; performance (water content, fresh concrete setting time and compressive strength) requirements, delivered in sealed watertight containers confirming plainly marked product name & type under this specification, net weight and /or volume, manufacturing and expiry date, non aggressiveness to environment, aggregates and metals in concrete etc. and mixing the admixture in non prestressed cement concrete mixture in the field in accordance with manufacturers recommendation and instruction; providing safety provisions in all respects etc. all complete as per instruction and approved by the Engineer-in-charge. Dose (quantity in milliliters per 50 kg bag cement) and brand/origin/ manufacturer with respect to particular brand of cement and particular stock of aggregates and method of use to be determined by mix design / trial mix at the cost of contractor and approved by the Engineer. Supply and use of water-reducing high range chemical admixture in concrete, complying ASTM C-494 Type - F of approved brand/origin/manufacturer and supplied by only manufacturer's authorized dealer with certificate of origin. The admixture required to produce concrete of consistency by 12% or greater (flowing concrete) and for higher strength of concrete.	P/liter	100	290.00	29,000.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
21	Minimum 12 mm thick cement sand (F.M-1.2) **water proof, damp proof, dry and breathable plaste**r (1:4) with water proof Izonil Cement (STN-EN -1015-11 , Compressive Strength 34 MPa ,Max depth of water penetration into hardened plaster is <1 mm) or equivalent compound to wall surface, finishing the corner and edges including washing of sand, cleaning the surface, scaffolding and curing at least for 3 days, cost of water, electricity and other charges etc. all complete in all respect as per drawing and accepted by the Engineer–in-charge. (**Izonil Cement**/equivalent compound: water proof, damp proof, dry and breathable cement)	m^2	130	504.00	65,520.00
22	Minimum 12 mm thick cement sand (F.M. 1.2) plaster (1:4) with fresh cement to both inner-and outer surface of wall, finishing the corner and edges including washing of sand, cleaning the surface, curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) ground floor.	m^2	450	243.00	109,350.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
23	Exterior standard acrylic emulsion paint of approved best quality and color having water resisting properties and resistance properties against fungi, fading & flaking delivered from authorized local agent of the manufacturer (Berger weather coat smooth/ Elite smooth exterior/ Asian apex weather coat or equivalent brand) in a sealed container; applying to exterior surface with surface preparation including cleaning, drying, making free from dirt, grease, wax, removing all chalked and scaled materials, fungus, mending good the surface defects using sand paper and necessary scaffolding; applying 1 coat of exterior sealer of specified brand on prepared surface; then applying 1 coat of exterior putty of specified brand for levelling, spot filling, crack filling and cutting by sand paper/zero water paper; finally applying 2 coats of exterior emulsion paint spreading by brush/roller/spray & necessary scaffolding etc. upto desired finishing, elapsing specified time for drying or recoating; all complete in all floors and accepted by the Engineer-in charge	m^2	450	238.00	107,100.00
24	Supplying, fitting, fixing 450 mm dia. C.I manhole cover with ring and locking arrangement, heavy type of minimum 25 kg in the roof of tank complete as per design and direction of the Engineer.	each	1	2,000.00	2,000.00
25	Supply and installation of the top of the tank (at roof level) 100 mm dia. 3.65mm thick G.I gas vent pipe (made approximately 680 mm length of GI pipe) including 2 nos. of seamless bend with welding properly cross wise 10 mm dia. MS rod (2 nos. each 300 mm length) at the end of the pipe that to be embedded into the concrete of the roof slab. Stainless steel wire mesh to be fixed with clamp at the mouth of pipe as per direction of Engineer in Charge.	each	2	2,500.00	5,000.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
26	Manufacturing, supplying, fitting, fixing in position of a pre fabricated ladder for riding at the top of OHT, made of 2nos 50mm dia GI pipe (with wall thickness 3.65mm) at the vertical direction & 25 mm dia GI pipe (with wall thickness 3.25mm) in steps 400mm long pieces fitted between the vertical pipes by welding @ 250mm C/C as per drawing and design. Safety net to be provided in the ladder made of 25x3 mm sized “D" shaped MS flat bar fitted in the ladder @ 450mm c/c by welding in the vertical pipes of the ladder in/c fitting two nos same size flat bar vertically with the rounded binder (height of "D" should be sufficiently high to pass the persons riding , no safety barrier to be provided in landing places). The ladder to be fitted with landing with extended MS rod of landing upto the top of OHT as per drawing including applying two coats of synthetic enamel paint over a coat of anti-corrosive prime coat etc. all complete as per design and direction of the Engineer in Charge.	P/m2	3.25	4,000.00	13,000.00
27	Construction of horizontal railing on roof and landing with 25 mm dia. G.I pipe @ 300 mm /320mm C/C and 40mm dia at top through 50mm G.I vertical posts @ 1000 mm C/C including bending, placing & welding and two coat of painting with a coat of putty and priming etc. all complete as per design and direction of E/C. Size of vertical post is 50 mm Dia	P/m^2	33.5	2,200.00	73,700.00
28	Supply & installation of Cat ladder: Supply and installation of 300mm width cat ladder prepared with 20m dia MS rod @450mm c/c (as foot rest) including supply of all materials, labors, tools etc. all complete as per direction of the Engineer-in-Charge.	P/m	25	500	12,500.00
29	Supply & installation of Safety Cage (R600mm) for ladder: Supply and installation of 600mm radius circular shape safety cage prepared with 20mm dia MS rod @750mm c/c welded to MS angle including supply of all materials,	P/m	30	500	15,000.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
	labors, tools etc. all complete as per direction of the Engineer-in-Charge.				
30	Supplying, fitting, fixing water level indicator of 10 m long made of Aluminum sheet of 450 mm wide and 6 mm thick, properly graduated and rib biting to it 2 nos. 25mmx25mmx4mm angle (aluminum) for the protection of the movable indicator including 3 coats painting and supply of all devices like pulleys, stainless steel wire (6mm), float valve, movable indicator etc. complete as per design, drawing and direction of the E/C.	item	1	5,750.00	5,750.00
31	Supplying, installing, fitting, fixing and jointing the inlet, outlet, overflow and wash out pipes, fittings & all specials in correct position and alignment with necessary clamps (as per drawing) including two coat of painting over a coat of anti corrosive priming as well as supply of 3mm thick rubber gaskets, rubber ring, G.I nuts & bolts, welding flanges to pipes etc. all complete as per specification, design and direction of Engineer in charge.				0.00
	a) GI Pipe				0.00
	i) 150 mm dia. 5.4 mm thick outlet pipe	meter	25	3,485.00	87,125.00
	ii) 100 mm dia. 3.65 mm thick inlet pipe	meter	25	2,898.00	72,450.00
	iii) 75 mm dia. 3.25 mm overflow and washout pipe	meter	40	2,183.85	87,354.00
	b) CI Dresser Coupling including rubber ring				0.00
	i)150mm dia.	each	2	935.00	1,870.00
	ii)100mm dia.	each	2	642.87	1,285.74
	c) MS Bend (flanged, 45/90 degree)				0.00
	i)150 mm dia	each	2	3,460.93	6,921.86
	ii)100 mm dia	each	2	2,662.25	5,324.50
	iii)75 mm dia	each	4	1,996.69	7,986.76
	d) CI flange adapter				0.00
	i)150mm dia.	each	2	1,461.08	2,922.16

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
	ii)100mm dia.	each	2	1,314.97	2,629.94
	iii)75mm dia.	each	2	1,168.86	2,337.72
	e) Loose flange only pipe jointing				0.00
	i) 150mm dia.	each	12	1,667.50	20,010.00
	ii) 100mm dia.	each	12	1,667.50	20,010.00
	iii) 75mm dia.	each	20	1,150.00	23,000.00
32	Sluice Valve:				0.00
	Fitting and fixing sluice valve including supply of rubber ring, rubber packing, nuts, bolts, flange adapter etc. Complete as per design, drawing and direction of the E/C.				0.00
	i) 150 mm dia. (delivery line)	each	1	11,021.00	11,021.00
	ii) 75 mm dia. (washout line)	each	1	5,250.00	5,250.00
	b) Construction of new sluice valve chambers (1000mm x 1000mm x 1000mm)(inside) with kiln burnt 1st class bricks. Providing flat soling at the bottom of the chamber, filling the gaps with FM 0.1 sand and leveling, on which 75 mm C.C.(1:2:4) to be casted. 250 mm brick work with 1:4 mortar of approved cement & sand. 100 mm thick top RCC slab to be casted with a uplifting ring made by 12 mm dia. rod at the center using coarse sand (FM = 2.2) as fine aggregate and nominal maximum (19mm) size downgraded brick chips as coarse aggregate with 12mm dia. MS rod @ 150mm C/C in both the ways with Portland cement (1:2:4) as per drawing. 13mm thick (1:4) cement plastering both the inside and out side of the chambers (net cement finishing only inside of the chamber) with supplying of cement & sand of FM 1.5 and curing brick work, concrete & plastering works. as per drawing and direction of the Engineer.	each	1	18,240.00	18,240.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
33	Making main Earthling Electrode by driving below ground level 6m long 38 mm dia. G.I pipe and 1 m long 38mm dia. copper pipe jointed properly with threaded socket coupling, the copper pipe being deeper at the socket coupling, the copper pipe being deeper at the bottom complete with supply of all materials as per drawing and direction of the Engineer in Charge.	each	1	12,650.00	12,650.00
34	Providing and fixing 25mm dia. 750mm long solid copper rod having four stripes welded to the rod at the top as lighting conductor for lightning protection and fixing it to the top of OHT with securely bonded copper base plate 8mm thick and 150x150mm as per drawing and direction of the Engineer in Charge.	each	1	4,600.00	4,600.00
35	Making earthling connection between main Earthling Electrode and Lightning Arrester with 4-SWG HDBC wire by jointing with proper soldering the wire at the bottom of the copper pipe and the lighting arrester including drawing the wire through the earth as per drawing and direction of the Engineer in Charge.	meter	40	126.50	5,060.00
36	Construction of approach road and hard standing (HBB) (125mm) and end edging both over single layer brick flat soling road, with 1st class or picked jams bricks, including filling the gap between brick of HBB with sand cement mortar (1:3) and flush pointing (1:2) including preparation of bed of 150mm layer of sand (1:2) including preparation of bed of 150 mm layer of sand as per drawing and direction of the Engineer in Charge.	m^2	10	662.00	6,620.00
37	Testing and commissioning the over head tank with full of water at least 3 days, the test include the over turning, leaking and soaking of the tank as well as pipes and fittings. the contractor will repair all kinds of leaking and soaking at his own cost as per drawing and direction of the Engineer in Charge.	item	1	10,000.00	10,000.00

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
38	Disinfecting the overhead tank with Chlorinated water containing 50mg/1 of Chlorine for a period of at least 24 hours to the inner surfaces and shell wall of OHT etc. finally clean them by applying clear water profusely etc. complete as per direction of the E/C.	item	1	12,000.00	12,000.00
39	Providing / bamboo/ wooden/ steel form staging and stair around the tank up to its full high for casting all R.C.C works and placing all pipes & fitting and railing etc. and dismantling the same after completion of the works as per direction of the E/C	item	1	225,000.00	225,000.00
40	Supplying and fitting approved quality light (security light) with water tight cover consisting of hexagonal conical shaped polished body made by brass including supply of 100 watt valve all complete as per direction of E/C	no.	1	5,750.00	5,750.00
41	Constructing RCC (fc'=22MPa, minimum f'cr=27MPa in nominal mix1:2:4 with stone chips) surface drain of 300 mm clear width and depth up to 300 mm with 125 mm thick check walls and 125 mm thick base over one layer of brick flat soling. The surface having minimum 12 mm thick cement sand (F.M. 1.2) plaster (1:3) and neat cement finishing with cement curing at east for 7 days including excavation in all kinds of soil, back filling with fine sand (F.M. 0.8), consolidating and dressing, cost of water, electricity, other charges etc. complete and accepted by the Engineer in charge.	P/m	5	2,760.00	13,800.00
42	Providing apron with 50 mm thick cement concrete (1:2:4) with cement, coarse sand and picked jhama chips including breaking chips and one layer brick flat soling at bottom with first class or picked jhama bricks including cutting earth for preparation of bed and filling the interstices with local sand (F.M. 0.8) including finishing, dressing, curing at least for 7 days etc. all complete, including cost of water, electricity, other charges accepted by the Engineer in charge.	P/m2	4.5	917.00	4,126.50

Item 4: Part "A,B & C" : R.C.C Over Head Water Tank					
SL	**Description of Items**	**Unit**	**Quantity**	**Rate in Taka**	**Amount in Taka**
43	Site cleaning: After completion of all works, all unused materials must be removed from the site, clean and leveling the site all complete as per direction of Engineer in Charge.	Item	1	4,025.00	4,025.00
44	Writing the message (to be given later) in various font of words with approved paint and color on the body of OHT including supply of all materials and necessary scaffolding et. All complete as per direction of E/C.	item	1	15,000.00	15,000.00
45	Design & drawing of the Production tubewell, Overhead Tank & treatment plant as on ground situation depending on water Quality of Desired capacity and pipe line network on the basis of subsoil investigation report from a reputed institute/Consultant firm/ Individual Consultant and Supply all detail drawing and design with specification, 5 set each (A3) size etc. All complete as per direction of E/C	LS	1	500,000.00	500,000.00
Part "E" Total For 01 No R.C.C Over Head Water Tank =					**5,556,670.44**

Department of Public Health Engineering (DPHE)

Name of work : Construction of Surface Water Treatment Plant (Capacity: 20 m3/Hr.).

Part "K" : Surface Water Treatment Plant (Capacity: 20 m3/Hr).

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
Part-A : Civil Works					
1	Mobilization of equipment, materials, including piling equipment (such as drilling rig, welding machine, generator, construction materials for labour shed etc.) and arrange non-saline & clean water (of drinking-water quality) for entire construction & curing works and site clearance etc. all complete as per direction of the Engineer in Charge (E/C).	Sqm	68.00	169.00	11,492.00
2	Surveying and providing layout with survey instruments, pegging, marking, establishing bench marks at strategic points and marking etc. all complete as per drawing, specification and direction of the E/C.	Sqm	68.00	24.00	1,632.00
3	Carry-out subsoil investigation prior up to 40m and Topographical survey with total station method to go for construction if proposed site is changed from earlier tested site or non-availability of site or for any other reason(s) and submission of individual report showing data analysis and recommendation of proposed deep or shallow foundation with bearing capacity value of soil including analysis of soil, checking of foundation design etc. All complete as per direction of the E/C. Note that, payment for subsoil investigation works will be made, only if the said works was considered necessary and accordingly done as per direction of the E/C.	LS	1.00	26,528.00	26,528.00
4	Supplying, fabrication, and fixing to details as per design: deformed bar reinforcement in concrete in accordance with BDS ISO 6935-2: 2009 under Ductility Class D only, including straightening and cleaning rust, if any, bending and binding in position with supply of GI wires, splices (laps) etc. complete in all respects and accepted by the Engineer (Measurement shall be recorded only on Standard Mass per Unit length of Bars, while, dia of bars exceeds its standard). 420/400-grade (B420/400DWR) / 400G ribbed or deformed bar with minimum fy (ReH)= 420/400 MPa & tensile strength (fu or Rm) at least 525 MPa, minimum elongation after fracture and total elongation at maximum force is 16% and 8% respectively.	Kg	8000.00	82.00	656,000.00
5	Earth Work in Excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, leveling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the E/C, subject to submit method statement of carrying out excavation work to the E/C for approval. However, E/C's approval shall not relieve the contractor of his responsibilities and obligations under the contract.	Cum	120.00	88.00	10,560.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
6	Shore protection work during excavation in foundation trenches beyond 1.5 m depth to protect loss due to damage of property by palisading accepted by the Engineer-in-charge, [The rate is including the cost of vertical post]	Sqm	75.60	877.00	66,301.20
7	Sand filling in foundation trenches and plinth with sand having FM: 0.5 to 0.8 in 150 mm layers including leveling, watering and compaction to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming Each layer up to finished level as per design supplied by the design office only etc. all complete and accepted by the E/C.	Cum	50.00	635.00	31,750.00
8	Supply and laying of single layer polythene sheet weighing one kilogram per 6.5 square meter in floor or where below cement concrete complete in all respect and accepted by the E/C.	Sqm	70.00	42.00	2,940.00
9	Single layer brick flat soling in foundation , floor, RCC road, boundary wall with first class bricks including preparation of bed and filling the interstices of sand (FM = 0.80), leveling etc. complete and as per direction of the E/C.	Sqm	70.00	438.00	30,660.00
10	Earth filling for foundation trenches & site development in 150 mm layer to achieve minimum dry density of 90% with optimum moisture content (Modified Proctor Test) including carrying, watering, leveling, dressing and compacting to a specified percentage Each layer up to finished level etc. all complete and accepted by the E/C.	Cum	100.00	149.00	14,900.00
11	Lean cement concrete work beneath the base and in other places where need, in ratio (1:2:4) with cement, mixture of sand (FM 1.2) and 19 mm down graded stone chips including shuttering, curing, supplying necessary materials etc. all complete as per drawing, specification and direction of the E/C.	Cum	5.25	6,579.00	34,539.75
12	125 mm thick brick works with 1st class bricks in cement sand (FM: 1.2) mortar (1:4) and bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hr. before used and washing of sand curing at least for 7 days in all complete including cost of water, electricity and others charges etc. all complete as per drawing, specification and direction of the E/C.	Sqm	15.00	948.00	14,220.00
13	250 mm thick brick works with 1st class bricks in cement sand (FM: 1.2) mortar (1:4) and bond with connected walls including necessary scaffolding, raking out joints, cleaning and soaking the bricks for at least 24 hr. before used and washing of sand curing at least for 7 days in all complete including cost of water, electricity and others charges etc. all complete as per drawing, specification and direction of the E/C.	Cum	6.00	6,040.00	36,240.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
14.a	Reinforced cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 and 1:2:4 having minimum f'cr=30 Mpa & 24Mpa and satisfying a specified compressive strength f'c=25 Mpa & 19Mpa at 28 days on standard cylinders as per standard practice of Code ACI/ BNBC/ ASTM & Cement conforming to BDS EN-197-1-CEM 1 (52.5 N)/ ASTM-C 150 Type-I, best quality Sylhet sand or coarse sand of equivalent FM: 2.2 and 20 mm down well graded stone chips conforming to ASTM C-33, making, placing shutter in position and maintaining true to plumb, making shutter water-tight, properly placing reinforcement in position; mixing with standard mixer machine with hopper, fed by standard measuring boxes, casting in forms, compacting by vibrator machine and curing at least for 28 days, removing centering-shuttering after specified time approved; including cost of water, electricity, testing charges of materials and cylinders, other charges etc. all complete approved and accepted by the E/C. i) 1:1½:3 RCC (246 kg/cm2) for casting slab & walls with 19mm down graded stone chips for water retaining structure/Water Reservoir with 1% Water reducing admixture of approved quality by weight of cement (0.5kg per 50kg of cement) except cost of reinforcement, etc. all complete as per drawing, specification and direction of the E/C. a) All Base, walls & water face slab	Cum	46.80	12,367.00	578,775.60
14.b	Formwork, prop and necessary supports	Sqm	274.70	408.00	112,077.60
14.c	iii) 1:2:4 RCC (211 kg/cm2) for casting all roof slab, lintel, false slab, sunshade, RCC road, stair etc. with 19 mm down graded 1st class brick chips , except cost of reinforcement etc. all complete as per drawing, specification and direction of the E/C.	Cum	3.50	12,243.00	42,850.50
14.d	Formwork, prop and necessary supports	Sqm	3.75	387.00	1,451.25
15	Supplying, fitting and placing properly in position 200 mm X 19 mm size PVC water stopper at each construction joint of water retaining structure to ensure water tightness of the joint including supply of materials etc. all complete as per direction of the E/C.	m	61.00	1,017.00	62,037.00
16	Supplying, fitting, fixing 600 mm dia C.I manhole cover of approved quality with ring and locking arrangement , heavy type of minimum 25 kg in the roof, complete as per design and direction of the E/C.	Each	1.00	1,869.00	1,869.00
17	Cement concrete work (1:2:4) in construction of thrust block and pipe support with cement, mixture of coarse (FM 2.5) and medium sand (FM 1.5), 19 mm downgraded picked jhama chips, including shuttering, including breaking chips, screening, mixing, laying, compacting to levels and curing at least 7 days including the supply of water, electricity and	Cum	2.00	7,643.00	15,286.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
18	Providing apron with 50 mm thick cement concrete (1:2:4) with cement, coarse sand and picked jhama chips including breaking chips and one layer brick flat soling at bottom with first class or picked jhama bricks including cutting earth for preparation of bed and filling the interstices with local sand (FM: 0.8) including finishing, dressing, curing at least for 7 days etc. all complete, including cost of water, electricity, other charges all complete as per specification and direction of the E/C.	Sqm	11.50	917.00	10,545.50
19.i	i) 12 mm thick cement plaster (1:3) with neat cement finishing to inside wall & water face column of water retaining structure with 0.5% water reducing admixture of approved quality by weight of cement (0.25 kg per 50 kg of cement) including neat cement finishing etc. All complete as per direction of the E/C.	Sqm	225.00	295.00	66,375.00
19.ii	ii) 12 mm plaster (1:4) to all outer surfaces of water retaining structure & both side of brick wall.	Sqm	105.00	243.00	25,515.00
19.iii	Supplying 100 mm dia best quality uPVC B-grade rain water down pipe fitting and fixing in position including bends, min. 20x3 mm F.I bar clamp and nails, cutting groove/hole in walls/ concrete slabs, mending good of damages etc. all complete as per direction of the E/C.	m	4.50	701.00	3,154.50
20	Supplying movable aluminum ladder of approved design and size as per field requirements and direction of the E/C.	Each	1.00	5,680.00	5,680.00
21	Construction of surface drain of 300 mm clear width and depth up to 300 mm in brick masonry with 125 mm thick check wall in cement sand (FM: 1.2) mortar (1:6) over av. 75 mm thick cement concrete base (1:3:6) over one layer of brick flat soling. The surface having minimum 12 mm thick cement sand (FM: 1.2) plaster (1:3) and neat cement finishing with cement curing at least for 7 days including excavation in all kinds of soil, back filling with fine sand (FM: 0.8), consolidating and dressing, cost of water, electricity, other charges etc. All complete as per drawing, specification and direction of the E/C.	m	12.00	2,760.00	33,120.00
22	Supplying, fitting & fixing all grills of any design made with 25 x 6 mm FI bar including fabricating welding cost of electricity & tools & plants etc. .Complete for all floors accepted by the E/C (total weight per meter square should be min 42.88 kg & add or deduct @ Tk 35 for each kg (excess or less respectively)	Sqm	60.00	2,334.00	140,040.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
23	Supplying, fitting and fixing of 12 mm dia G.I pipe stair railing of any standard height and design and shape with 50 mm x 50 mm x 6 mm M.S. plate at the base of 12 mm dia G.I. Pipe and fitting & fixing by welding. Placing the pipes vertically @ 125 mm c/c (2 nos. in each steps) 150 mm embedded into the R.C.C tread of stair case after cutting grooves and mending good the damages with C.C. and providing 38 mm x 6 mm F.I. bar on the top of G.I. pipe to provide 37 mm G.I. pipe hand rail of any design including polishing, painting etc. all complete and accepted by the Engineer-in-charge.(Exposed area of railing will be considered for measurement, rate is excluding the cost of paint, wood for railing)	Sqm	20.00	3,736.00	74,720.00
24	Mild steel, grade 250 with minimum fy = 250 MPa, work in roof truss and Steel Column: supplying and fabrication of mild steel sections as per design, hoisting, fitting and fixing in position with bolt and nuts or rivets or welds and providing two coats of anti-corrosive paint over a prime coat of red oxide paint etc. complete and accepted by the Engineer-in charge.(Measurement to be given for truss member and Steel Column only).	kg	2000.00	138.00	276,000.00
25	Supply and installation of 2.0 mm thick fiber glass sheet (transparent sheet) for roof, wall etc. on M.S. purlin, angle etc. with 'J' hook or screws with washer and putty, all complete as per drawing, specification and direction of Engineer-in-charge.	Sqm	70.31	1,315.00	92,457.65
26	1.5 mm thick plain fiber glass sheet ridging with 300 mm lap on either side fitted and fixed with galvanized bolts and nuts etc. all complete and accepted by the Engineer-in charge.	meter	8.25	769.00	6,344.25
27	Supply and application of corrosion protection paint to the surface of the structural steel members conforming to SA 2.5; Steel members to be shot blasted inside the enclosed shot blasting chamber, final coat paint must be applied on site after installation, including the cost of primer, testing and necessary accessories, all complete as per drawing, specification and direction of Engineer-in-charge.	kg	25.00	26.00	650.000

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
28	ii) Exterior standard acrylic emulsion paint of approved best quality and color having water resisting properties and resistance properties against fungi, fading & flaking delivered from authorized local agent of the manufacturer (Berger weather coat smooth/ Elite smooth exterior/ Asian apex weather coat or equivalent brand) in a sealed container; applying to exterior surface with surface preparation including cleaning, drying, making free from dirt, grease, wax, removing all chalked and scaled materials, fungus, mending good the surface defects using sand paper and necessary scaffolding; applying 1 coat of exterior sealer of specified brand on prepared surface; then applying 1 coat of exterior putty of specified brand for levelling, spot filling, crack filling and cutting by sand paper/zero water paper; finally applying 2 coats of exterior emulsion paint spreading by brush/roller/spray & necessary scaffolding etc. up to desired finishing, elapsing specified time for drying or recoating; all complete in all floors and accepted by the Engineer-in charge.	Sqm	105.00	238.00	24,990.00
29	Manufacturing, supplying, fitting & fixing Collapsible Gate of any design & shape made of 25x 25 x 3mm channel placed @ 112 mm c/c vertically & connecting the same with Each other by 25 x 3 mm MS flat bars scissors 525 mm / 600mm long provided in 3 rows including cutting the different MS members to required size wheels, pulling handles on both sides, suitable locking arrangement, electrodes, grease & finally placing the same in position in between 2 (two) No. 50x 50 x 6mm MS tree rail made by welding 2 No. 50x 6mm MS flat bar fitted & fixed at top & bottom with R.R.C lintel/roof slab, floors and side wall with required No. 150 mm to 225mm long 38 x 6 mm MS. flat bar clamps one end welded with the gate member & the other end bifurcated & embedded in CC all the respective point in/c cutting holes & mending good the damages by pouring concrete (1:2:4) into the holes & finishing, etc. all complete, painting 2 coats with approved best quality synthetic enamel paint over a coat of anticorrosive painting, both end carriage, in/c greasing. all	Sqm	7.20	5,299.00	38,152.80
30	Construction of Masonry Inspection Pit with 250 mm thick brick work in cement mortar (1:4) including necessary earth work, side filling & one layer brick flat soling, 75 mm thick (1:3:6) base concrete for making invert channel & 12 mm thick (1:2) cement plaster with neat cement finishing etc. all complete up to a depth of 700 mm approved & accepted by the E/C.	Each	4.00	5,262.00	21,048.00
31	Supply and use of accelerating chemical admixture in concrete, complying ASTM C-494 Type - C of approved brand/origin/manufacturer and supplied by only manufacturer's authorized dealer with certificate of origin. An admixture that is to accelerate the setting time and early strength gain of concrete.	Liter	77.40	151.00	11,687.40

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
32	Design and drawing Treatment plant of 25 m^3/hr. capacity on the basis of raw water quality and Sub-Soil Investigation report from a reputed Institution/ Consultant firm/Individual Consultant and supply the all details drawing with specification 3 set each (A3 size) etc., All Complete as per direction in Engineer in charge For Arsenic & Iron Removal Treatment Plant	LS	1.00	100,00 0.00	100,000.00
33	Providing 3 sets of as-built Drawing subject to Engineer's approval produced in AutoCAD software in 17x 12 (A-3 size) standard drawing paper, and operating and maintenance manual of the equipment and plant incorporated in the works, if any, in original by the date stated in the particular conditions of contract (PCC). If the contractor does not supply the as- built drawings and operating and maintenance manuals by the date stated in the Particular Conditions of Contract (PCC), or they don't receive the Engineer's approval, the Engineer shall withhold the amount stated in the PCC from the payments due to the Contractor. The as-built drawings must show the permanent works as actually constructed and reflect the revision of tender drawings and drawings supplied to the contractor during the contract as well as revisions of drawings supplied by the contractor during to the contract. (One set of as-built drawings shall be considered for measurement and payment).	per Tend er	1.00	24,423. 00	24,423.00
Part-B : Electro-Mechanical Works					
A	**Primary Filtration**				
34	Supplying Free-Fall raw water System of minimum 20 m^3/hr. capacity by fabricating, welding, fitting, fixing etc. MS pipe (of different dia) of duly approved quality and mounting the system minimum 0.30 m above 4-walls of the Aeration Tank, fitting, fixing etc. on top of the RCC walls using MS plate, stainless nuts, royal bolts, gasket, clamp, etc. / welding ends of the vertical stands with deformed bars in position prior to casting the RCC walls (whatever feasible) and connecting ends of the inflow pipes with the underground pipeline network through a header pipe receiving raw water from Production Tube-Wells (PTWs) installed at different locations in the light of the approved design-drawing of the system. Note that total cost of this system includes, aside from the above mentioned materials and works, costs of carrying, placing, water, electricity, hiring of machinery & equipment, labour wage etc. and also on-site test of water for dissolved oxygen to be done by collecting water sample at the point of inflow of the fallen/sprinkled water from the tank into the adjacent flume as per direction of the Engineer-in-Charge (E/C). Also note that performance of this system will be considered satisfactory, subject to ensuring minimum 15% dissolved oxygen in raw water during the process of falling/sprinkling in the tank.	Set	1.00	30,000. 00	30,000.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
35	Supplying and installation of following specified SS 60mesh screen for aeration bed including preparation of graded sand with stone for aeration bed of thickness 750mm , as per direction of EIC including VAT and IT & others taxes.	Sqm	8.00	15,000.00	120,000.00
36	Supply and installation of Lamella Clarifier / Lamella Tube Settler: Shape of the Tube: Hexagonal Chevron, MOC of the Lamella Sheet: PVC/PP, Size of the individual Lamella Sheet: 1.0 m x 1.0 m, Thickness: 1.0 mm (+/- 0.1 mm), Setting of the Lamella Sheet: Placed in 45° inclined position against one of the 2 width-side walls of the Lamella Clarifier with each 2 sheets placed face-to-face forming a number thorough hexagonal tubes width-wise one after another, and thus formed bundle of straight but inclined hexagonal tubes packed up to other width-side end of the Lamella Clarifier, and resting on the base frame fixed at specific design-height from bottom of the Clarifier. Plan Settling Area of the Media: 12 m^2/m^3, Fitting Arrangement: Tongue Groove. Brand: Gfiber/Heron/Equivalent Country of Orign: USA/Taiwan	Cum	10	25000.00	250,000.00
37	Supply and installation of Mechanical Structural support for Tube Settler: MOC: Hot rolled MS Steel with non corrosive epoxy painted frame suitable for installation of tube settler media	LS	1	50000.00	50,000.00
B	**Pressure Filter and Pump**				
38	Supplying. fitting, fixing the Multi-Grade filter with the supply of following etc., all complete as per drawing, specifications and instruction of Engineer-in-Charge.Flow rate: 25 m^3/hr.Maximum operating pressure: 40 psiSafety factor: 4:1Maximum operating temperature: 120°FType: Down flow.Tank Size: (Dia X H) 1600mm X 2400mmShell Thickness: 8mmMOC of Pressure Vessel: Stainless Steel (SS)Control Valve: Manual Butterfly Valves,Front Piping: 75mm Dia MS PipeEmergency Outlet: 50mm Dia MS PipeVacuum breaker piping : 25mm dia uPVC pipe.Air Vent Piping: 38mm Dia MS PipeFilter media: Sand, Gravel and Manganese/Birm (As required)Accessories : Pressure gauge (SS well type), sample valves, Nut Bolt (MS), Filter Nozzle, Water Label Indicator, Leg Pipe & Plate, Internal Fittings, Bend, Tee and necessary fittings.Origin of Media: USA / UK	Nos.	1.00	690,000.00	690,000.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
39	Supplying. fitting, fixing the Activated Carbon filter with the supply of following etc., all complete as per drawing, specifications and instruction of Engineer-in-Charge. Flow rate: 25 m^3/hr. Maximum operating pressure: 40 psi Safety factor: 4:1 Maximum operating temperature: 120°F Type: Down flow. Tank Size: (Dia X H) 1600mm X 2400mm Shell Thickness: 8mm MOC of Pressure Vessel: Stainless Steel (SS) Control Valve: Manual Butterfly Valves, Front Piping: 75mm Dia MS Pipe Emergency Outlet: 50mm Dia MS Pipe Vacuum breaker piping : 25mm dia uPVC pipe. Air Vent Piping: 38mm Dia MS Pipe Filter media: Activated Carbon (As required) Accessories : Pressure gauge (SS well type), sample valves, Nut Bolt (MS), Filter Nozzle, Water Label Indicator, Leg Pipe & Plate, Internal Fittings, Bend, Tee and necessary fittings. Origin of Media: USA / UK	Nos.	1.00	765,000.00	765,000.00
40	**Vessel Feed Pump:(1W+1S)**Supply, testing (in BUET/CUET/RUET/KUET/MIST) and installation of High Lift centrifugal water pump manufactured according to DIN/ NEMA/ ICE/ BS/ VDE/JIS and ISO 9001 standard having the following specification:- Discharge Q: 25 m3/hr to 42 m3/hr (Min 25 m3/hr.) Head H: min 32.00 m to max 47.00 mMOC: Pump Body, Impeller Body Back Plate -Cast IronPower: To be quoted by the supplier substantiated by performance curve and catalogues. Efficiency: Maximum efficiency to be quoted by the supplier & substantiated by performance curve and shall not be less than 70%Overall Efficiency: Not less than 50%Warranty: Minimum 03 (Three) Years Motor: 400V AC (-10%, +5%) Phase: Three Phase Frequency: 50Hz RPM: 2900 Motor Type: Induction type motor with C.I. base frame, Stainless Steel Shaft, back pull out design, Insulation class-F, protection IP44(minimum) etc. all complete as per direction of E/C. Brand :Pedrollo/Caparari/Apex, Origin: Italy/Germany/UK	Set	2.00	182,572.00	365,144.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
41	**OHT Delivery Pump: (1W+1S)** Supply, testing (in BUET/CUET/RUET/KUET/MIST) and installation of High Lift centrifugal water pump manufactured according to DIN/ NEMA/ ICE/ BS/ VDE/JIS and ISO 9001 standard having the following specification:- Discharge Q: 25 m3/hr to 42 m3/hr (Min 25 m3/hr.) Head H: min 25.00 m MOC: Pump Body, Impeller Body Back Plate -Cast Iron Power: To be quoted by the supplier substantiated by performance curve and catalogues. Efficiency: Maximum efficiency to be quoted by the supplier & substantiated by performance curve and shall not be less than 70% Overall Efficiency: Not less than 50% Warranty: Minimum 03 (Three) Years Motor: 400V AC (-10%, +5%) Phase: Three Phase Frequency: 50Hz RPM: 2900 Motor Type: Induction type motor with C.I. base frame, Stainless Steel Shaft, back pull out design, Insulation class-F, protection IP44(minimum) etc. all complete as per direction of E/C. Brand :Pedrollo/Caparari/Apex, Origin: Italy/Germany/UK	Set	2.00	182,572.00	365,144.00
42	**Mud Pump:** Providing & fixing single stage 2800-2900 RPM centrifugal water pump motor set monobloc type manufactured according to EN ISO 9906 GRADE 3B / DIN / NEMA / IEC / BS / VDE / JIS & ISO 9001 standard of following capacity suitable for operation at single phase, 230 V ± 5%, 50 Hz AC having insulation: class F & protection: IPX4 (minimum) manufactured by CE certified / UL listed countries as per sample accepted / approved by the engineer. Power: 1.5 HP Discharge : 50-200 liter/min Head: 20-31 meter Suction Dia: 40mm Delivary Dia: 25 mm	Set	3.00	36,586.00	109,758.00
C	**Pipe Fittings and Valves**				
43	Supply, installation, fixing and jointing the following pipes, fittings, valves and specials in correct position and alignment with 2 nos 3mm thick rubber gaskets for each flanged joints etc. all complete				
	a) Seamless MS pipes (Full length of Pc MS pipe shall be at least 6 meter and length of short piece shall be as per drawing and field requirement).				
	i) 100 mm	m	20.00	1,500.00	30,000.00
	ii) 75 mm	m	25.00	1,378.00	34,450.00
44	**MS Bend** for following size of pipes				
	a) MS bend, 22.5/45/90 degree:				
	i) 75 mm	Pc	8.00	1,736.00	13,888.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
	ii) 100 mm	Pc	10.00	2,315.00	23,150.00
45	**MS Tee** (Molded and Smooth) for following size of pipes				
	a) MS Tees				
	i) 100 mm x 100 mm x 100 mm	Pc	2.00	3,670.00	7,340.00
	ii) 75 mm x 75 mm x 75 mm	Pc	2.00	1,736.00	3,472.00
46	**MS Reducer/Enlarger** (Molded & Smooth)				
	i) 75 mm x 50 mm	Pc	2.00	1,200.00	2,400.00
	ii) 75 mm x 38 mm	Pc	2.00	1,100.00	2,200.00
	i) 100 mm x 50 mm	Pc	2.00	1,800.00	3,600.00
	ii) 100 mm x 40 mm	Pc	2.00	1,750.00	3,500.00
47	**Sluice Valve** (PN 10):				
	i) 100 mm	Pc	1.00	8,500.00	8,500.00
	ii) 75 mm	Pc	1.00	5,250.00	5,250.00
48	**Butterfly Valve** (PN 10) :				
	i) 100 mm	Pc	4.00	6,100.00	24,400.00
	ii) 75 mm	Pc	4.00	4,200.00	16,800.00
49	**Ball Valve** (PN 10)				
	i) 12 mm	Pc	4.00	380.00	1,520.00
50	**Loose Flange** for following size of pipes				
	a) MS loose flange				
	i) 75 mm	Pc	20.00	600.00	12,000.00
	ii) 100 mm	Pc	20.00	820.00	16,400.00
	b) MS blind flange				0.00
	i) 100 mm	Pc	2.00	1,000.00	2,000.00
51	**Pressure Gauge** Range: Up to 250 psi, Dial: 100 mm (4 inch), oil filled.	Pc	2.00	1,800.00	3,600.00
52	Supply, fitting, fixing etc. of **Flanged Type Foot Valve** with maximum working pressure: 2 kg/cm^2, Applied temperature: 10°C - 80°C, Disk: Ductile Iron, Screen: Stainless Steel (SS).				
	i) 50 mm	Pc	2.00	3,000.00	6,000.00
53	SS Nut-Bolt				
	i) 16 mm dia.	Pc	40.00	30.00	1,200.00
	ii) 12 mm dia.	Pc	10.00	25.00	250.00
54	**Rubber Gasket**	Pc	40.00	50.00	2,000.00
55	**Rowel Bolt**	Pc	50.00	30.00	1,500.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
56	**Flexible Joint**				0.00
	i) 100 mm	Pc	2.00	3,000.00	6,000.00
	i) 75 mm	Pc	2.00	1,500.00	3,000.00
57	**Non Return Valve**				
	i) 100 mm	Pc	2.00	15,000.00	30,000.00
	i) 75 mm	Pc	2.00	10,000.00	20,000.00
58	Supply and installation of **Liquid Level Sensor**: Liquid level switches provide high-reliability monitoring and detection of a wide range of fluid media. Requirements can range anywhere from the sensing of water and wastewater, to biohazards, to even demonized or potable water and **float-based multiple liquid level sensing technologies** may also be incorporated within a single application. Brand: Radar / HANYOUNG Country of Origin: Taiwan / Korea	Each	2.00	5,000.00	10,000.00
59	Supply and installation of **Liquid Level Sensor**: Liquid level sensors provide high-reliability monitoring and detection of a wide range of fluid media. Requirements can range anywhere from the sensing of water and wastewater, to biohazards, to even demonized or potable water and **conductivity-based multiple liquid level sensing technologies** may also be incorporated within a single application. Brand: Radar / HANYOUNG Country of Origin: Taiwan / Korea	Each	1.00	8,000.00	8,000.00
60	Supply and fixing of pressure switch. Media: Steam, Water and Air Ambient Temperature: 20°C to 70°C Media temperature: Up to 120°C Enclosure: IP65 Switch Type: SPDT, Snap Action Microswitch Brand: Radar / HANYOUNG Country of Origin: Taiwan / Korea	Pc	2.00	8,000.00	16,000.00
D	**Electrical Works**				
61	**Transformer**: Supply and installation of oil immersed natural air cooled 3-Phase, 50Hz,11KV/0.415KV distribution transformer of DYN11 vector group complete with two windings of high conductivity copper having percentage impedance 4-6.5% basic impulse insulation level 75 KV, dielectric strength 28 KV (for 1 min) HT & LV porcelain bushings, manual 5 position standard tap changer, conservator, thermometer, oil inlet & outlet valves, oil level indicator, dehydrating breather, lifting lugs, earthing terminals wheel, data plate etc. including painting, suitable for operation at 40°C ambient temperature with maximum temperature rise 60°C locally manufactured and tested in Bangladesh as per NEMA/VDE/IEC/BS standard.	Each	2.00	97,924.00	195848.00
	a) Capacity 15KVA				
	b) No load loss 80 watt (max.)				

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
	c) Full load loss 275 watt (max.)				
	Manufactured by Government of Bangladesh (GOB) owned / shared company or the valid ISO-9001 certified company having type test certificate for the required or higher capacity of transformer according to relevant IEC standards from any internationally accredited independent laboratory.				
62	Supply and installation of metal clad surface mounting type 3- phase 400 Volt ±5% volt 50 Hz. automatic DOL / star-delta motor control panel for the following capacity centrifugal pump motor set. This device will get sense to start pump when water in the overhead tank get down to a certain level and will stop when the water in the tank reach to a certain level. This process will be same for the underground reservoir. Main component manufactured in accordance with EN ISO 9906 GRADE 3B DIN / NEMA / IEC / BS / VDE / JIS & ISO 9001 standard comprising of circuit breaker of required capacity, ammeter and voltmeter with selector switch of proper circuit ratio & burden, indicating light for 3-phase, on–trip indicating lamp, main & auxiliary contactors, thermal over load relay timer, on / off push button, electrical relay for protection against phase failure, phase reverse complete with necessary wires, cables, lugs, cables, cables ties, connection etc. of the following as per direction of the engineers (10 HP or According to requirement	set	2.00	90,000.00	180,000.00
	- 1 nos 100A, 25 KA three phase molded case circuit breaker (TP MCCB) with adjustable thermally delayed over load protection and electromagnetic short-circuit release.				
	- 3 nos. Voltmeter scaled 0-500 V with protective fuse.				
	- 3 nos. Ammeter scaled 0-100 A with protective fuse.				
	- 3 nos. 100/5A current transformers with suitable accuracy and burden.				
	- 1 set 200A, TP & N electrolytic copper bus bar.				
	- 3 nos 30A, 16 KA three phase molded case circuit breaker (TP MCCB) with adjustable thermally delayed over load protection and electromagnetic short-circuit release.				
	-1 no complete set automatic Star-Delta starter unit complete with magnetic contractors of adequate rating, thermal overload protection relays, dry run protection relay, on-off push button switch, run and trip indication lamp, control fuse, necessary cables, cable lugs, cable ties, connectors, etc. as required suitable for operation & safety protection of 11.2 KW Pumping Equipment.				

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
	-2 nos complete set automatic Star-Delta starter unit complete with magnetic contractors of adequate rating, thermal overload protection relays, dry run protection relay, on-off push button switch, run and trip indication lamp, control fuse, necessary cables, cable lugs, cable ties, connectors, etc. as required suitable for operation & safety protection of 7.5 KW Pumping Equipment.				
	-3 sets of 3-phase, 400 Volts, 50 Hz 5 KVARSF6 gas field dry type self healing capacitor bank with build-in discharge resistor.				
	- 3 nos. 30/5A current transformers with suitable accuracy and burden.				
	-2x3 nos. Ammeters having scale 0-30A with Current Transformer of suitable accuracy and burden.				
	- 3 nos. phase indication lamps (Blue /Red /Yellow).				
	-1 no 30A SP MCB for Domestic Services				
	-1 set of control fuses of adequate rating				
63	Light Fittings and Related Works: Supplying, fitting and fixing of the following light fittings and related work as per sample approved (including lamp) (ii) The box type special security light fitting of Crescent cat No. CML-209 or Gloria cat No. GWT-735 or Shwash cat No. BF(WT)-10 or equivalent approved brand consisting of steel sheet body 185mm height & 135mm x 98mm bottom with powder coated maroon paint, outside covered by white glass, brass holder, earth terminal necessary wiring with 2 x 0.4 sq.mm stranded PVC insulated flexible FR cable etc. with 30 watt energy saving lamp.	Set	2.00	1,334.00	2,668.00
64	Cables and related works: Supply and installation of cables and related works including supply and installation of cable accessories such cable lugs, sockets, conduit pipes of appropriate sizes, cable trench etc. all complete and accepted by the Engineer-in-Charge.				
	(i). 1C-1 X 16 rm NYY cable from HT line to transformer to meter to LT Panel.	m	50.00	365.00	18,250.00
	(ii). 1C-1 X 10 rm NYY cable from starter of LT panel to pump-motor.	m	60.00	250.00	15,000.00
	(iii) 1C-2 x 2.5 sq.mm(BYM) cable with 2.5 sq.mm (BYA) ECC wire through 16mm dia 1.5mm thick (water grade) PVC conduit from DB to Switch board	m	30.00	50.00	1,500.00

Item No: 5	Description of Works	Unit	Quantity	Unit Rate	Amount
65	Commissioning, Testing and Operation & Maintenance (O&M) of **the Treatment Plant** upon completion of the construction works for a period of consecutive fixed number of months including supply of necessary tools, mechanical and electrical spare parts and accessories, raw water treatment and disinfecting chemicals like sodium hypochlorite solution/bleaching powder etc. and payment of all utility charges like oil-fuel, electricity, water, gas bills, and any other overhead expenses for smooth O&M of the pressure filter and testing of raw and treated water samples to ascertain dosing rate of the chemicals from time-to-time, as required, depute minimum 3 (three) Nos. of both technical & non-technical persons at the plant site on full-time basis to ensure proper O&M, organize and conduct on-the-job training to adequate number of DPHE/Pourashava staff in order to make them able to take over the O&M activities properly, and finally hand over to the Approved Authority through DPHE, all complete as per direction and satisfaction of the E/C.	Month	12.00	10,000.00	120,000.00
Sub-Total for Arsenic Iron Removal Plant (Capacity: 20 m3/Hr.)					**6,303,745.00**

DEPARTMENT OF PUBLIC HEALTH ENGINEERING			
Rural Piped Water Supply Scheme in Shimulbank village, Shimulbank Union, Shantiganj Upazila, Sunamganj District			
Sl. No.	**Description**		**Estimated Amount in BDT**
ITEM-01:	**Estimate for Installation/Construction of Surface water intake station, Pump House, Electric Panel Board etc., electrification with transformer (All the items include VAT, Tax & profit)**		
	Part A	Floating Intake Station & Pumping System	2,061,432.00
	Part B	Pump House	529,434.23
	Part C	EXTERNAL & INTERNAL ELECTRICAL WORKS FOR INTAKE STATION (Floating Intake) :	1,106,551.00
ITEM-02:	**Estimate for the Construction of House connection works**		
	Part A	House connection works with meter	1,655,175.00
ITEM-03:	**Estimate for the Construction of HDPE pipe line works**		
	Part A	Pipe line Works	3,659,928.38
ITEM-04:	**Estimate for Construction of 100m3/hr capacity Over Head Tank etc.**		
	Part A	Civil Works	5,556,670.44
	Part B	Mechanical Works	
	Part C	Electrical Works	
ITEM-05:	**Estimate for construction of Surface Water Treatment Plant**		
	Part A	Civil Works	6,303,745.00
	Part B	Mechanical Works	
	Part C	Electrical Works	
		Total Cost of Scheme (BDT)	**20,872,936.05**

Capital Cost estimation for Sunamganj Village

Village	Final Selected Intervention		Capital Cost (Tk.)
	Name	Number	
Shimulbank, Sunamganj	1. Rural Piped Water Supply scheme (Source: Surface Water)	1	20,872,936.05
		Total Cost	**20,872,936.05**

The cost estimation of the finally selected option for Sanitation of the four arsenic contaminated villages are given below

Conversion of single pit latrine to twin pit latrine

Cost Estimate

Part "A" : Single to Twin Pit Latrine (Construction of One New pit and Connecting with Latrine etc. With Existing Latrine, a Single Pit,)

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
1	Mobilization and cleaning site before commencing actual physical work and during contract period and demobilization after completion of the works under contract to be accepted by the Engineer-in-charge. This work shall also cover clayey cleaning and clearing, cutting or filling, dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer-in-charge, where, payments are to be based on ground area determined by the Engineer-in-charge and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer-in-charge.	Sqm	3.00	169.00	507

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
2	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer-in-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer's approval shall not relieve the contractor of his responsibilities and obligations under the contract. Earthwork in excavation in foundation trenches up to 1.5 m depth and maximum 10 m lead: in soft clayey soil / loose sand / silt	Cum	5	88	440
3	Sand filling in trenches and plinth with sand having F.M-0.5 to 0.8 in 150 mm layers including levelling, watering and compaction to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level as per design supplied by the design office only etc. All complete and accepted by the Engineer in charge.	Cum	1	635	635
4	Supplying and laying of single layer polythene sheet weighing one kilogram per 6.5 square meter in floor or anywhere below cement concrete complete in all respect and accepted by Engineer-in-charge.	Sqm	0.75	42	31.5
5	One layer brick flat soling in foundation or in floor with first class/picked jhama bricks including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-charge.	Sqm	0.75	420.00	315.00
6	Mass concrete (1:3:6) in floor with cement Sand (F.M. 1.2) and picked jhama chips including breaking chips, screening, mixing, laying, compacting to levels and curing for at least 7 days in/c the supply of water, electricity and other charges and costs of tools and plants etc. aii complete as per drawing & direction of the engineer-in-charge.	Cum	0.05	6647.00	332.35

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
7	125 mm brick works with first class bricks in cement sand (F.M. 1.2) mortar (1:4) and making bond with connected walls including necessary scaffolding, racing out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer.	Sqm	1	917	917.00
8	Providing minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to plinth wall with cement (1:4) up to 150 mm below ground level including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) ground floor.	Sqm	3	280	840.00
9	Supplying 50 mm inside dia best quality uPVC waste and ventilation pipe having specific gravity 1.35 - 1.45, wall thickness 2.5 mm - 3.0 mm, and other physical, chemical, thermal, fire resistivity properties etc. as per BSTI approved manufacturer standards or ASTM, BS/ISO/IS standards fitting and fixing in position with sockets, bends, of uPVC Pipe with all accessories such as Round grating /domed roof grating bands, sockets etc. approved and accepted by the Engineer- in- charge.	RM	3	407	1221
10	R.C.C. Ring : Construction, Supplying, fitting and fixing of RCC rings of inner dia 48 inch and outer dia 52.5 inch, height 12 inch and thickness 2.25 inch having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C in horizontal & vertical directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc, w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, labor and transportation, VAT and IT)	Each	8	800	6400

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
11	R.C.C. Slab for soak well: Construction, Supplying, fitting and fixing of RCC (1:2:4) slab having 52.5 inch dia 3 inch thick having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C both directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc., w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, labour and transportation, VAT and IT)	Each	1	800	800
12	Construction of masonry inspection pit with 250 mm thick brick work in cement mortar (1:4) including necessary earth work, side filling and one layer brick flat soling, 75 mm thick (1:3:6) base concrete for making invert channel and 12 mm thick (1:2) cement plaster with neat finishing etc. all complete up to a depth of 700 mm approved and accepted by the Engineer- in- charge.	Each	1	3530	3530
13	R.C.C. Slab for inspection pit: Construction, Supplying, fitting and fixing of RCC (1:2:4) slab having 2'-4"x2'-4" size having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C both directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc, w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, labour and transportation, VAT and IT)	Each	1	400	400
	Total =				**16368.85**

Twin Pit Latrine

Cost Estimate

Part "A": Twin Pit Latrine (With CI Sheet Roof, Fencing and Door, RCC Slab with Ceramic Pan, Precast RCC Pillar etc.)

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
1	Mobilization and cleaning site before commencing actual physical work and during contract period and demobilization after completion of the works under contract to be accepted by the Engineer-in-charge. This work shall also cover clayey cleaning and clearing, cutting or filling, dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer-in-charge, where, payments are to be based on ground area determined by the Engineer-in-charge and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer-in-charge.	Sqm	7.50	169.00	1267.5
2	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer-in-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer’s approval shall not relieve the contractor of his responsibilities and obligations under the contract. Earthwork in excavation in foundation trenches up to 1.5 m depth and maximum 10 m lead: in soft clayey soil / loose sand / silt	Cum	12.75	88	1122
3	Sand filling in trenches and plinth with sand having F.M-0.5 to 0.8 in 150 mm layers including leveling, watering and compaction to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level as per design supplied by the design office only etc. All complete and accepted by the Engineer in charge.	Cum	0.85	635	539.75
4	Supply, fitting and fixing of R.C.C Pre Cast Concrete (pillar ratio of cement, sand and khoa 1:2:4) having with 3nos 6mm dia M.S Bar in horizontal and tie bar #10 MS Wire at 8 inch C/C vertical directions. Column Size 4 inch x 4 inch and 108 inch long. Fitting the same vertically in the ground as per drawing and direction of EIC.	Each	4	500	2000

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
5	Supplying and laying of single layer polythene sheet weighing one kilogram per 6.5 square meter in floor or anywhere below cement concrete complete in all respect and accepted by Engineer-in-charge.	Sqm	0.6	42	25.2
6	One layer brick flat soling in foundation or in floor with first class/picked jhama bricks including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-charge.	Sqm	3.95	420.00	1659.00
7	Mass concrete (1:3:6) in floor with cement Sand (F.M. 1.2) and picked jhama chips including breaking chips, screening, mixing, laying, compacting to levels and curing for at least 7 days in/c the supply of water, electricity and other charges and costs of tools and plants etc. all complete as per drawing & direction of the engineer-in-charge.	Cum	0.40	6647.00	2658.80
8	125 mm brick works with first class bricks in cement sand (F.M. 1.2) mortar (1:4) and making bond with connected walls including necessary scaffolding, racing out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand curing at least for 7 days in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer.	Sqm	5.14	917	4713.38
9	Providing minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to plinth wall with cement (1:4) up to 150 mm below ground level including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) ground floor.	Sqm	7.92	280	2217.60
10	Supplying, fitting and fixing of Bangladesh pattern, long pan with foot-rest, made of vitreous China clay and preparing the base of pan with cement mortar (1:4) and with wire mesh or rods, if necessary in all floors including making holes wherever required and mending good the damages and fitting, fixing, finishing etc. complete with all necessary fittings and connections approved and accepted by the Engineer-in-charge. 530 mm x 430 mm x 210 mm size, 12.5 kg of weight Color : White	Nos	1	1737	1737.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
11	Supplying 50 mm inside dia best quality uPVC waste and ventilation pipe having specific gravity 1.35 - 1.45, wall thickness 2.5 mm - 3.0 mm, and other physical, chemical, thermal, fire resistivity properties etc. as per BSTI approved manufacturer standards or ASTM, BS/ISO/IS standards fitting and fixing in position with sockets, bends, of uPVC Pipe with all accessories such as Round grating /domed roof grating bands, sockets etc. approved and accepted by the Engineer- in- charge.	RM	2	407	814
12	Supply, fitting and fixing of best quality 12 mm PVC Bib Cock including uPVC, Nipple etc. All complete as per direction of EIC	Each	2	150	300
13	R.C.C. Ring : Construction, Supplying, fitting and fixing of RCC rings of inner dia 48 inch and outer dia 52.5 inch, height 12 inch and thickness 2.25 inch having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C in horizontal & vertical directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc, w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, labor and transportation, VAT and IT)	Each	16	800	12800
14	R.C.C. Slab for soak well: Construction, Supplying, fitting and fixing of RCC (1:2:4) slab having 52.5 inch dia 3 inch thick having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C both directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc, w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, labor and transportation, VAT and IT)	Each	2	800	1600
15	R.C.C. Slab for inspection pit: Construction, Supplying, fitting and fixing of RCC (1:2:4) slab having 2'-4"x2'-4" size having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C both directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc, w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, labor and transportation, VAT and IT)	Each	1	400	400

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
16	Supply and installation of 20BWG thick corrugated galvanized iron sheet(Bangladesh made) having min weight 63-65 kg per bundle (2'-6" width, 70 — 72 rft long) fitted and fixed on M.S. sections with 'J' hook or wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer-in-charge.	Sqm	18.03	547	9862.41
17	Supply and installation of 38mm x 38mm x 3mm angle section as fitting the same on roof and fence with necessary materials including necessary wielding anti corrosive red/gery oxide paint etc. all complete and accepted by the Engineer-in-charge.	Rm	30	90	2700
18	**Other Supplies & Accessories fitting, fixing & supplying**				
18.1	Stud Nail (2.5 inch)	kg	2	80	160.00
18.2	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
18.3	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
18.4	Hinges	Nos	3	50	150.00
18.5	Screw for Hinges	Dozen	1	100	100.00
18.6	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
18.7	PVC pipe (1.5 dia) Gas Pipe	Ft	20	25	500.00
18.8	uPVC Long Trap (4" dia)	Nos	1	250	250.00
18.9	uPVC pipe (4" dia)	Ft	20	85	1700.00
	Total =				**49846.64**

Capital Cost Estimation for Sanitation in four villages of arsenic contaminated area

Village	Final Selected Intervention		Capital Cost (Lac Tk.)
	Name	Number	
Shimulbank, Sunamganj	1. Conversion of single pit latrine to twin pit latrine	195	32
	2. Twin Pit Latrine	105	52
Saikchail, Cumilla	1. Conversion of single pit latrine to twin pit latrine	390	64
	2. Twin Pit Latrine	205	102
Tipna, Khulna	1. Conversion of single pit latrine to twin pit latrine	300	49

	2. Twin Pit Latrine	145	72
Datinakhali, Satkhira	1. Conversion of single pit latrine to twin pit latrine	410	67
	2. Twin Pit Latrine	198	99
Total Cost			**537**

6. Economic and Financial Analysis

6.1 Introduction

Forty villages from fifteen districts were selected for the project based on nine criteria. Out of the forty villages, fifteen villages were selected to pilot the project and detailed survey was conducted in these fifteen villages. Study 6 concentrates on the availability of surface water in the selected villages and financial and economic cost benefit analysis of intervention in four villages is conducted in this section, the details of which are given below.

District	Upazila	Union	Village
Cumilla	Monohorganj	Bipulshar	Shekchail
Khulna	Dumuria	Khurnia	Tipna
Satkhira	Shyamnagar	Labsa	Datinakhli
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank

Both financial and economic analyses have been carried out to assess economic feasibility of the planned interventions to increase access to safe water and sanitation system to the people of the said villages. The following section that describes the approach and method of cost-benefit analysis (both financial and economic) of the project. The analysis is carried out for this study considering the villages as mentioned above. Finally, the analysis produces the values of the indicators such as NPV, BCR, and IRR.

6.2 Financial Appraisal

Financial cost-benefit analysis of the investment, based on current market has been carried out to ascertain financial viability of the intervention project in the village of a. Moreover, the analysis measures the investment worth of proposed intervention to improve existing water supply and build improved water supply systems.

Identification of Costs and Benefits

Costs and benefits have been developed for the project based on the SWOT analysis and design of intervention to improve/build improved water access and safe water sources as well as improved sanitation.

Tangible benefits such as value of time saved due to better access to safe water, health benefits realized as healthcare cost saving and the value of less productive time lost due to decreased rate of water-borne disease have been identified as the direct benefits of this project.

Quantification and Valuation of Costs and Benefits

Costs: Two categories of costs are identified for this project and they are discussed below:

Infrastructure cost: Seven water access strategy were considered when designing intervention to improve water access: 1) rural piped water supply, 2) mini piped water supply, 3) Tube well with submersible pump, 4) water supply via ring well, 5) water purification plant.

Depending on the technical feasibility and unique requirement of each village, an intervention plan is drafted and the cost of infrastructure is then determined. The cost of water supply is 613 lacs and the cost of sanitation is 586 lacs. The total cost is 1318 lacs including price as well as physical contingency.

Table 6.1: Financial Investment Cost (BDT in Lac)

District	Upazila	Union	Village	Number of Household (HH)	Water supply cost	Sanitation cost	Total Financial Cost (BDT in Lac)
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	136	181	317
Khulna	Dumuria	Khurnia	Tipna	772	17	133	150
Satkhira	Shyamnagar	Labsa	Datinakhli	568	250	181	431
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank	462	210	92	302
Total				**613**	**586**		**1199**
Physical contingency							60
Price contingency							60
Total							**1318**

(1) O&M cost: For the sustainability of the project, required annual maintenance costs are necessary. The O&M (operation and maintenance) costs are incurred due to the operation and maintenance of the water supply systems such as regular cleaning and upkeep of the water source and supply structure. The annual maintenance cost is required throughout the lifetime of the project and it will start after the implementation of the project. The financial O&M cost of the project is BDT 12 Lac and the economic O&M cost is 10 Lac.

(2) Benefit: Three kinds of benefits are identified for this project. With project and without project scenarios are considered to find incremental benefit due to the project. These are discussed below:

(1) Time saving due to closer physical access to water and sanitation: Immediate access and less waiting time for improved water sources and sanitation means people use this time elsewhere in productive pursuits, giving rise to benefits. To calculate this, survey data on average time spent on accessing water i.e. average time required to travel to the water source and average time spent in line to collect water were used. The value of time is assumed to be BDT 62.50 per hour. According to the assumption, water will be available instantly after the project is implemented. Therefore, it is assumed that with the project, the average time required to access water will half of what it was without the project.

(2) Healthcare cost savings due to seeking less healthcare: Significant and beneficial health impacts are associated with improvements in access to safe water and sanitation6. Therefore, this project's benefits include reduction in people getting sick from water-borne diseases. They will have to spend less on healthcare, which is a benefit accrued to the project's stakeholders. To calculate this, rate of water-borne disease and the average cost of healthcare is needed. Without project, the disease rate is assumed to be 20% on average, and cost of healthcare is taken from survey data. With the project, the disease rate is assumed to halve (4%).

(3) Savings related to less productive time losses due to disease: As people will be sick less frequently than without project, they will spend less time being sick and will be able to spend this time in productive pursuits, which is a benefit. To calculate this, rate of water-borne

[6] Waddington, H., Snilstveit, B., White, H. & Fewtrell, L. Water, sanitation and hygiene interventions to combat childhood diarrhea in developing countries. The International Initiative for Impact Evaluation (3ie), New Delhi, India

disease, the average days lost due to water-borne disease and the value of a productive day is needed. Without project, the disease rate is assumed to be 20% on average, average days lost due to water-borne disease is 73 days and the value of a productive day is assumed to be BDT 500. According to assumptions, with project the disease rate will decrease to 4% and average days lost due to water-borne disease will be 37 days.

Table 6.2: Financial Incremental Benefit (BDT in Lac)

Benefits		
Time saved benefit of water supply	**Time saved benefit of sanitation**	**Health benefit**
78	119	430

Analysis

For financial cost-benefit analysis, cash flow is the market value of net incremental benefit of the project by year. Cash flow shows the difference between the values of cash inflow (revenues or values of benefit from the project) minus the values of cash outflow (costs of the project). The cash flow is calculated on annual basis for the plan period. For this project, the values of cost and benefits components are summed to calculated aggregate investment cost, aggregate maintenance cost, aggregate time saved benefit, aggregated healthcare cost saving and aggregate savings on loss of productive time due to water-borne disease in order to do cash flow analysis for the whole study. The following Table shows the financial cash flow of the project.

Table 6.3: Financial Cash Flow (BDT in Lac)

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit of water supply	Time saved benefit of sanitation	Health benefit	Total Benefit	
1	359.55		360				0	-359.55
2	479.4		479				0	-479.4
3	479.4		479				0	-479.4
4		12	12	78	119	430	626	615
5		12	12	78	119	430	626	615
6		12	12	78	119	430	626	615
7		12	12	78	119	430	626	615
8		12	12	78	119	430	626	615
9		12	12	78	119	430	626	615
10		12	12	78	119	430	626	615
11		12	12	78	119	430	626	615
12		12	12	78	119	430	626	615
13		12	12	78	119	430	626	615
14		12	12	78	119	430	626	615
15		12	12	78	119	430	626	615
16		12	12	78	119	430	626	615
17		12	12	78	119	430	626	615
18		12	12	78	119	430	626	615

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit of water supply	Time saved benefit of sanitation	Health benefit	Total Benefit	
19		12	12	78	119	430	626	615
20		12	12	78	119	430	626	615

The benefit of the project will start accruing after the 3-year implementation period. According to assumptions, in the first year after implementation only half of the potential benefit will be realized and full potential benefit will be realized every year after that.

Key Assumptions considered in exercises

1. Project's implementation period is 3 years;
2. Project's economic life is assumed to be 20 years;
3. Discount rate is 12%; and physical and price contingency is assumed at 5%.
4. All taxes and subsidies are excluded from economic values of costs and benefits. For calculation of economic values of cost and benefit, conversion factors have been applied;
5. Only direct benefits are value of time saved, savings on healthcare cost and savings on loss of productive time due to water-borne disease;

The indicators and the Analysis Results

With view to measuring private profitability, discounting method of cost-benefit analysis has been applied for computation the values of the indicators. These are given below:

i. Financial Net Present Value (FNPV)

Financial NPV represents the sum of present values of financial cash flow thought out the planning period. Positive value of FNPV indicates that the project is profitable. The formula is given below:

FNPV = $\sum_{t=1}^{t=n}(B_t - C_t)/(1+i)^t$

Where

B_t is benefits for each year of the project;

C_t is for cost in each year of the project;

t is the discounting period from year 1 through n^{th} year; and

i is the interest (discount) rate.

ii. Financial Benefit Cost Ratio (FBCR)

Financial Benefit cost ratio, it is the sum of the discounted value of benefits stream divided by the sum of discounted value of total cost stream of the project. It indicates present value of benefits per unit of cost. Formula for each of the discounted measures (Gittnger, 1982)[7] is given below

FBCR = $\sum_{t=1}^{t=n} B_t/(1+i)^t \div \sum_{t=1}^{t=n} C_t/(1+i)^t$

[7] Gittenger J.P. Economic Analysis of Agricultural Project, The WB, Washington, USA, 1982, p361

iii. Financial Internal Rate of Return (FIRR)

Financial Internal Rate of Return (FIRR) is an indicator used in cost-benefit comparison for estimating the profitability of a potential investment. FIRR is the rate of return on the investment at which NPV of cash flow stream is 0 (zero).

FIRR = $\sum_{t=1}^{t=n}(B_t - C_t)/(1+i)^t$ = 0

The cut-off rate for the FIRR is 12 per cent. The FIRR compares with the Weighted Average Cost of Capital. If FIRR is found more than 12 per cent, the project seems to be acceptable to the decision maker.

Financial indicators	Values of the indicators	Decision rules
FNPV (BDT in lac)	2,071.33	Positive value is acceptable
FBCR	2.87	Value >1 is acceptable
FIRR	34%	≥ 12% is acceptable.

The discount method (Present value method) of project analysis has been applied for the calculation of the values of the indicators. From the interpretation of all 3 indicators' values, it can be said that the project is profitable given the cost and benefit assessment. A positive value of the financial net present value signifies a project with more than cash inflow than cash outflow for its lifetime, calculated at present value. So, this project is expected to generate more cash than it will spend. As the benefit-to-cost ratio is greater than 1, the benefits generate by the project outweigh the costs incurred because of project activity and indicate that it's justified. The internal rate of return is well above the required rate of return at 34% which is the expected compound annual rate of return that will be earned on this project. However, the real rate of return for each year may vary.

Concluding Remarks: Given the value of the indicators and their standard interpretation, the project is profitable and should be pursued.

6.3 Economic Appraisal

Economic adjustments are made to financial data using standard conversion factor after which costs and benefits are appraised from the point of view of the entire economy. Economic analysis measures the investment worth of the project from the perspective of the country as a whole. In this regard, cost-benefit comparison for the investment considering economic value (using efficiency or shadow prices), the amount by which production of the project outputs or use of the project inputs changes national income. Economic cost benefit analysis is necessary to decide whether the project will contribute towards reaching national plan objectives.

Identification of Direct, Indirect and Associated Costs and Benefits

Identification and quantification procedure of all direct costs and direct benefits of the project have been discussed in the above financial section.

There are some potential indirect benefits from this intervention, which are not included in the cash flow analysis. These are categorized below:

1) Indirect Benefit: There are numerous indirect benefits; firstly, better water access will mean less dehydration from lack of safe drinking water, which is a health benefit. One benefit of improved access to safe water and sanitation is the improvement in educational levels due to higher enrollment and attendance rates. Supply of safe drinking water will also mean less time and costs spent on treating drinking water.

2) In terms of sanitation, less dehydration from not drinking due to poor latrine access is a potential benefit of building better latrines. Part of improved sanitation is safe disposal of human waste, which in turn may be used along with animal waste as input to biogas production that can lead to fuel cost savings and income opportunities.

3) Intangible Benefit: One of the intangible benefit of the project is the improved quality of life in terms of less time spent hauling water from the source to household- this time can instead be saved for leisure and non-economic pursuits. Another benefit is the gender impact improved access to water may have. In most cases, women do the task of water bearing and if they no longer have to bear that unfair burden, they can spend time elsewhere in more fulfilling activities.

4) A significant intangible benefit of the intervention is the improved quality of life in terms of safety, privacy, dignity, comfort etc. that come with improved sanitation access. Environmental benefit in terms of less water and soil polluted from poor sanitation is another intangible benefit arising from improved access to sanitation.

Quantification and Valuation of Costs and Benefits

Domestic financial prices of inputs and outputs of the project overstate to the value of real prices (international prices) equivalent. Thus, it is necessary to adjust the financial prices to economic prices to reflect resource cost to the country as whole. Broad categories of financial investment costs have been converted into economic values by specific conversion factors and standard conversion Factor. Economic analysis (cost-benefit comparison) is carried taking the adjusted economic value of investment and operation and maintenance (O&M) costs applying conversion factors. Using same approach and method, benefits are also adjusted for economic values of components. For the purpose, the following guidelines have been used. These are given below:

1. Conversion Factor (CF) for various broad components are taken from FPCO Guidelines[8] to adjust local financial prices (eliminating market distortions) for traded and non-traded items;
2. Foreign exchange is considered to be boarder price and foreign exchange value remains the same as financial value i.e. the factor is 1 (one).

Table 6.4: Economic Investment Cost (BDT in Lac)

Items of Cost	**Financial cost**				**Conversion factor**	**Economic cost**			
Year	**Year 1**	**Year 2**	**Year 3**	**Total**		**Year 1**	**Year 2**	**Year 3**	**Total**
Base cost	359.55	479.4	359.55	1199	0.902	324	432	324	1081
Physical contingency	-	-	59.925	60	0.902	-	-	54	54
Price contingency	-	-	59.925	60	0	0	0	0	0
Total	**359.55**	**479.4**	**479.4**	**1318**	**-**	**324**	**432**	**378**	**1135**

[8] FPCO Guidelines for Project Assessment, (May1992) MoWR (renamed), Dhaka

Table 6.5: Economic Incremental Benefit (BDT in Lac)

Benefits		
Time saved benefit of water supply	**Time saved benefit of sanitation**	**Health benefit**
70.36	107.18	387.50

Analysis

The values of cost and benefit by villages are calculated and aggregated for cost-benefit analysis. Costs include investment and maintenance of the items of work. On the other hand, benefits include aggregated time saved benefits, aggregated healthcare cost saving and aggregate savings on loss of productive time due to water-borne disease in order to do cash flow analysis for the whole study 6. These aggregate values are then converted into economic values through multiplying by standard conversion factors. The following Table shows cash flow of economic values by year.

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Economic Benefit	Total Benefit	
1	252		252.4				0	-252.4
2	337		336.5				0	-336.5
3	337		336.5				0	-336.5
4		10	10.5	70.4	107.2	387.5	565.1	554.6
5		10	10.5	70.4	107.2	387.5	565.1	554.6
6		10	10.5	70.4	107.2	387.5	565.1	554.6
7		10	10.5	70.4	107.2	387.5	565.1	554.6
8		10	10.5	70.4	107.2	387.5	565.1	554.6
9		10	10.5	70.4	107.2	387.5	565.1	554.6
10		10	10.5	70.4	107.2	387.5	565.1	554.6
11		10	10.5	70.4	107.2	387.5	565.1	554.6
12		10	10.5	70.4	107.2	387.5	565.1	554.6
13		10	10.5	70.4	107.2	387.5	565.1	554.6
14		10	10.5	70.4	107.2	387.5	565.1	554.6
15		10	10.5	70.4	107.2	387.5	565.1	554.6
16		10	10.5	70.4	107.2	387.5	565.1	554.6
17		10	10.5	70.4	107.2	387.5	565.1	554.6
18		10	10.5	70.4	107.2	387.5	565.1	554.6
19		10	10.5	70.4	107.2	387.5	565.1	554.6
20		10	10.5	70.4	107.2	387.5	565.1	554.6

Assumption

1. Project's implementation period is 3 years;
2. It is assumed that the project's economic life is 20 years;

3. Discount rate is 12% as well as price and physical contingency are assumed at 5%.
4. All taxes and subsidies are excluded from economic values of costs and benefits. For calculation of economic values of cost and benefit, conversion factors have been applied;
5. Standard conversion factor is 0.902

Indicators and the Analysis Results

Economic cost benefit analysis has been carried out with the economic cash flow for estimating the economic indicators. Discounting method of cost-benefit comparison has been used for calculating the values of the said indicators. These are:

(i) Economic Net Present Value (ENPV)

Economic NPV represents the sum of present values of economic cash flow throughout the planning period. Positive value of ENPV indicates that the project is profitable, benefits cover the investment and O&M costs during the 20-year plan period. The formula is given below:

ENPV = $\sum_{t=1}^{t=n}(EB_t - EC_t)/(1+i)^t$

Where

EB_t is economic benefits for each year of the project;

EC_t is for economic cost in each year of the project;

t is the discounting period from year 1 through n^{th} year; and

i is the interest (discount) rate.

(ii) Economic Benefit Cost Ratio (EBCR)

Economic Benefit cost ratio is the sum of the discounted value of economic benefits stream divided by the sum of discounted economic value of total cost stream of the project. It indicates present value of benefits per unit of cost. Formula for each of the discounted measures (Gittnger, 1982)[9] is given below:

EBCR = $\sum_{t=1}^{t=n} EB_t/(1+i)^t \div \sum_{t=1}^{t=n} EC_t/(1+i)^t$

(iii) Economic Internal Rate of Return (EIRR)

Economic Internal Rate of Return (FIRR) is an indicator used in cost-benefit comparison for estimating the economic viability of a project. EIRR is the rate of return on the investment at which the Net Present Value of cash flow stream is 0 (zero).

EIRR = $\sum_{t=1}^{t=n}(EB_t - EC_t)/(1+i)^t = 0$

Economic indicators	Values of the indicators	Decision rules
ENPV (BDT in lac)	1,907	Positive value is acceptable
EBCR	2.99	Value >1 is acceptable
EIRR	35%	≥ 12% is acceptable.

The discount method (Present value method) of project analysis has been applied for the calculation of the values of the indicators. From the interpretation of all 3 indicators' values, it can be said that the project is profitable given the cost and benefit assessment. A positive value of the financial net present value signifies a project with more than cash inflow than cash outflow for its lifetime, calculated at present value. So, this project is expected to generate more cash than it will spend. As the benefit-to-cost ratio is greater than 1, the benefits generate by the project outweigh the costs incurred because

[9] Gittenger J.P. Economic Analysis of Agricultural Project, The WB, Washington, USA, 1982, p361

of project activity and indicate that it's justified. The internal rate of return is well above the required rate of return at 35% which is not the expected compound annual rate of return that will be earned on this project. However, the real rate of return for each year may vary.

Concluding Remarks: Given the value of the indicators and their standard interpretation, the project is profitable and should be pursued.

6.4 Financial/ Economic Risk Analysis

To assess the impact any change in values of costs and benefits might have on the indicators in base case, a sensitivity analysis is conducted. Here, the analysis is done to account for unforeseen situations, i.e. four exemplary cases such as: total benefit decreases by 10%, total cost increases by 10%, cost decreased and benefit increases by 10% (best case scenario), cost increases and benefit decreases by 10%. The results are presented below:

Table 6.6: Results of Financial Sensitivity Analysis

	Benefits decreased by 10%	Total cost increased by 10%	Best Case	Worst Case
FBCR	2.62	2.62	3.48	2.38
FNPV	1783	1961	2489	1672
FIRR	32%	32%	40%	29%

Table 6.7: Results of Economic Sensitivity Analysis

	Benefits decreased by 10%	Total cost increased by 10%	Best Case	Worst Case
EBCR	2.72	2.72	3.62	2.47
ENPV	1646	1811	2280	1551
EIRR	33%	33%	41%	30%

All the graphical representations for Financial Analysis and the calculations for both Economic and Financial aspects are given in the Appendix II.

7. Environmental and Social Impact Assessment

7.1 Introduction

Under **My Village My Town** project, water supply and sanitation services will be provided to rural households. The major environmental risk will emanate from water contamination, discharge of sludge and untreated faecal materials, noise and air pollution. The major social risk will be related to community health and safety issues. Given the labors will mostly be from the local area and level of supervision and training provision, the gender based violence (GBV) risk is likely to be low. Construction related impacts (noise, air and water pollution) will also occur which needs to be managed with proven best practices.

The expected ES impacts can be mitigated through implementation of appropriate environmental code of practice and ES management plans which are discussed below.

7.2 Potential Environmental and Social Impacts

Potential environmental impact in the Project may include the following

- **Noise and Air pollution** and disturbance from operation of vehicles, machineries and equipment can cause disturbance to people and the fauna near the project interventions. For example, piling or drilling can generate excessive noise. Migratory birds coming in the project site may decrease due to noise. Air Pollution by dust or gaseous emissions from vehicles and land clearing can impact nearby people, fauna and flora. Odours and pollution caused by leaking latrines and faecal sludge impacting surrounding water bodies, flora and fauna.
- **Soils impact** by erosion or pollution from chemical spills or improper disposal of waste materials. The waste materials can be from latrines (faecal sludge), construction materials and etc.
- **Vibration impacts** can occur during piling, drilling and vehicle movement. Vibration near steep slopes can also increase risk of landslides (during monsoon season, even several months after construction has finished). Excessive vibration can disturb the local sensitive fauna living near the construction sites or nearby forest areas.
- **Surface water** impacts can occur due to alteration of quantity or quality. For example, unintentional runoff from site can cause pollution to water bodies. Disposal of slurry for production tubewell installation may cause surface water (pond water or canal water) pollution. Also runoff from sites where waste materials have been disposed improperly can cause water pollution. Surface water can also be contaminated by faecal materials through leaking containments of the latrines or disposal of faecal sludge through traditional desludging process.
- **Groundwater impacts** can be impacted due to withdrawal of groundwater for water supply (production TW and piped water supply). Also, percolation from leaking latrines can cause pollution of aquifers.
- **Septage transportation** impacts can occur when septage will be transported from the twin pit latrines.

Environmental mitigation measures

- Use of offset twin pit latrines to reduce the risk of broken ‘p’ traps of existing toilets, increase the convenience (e.g., enabling the commode to be situated within the house), and facilitate easier emptying. When offset pit latrines have two alternating pits, the pit that is not used can neutralize the pathogens given sufficient time, enabling the safe removal of the faecal sludge. Adherence to the twin alternating offset pit latrine standard, along with the provision of training to households and local entrepreneurs on the correct procedures for O&M and safe disposal of faecal sludge, is considered to facilitate compliance to the SDG 6.2 'safely-managed' sanitation service standard.

- Any organic wastes from construction site or any source at construction site should be properly collected and disposed.
- Emission of dust can be mitigated by a number of measures together or separately.
  - ✓ Ensure that all trucks and vehicles used in the project area will comply with technical and environmental safety regulations.
  - ✓ Install dust cover on vehicles at the construction sites and during transportation. Dust control (watering dusty areas) on non-paved access roads.
  - ✓ Use of adapted Protective Personal Equipment (ear plugs, goggles, helmets, gloves, masks) where necessary.
  - ✓ Schedule the operation times for vehicles, machines working in the construction area to reduce air emissions.
- Noise pollution may be mitigated to certain degrees following the measures:
  - ✓ Perform the construction activities within the day time and minimize work done during the night.
  - ✓ Regulate the speed of traffic inside the site and in the surrounding areas in construction sites.
  - ✓ Regularly carry out maintenance and routine inspections on vehicles to ensure that they are meeting the technical standards. Old vehicles and construction machinery with poor quality shall be prohibited for being used within the project's activities.
  - ✓ Noise volume should not exceed 55 dBA at the nearest off-site reception location.
- Septage will be transported by septage hauler and no discharge or leakage will be allowed during transportation. Further, after proper treatment of septage to remove hazardous pathogens/destruction of infectious organisms they will also be disposed in suitable agricultural field since it contains nutrients that can reduce reliance on chemical fertilizer for agriculture. Treated sewage sludge can provide some part of the nitrogen and phosphorus requirements of many crops. However, the numbers of pathogenic and parasitic organisms in sludge need to be treated before application to the land by appropriate sludge treatment.

Potential Social Impacts

A number of moderate potential social impacts can arise from the Project interventions:

Potential social risks and impacts will revolve around gender (design, safety, impact on women's health); exclusion from benefits and consultation (especially women, elderly, persons with disabilities, indigenous, marginalized and vulnerable communities), land use (common/private property, optimizing access through strategic location, resettlement impacts if any, community health and safety and the type of labor used and associated impacts.

The project will entail use of labor for small scale civil construction in remote areas. Although labor will be mostly local incidence of GBV/SEA cannot be ruled out. Thus, there is a need for training and sensitization of workers on GBV issues, Contractor's Code of Conduct during bidding and monitoring in the field.

Community health and safety risks are also anticipated due to the removal and transportation of faecal sludge, and other minor construction related impacts if not properly managed. However, the Project is designed to reduce open defecation and improve the sludge management and transportation issues.

Human Health

The possible impacts from the existing unsanitary facilities and proposed project's interventions are as follows

- Contaminated water and poor sanitation facilities due to faulty design and inundation by seasonal flood and heavy rainfall that will cause cholera, diarrhea, dysentery and other water related diseases
- Stagnant water while construction phase may lead to spread out dengue, chikungunya, malaria and other vector borne diseases.
- During seasonal flood and heavy rain fall the excrete and other lavatory waste may wash away from the unsanitary toilet may cause significant pollution to the human health and environment by mixing with the nearby water body.
- Open defecation practices and inadequate sanitation facilities are particularly dangerous because waste from infected individuals can contaminate a community's land and water, increasing the risk of infection for other individuals.
- Ground water might be contaminated due to lack of proper management of the fecal sludge.
- Materials wash water from the construction sites may contaminate and cause the ambient waterbody
- Fugitive dust, PM2.5, PM10 during construction material deployment may cause the unfavorable environment for the community inhabitants. Unexpected accident or incident by the project vehicle may be a concern during project implementation.

As COVID-19 pandemic still going on, corona viruses may be transmitted to the community by the infected project workers.

Construction Phase Security

Inadequate construction site security poses a significant risk to assets, construction materials and property. Theft/vandalism of assets, materials and property would increase construction costs and cause delays in project completion. Improper security measures may pose security risk for construction workers and especially foreign staff on construction sites.

Access to equitable water and Sanitation services

Inadequate access to equitable water and sanitation services contaminated water and poor sanitation are linked to the transmission of diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid, and polio. Absent, inadequate, or inappropriately managed water and sanitation services expose individuals to preventable health risks.

Social Mitigation Measures

Following steps can be taken to reduce the risks and impacts from social point of view:

- To address the issue of GBV the PMUs and the Contractors will need to put mechanisms in place (CESMP, written and signed Code of Conduct, worker training and sensitivity) as well as a GRM to address this issue of potential GBV.
- Community health and safety must be ensured through proper design of toilets, haulage of septage, discharge of waste water etc.
- Workers must be provided with training and PPEs as well as they should require to follow COVID-19 protocol and keep social distancing from local communities. Provision of symptom reporting and medical evacuation also must be in place in case symptoms are seen in any workers.

7.3 Environmental and Social Management Plan (ESMP)

Environmental and Social Management Procedure

After a sub-project's location and design is known, screening of ES risks can be done. The purpose of screening is to get a preliminary idea about the degree and extent potential risks and impacts of a particular sub-project, which would subsequently be used to assess the need for further ES assessment. The screening would involve: (i) reconnaissance of the sub-project area and its surroundings (ii) identification of the major sub-project activities; and (iii) preliminary assessment of the impacts of these activities on the ecological, physicochemical and socio-economic environment of the sub-project surrounding areas.

It is expected that most of the sub-projects will require some form of feasibility study. This will help in the preparation of ES instruments. The recommendations from these ES instruments will need to be incorporated by the design team and also incorporated into the tender (bidding) documents. DPHE will then need to implement the proposed mitigation measures, monitor and report compliance.

The framework for assessing and managing ES issues in different sub-projects involves following necessary procedures and tools for screening and assessing ES impacts. These ES assessments of sub-projects need to comply with the Environment Conservation Rules 1997 and the World Bank's Environmental and Social Framework, including the 10 Standards (ESSs).

Sub-project Screening and Categorization

The formal ES assessment will be done after identification of the sub-project' design and location through ES checklists. This ES checklists will be developed for each sub-project. The purpose of the checklists is to identify potential risks and concerns to be addressed in the design phase of the sub-projects. ES Screening will determine whether sub- project interventions will require an IEE or a site-specific ES management plan.

The outcome of the screening process is determination of the category of the sub-project in terms of its ES risks. Considering potential environmental and social impacts and their significance, proposed sub-project interventions identified in the initial stage of implementation can be categorized into four levels:

1) High Risk
2) Substantial Risk
3) Moderate Risk
4) Low Risk

Considering the nature of the sub-projects, it is expected that most sub-projects will be of low or moderate risks.

In case of a moderately risk sub-project, it will require an IEE with a site-specific management plan. The IEE is a review of the reasonably foreseeable effects of a proposed development intervention/ activity on the environment. Participation and consultation with local communities are important in identifying the potential impacts and suitable mitigation measures. The major activities involved in carrying out an IEE include the following:

- Preparation of baseline within the sub-project influence area, against which impacts of the proposed sub-project would be evaluated;
- Assessment and evaluation of impacts of major project activities on the baseline during construction phase and operational phase;
- Identification of mitigation and enhancement measures
- Development of site-specific ES plans and monitoring measures.

The procedures for ES management for a moderately risk sub-project is shown in **Table 7.1** below.

Table 7.1. Procedures for ES management for a Moderate Risk Sub-Project

Sub-Project Phase	Procedure	Responsibility
Project Identification / Pre-Feasibility	ES Screening of sub-project	PMU, DPHE
Feasibility Study / Design	Conduct IEE/ESA and prepare ESMP Submission and clearance of the Sub-Projects by DoE.	PMU, DPHE
	Public consultations	PMU, DPHE
Detailed Design and Tendering	Ensure Mitigation measures included in Design	PMU, DPHE
	Ensure ES aspects are included in Bidding Documents	PMU, DPHE
Construction Works	Implement and monitor of management plans	PMU, DPHE
	Update IEE and other ES instruments as required	PMU, DPHE
Post-Construction	ES Audit	PMU, DPHE

The environmental and social management program should be carried out as an integrated part of the project planning and execution. It must not be seen merely as an activity limited to monitoring and regulating activities against a pre-determined checklist of required actions. Rather it must interact dynamically as a sub-project implementation proceeds, dealing flexibly with environmental impacts, both expected and unexpected. For all subprojects to be implemented under the project, the ESMP should be a part of the Contract Document.

The anticipated environmental and social impacts of the project and the suggested mitigation and enhancement measures and the responsible authority for implementing the mitigation and enhancement measures are provided in **Table 7.2.**

Table 7.2. Typical General Anticipated Environmental and Social Impacts of the subprojects, mitigation measures and responsible authority.

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
Setting up labor shed(s) for the workers	• Land encroachment • Solid and liquid wastes from the labor camp • Water/ environmental pollution	• Labor camp should be constructed at a distance from the water bodies and away from the settlement of the community • Construction of sanitary latrine/ septic tank system. • Erection of "no litter" sign, provision of waste bins/cans, where appropriate • Plan and design for the proper disposal of solid waste including 3R practices • Instruction of the workers to maintain clean environment in the camps and not to dispose of the solid and liquid wastes into the water bodies.	PMU, DPHE
	• Health of workers	• Training and awareness about hygiene practices among workers. • Availability and access to first-aid equipment and medical supplies	
	• Outside labor force causing negative impact on health and social well-being of local people.	• Contractor to employ local work force, where appropriate; promote health, sanitation and safety awareness.	
All Construction Works	▪ Beneficial impact on employment generation ▪ General degradation of environment ▪ Loss of natural vegetation and tress ▪ Loss of aquatic habitat ▪ Change of land cover and land uses ▪ Drainage Congestion and water logging ▪ Air, water and noise pollution ▪ Generation of liquid and solid wastes, debris.	▪ Employ local people in the project activities as much as possible. ▪ Give priority to poor people living in the project area in sub-project related works (e.g., excavation and other works, which do not require skilled manpower). ▪ Air, water and noise pollution measures should be incorporated during the construction of the sub-projects ▪ Proper management of solid waste management plan including waste collection, transport and disposal plan should be implemented and waste should not be disposed in open or low land. ▪ Provision for PPE, first aids in the construction site, proper handling and operation of the machinery and electrical equipment, adequate precautions for working near water body or at height and electrical used for construction, and control of	PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
	▪ Occupational health and safety	spillage and leakage of oils, fuels and others during the construction at the site.	
Site Preparation and other activities	▪ Water, air and soil pollution ▪ Cause water logging and drainage congestion ▪ Unhygienic environment and cause nuisance of environment.	▪ Construction facilities to be placed away from water bodies, natural flow paths. ▪ For tube-well sinking a minimum distance from latrines' soak well to be maintained. ▪ Any disruption of socially sensitive areas with regard to human habitation and areas of cultural significance will be avoided. ▪ The existing slope and natural drainage pattern on the site should not be significantly altered. ▪ The contractor shall ensure that site preparation activities do not lead to disruption of activities of the local residents.	PMU, DPHE
Construction Materials Stockyard	▪ Cause water stagnation ▪ Air pollution ▪ Occupational health and safety risk	▪ Maintain adequate moisture content of sand during transport and handling ▪ Carrying the materials especially loose soil and sand with adequate cover ▪ Avoid the accidental spillage of fuels, lubricants and other hazardous materials and storage of these materials over a raised platform, not directly on the ground and away from drainage connected to water body. ▪ Provide adequate signs and precaution in the stockyard.	PMU, DPHE
Carrying of the construction materials to the site	▪ Cause air pollution, noise and vibration. ▪ Disturb the nearby residents and roadside houses, educational institutes and shops.	▪ Construction materials especially loose sand, soil and other should be carried under covered condition ▪ Transportation of the construction materials have to be carried during the scheduled times, and mainly during the day.	PMU, DPHE
Land Acquisition	▪ Loss of agricultural production, fish resources. ▪ Loss of income and livelihoods. ▪ Social conflict.	▪ Avoid land acquisition as much as possible. ▪ Prior to start construction adequate compensation should be given to the affected communities' in-time according to RAP. ▪ Adequate compensation should be given for standing crops; ▪ Create job opportunities for the affected communities. ▪ Consultation required with all potentially affected households.	PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
Drainage/water congestion	• Stockpiling of construction materials on road side • Disposal of solid/debris into drains	• Provision for adequate drainage of storm water • Provision of adequate diversion channel, if required • Ensure adequate monitoring of drainage effects, especially if construction works are carried out during the wet season. • Construction activity should be recommended during the dry season; • Immediately removed and clean all the construction debris from the construction site as well as from the water bodies in a planned way • Duration of stockpiling should be minimized as much as possible. • Avoid the encroachment of the water bodies; • Construction workers shall be instructed to protect water resources.	Contractor, PMU, DPHE
Air pollution	• Vehicle exhaust emissions and combustion of fuels of construction vehicles and construction machineries • Dust from construction activities like excavation, earth and sand stockpiling during dry period. • Dust from crushing of construction materials.	• Construction machinery shall be properly maintained to minimize exhaust emissions • Dust generated as a result of clearing, leveling and site grading operations shall be suppressed using water sprinklers. • Dust generation due to vehicle movement on haul roads/access roads shall be controlled through regular water sprinkling. • Undertake air quality monitoring following the National Air Quality Standard (Schedule-2: Standards for Air Quality, ECR, 1997 and Amendment in 2005).	Contractor, PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
Noise Pollution and Vibration	• Due to operation of the construction equipment, construction activities, construction vehicles causing adverse impacts on the surrounding residents.	▪ Establish the work time in daytime hours and avoiding works during night. ▪ Use of low-noise and low vibration equipment and use of noise suppressors and mufflers in heavy construction equipment. ▪ Construction equipment and vehicles shall be fitted with silencers and maintained properly. ▪ Regulate use of horns and avoid use of hydraulic horns in project vehicles. ▪ Protection devices (ear plugs or ear muffs) shall be provided to the workers operating in the vicinity of high noise generating machines during construction. ▪ Noise level monitoring should be carried out following the National Noise Quality Standard (Schedule-4: Standards for Sound, ECR, 1997 and Noise Pollution (control) rules 2006). ▪ Vibration monitoring should also be carried out.	Contractor, PMU, DPHE
Water Pollution (surface and groundwater)	• Construction and general wastes from the construction sites. • Oil spill from the construction vehicles and construction camp can effect on fishes and aquatic wildlife (such as snakes, frogs etc.) • Discharge of liquid and septage from the labor camp.	▪ Prevent discharge of fuel, lubricants, chemicals, and wastes into adjacent rivers, khals or drains. ▪ A waste management plan should be prepared and follow strictly during the construction period. ▪ No waste should be thrown/disposed into the river/khal/canal ▪ Hazardous wastes management plan should be developed and followed the plan strictly in the construction site, if used. ▪ Monitor the surface and groundwater quality during the construction period of the sub-projects following the National Water Quality standards (Schedule-3: Standards for Water, ECR 1997).	Contractor, PMU, DPHE
Waste Management (solid, liquid and hazardous wastes).	• Improper storage and handling of construction and general liquid waste such as fuels, lubricants, chemicals and hazardous liquid onsite, and potential spills from these liquid materials may harm the environment and health of construction workers.	▪ Minimize the generation of sediment, oil and grease, litter, debris and solid wastes. ▪ No wastes should be throwing into the river/khal/canal ▪ Take all precautionary measures when handling and storing fuels and lubricants, avoiding environmental pollution. ▪ Encourage 3R in the construction camps, inorganic wastes can be sell or recycled.	Contractor, PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
	• Solid wastes from the labor camp.	▪ Adequate supply of garbage/waste bins in the construction camps and project site and proper disposal of wastes.	
Offensive odor (from improper disposal of wastes, toilet effluent and faecal sludge)	• Unhygienic condition in the labor camp and construction site, improper disposal and management of liquid and solid wastes.	▪ Adopt proper waste management, effluent and faecal sludge management.	Contractor, PMU, DPHE
Safety Issues	• Construction activities like boring for TW, machinery operations, drilling for pipeline laying, etc.	• Prevent entry of unauthorized personnel and proper storage and control of hazardous materials on site • Health and safety training to the labors • All the labors to wear ID cards and provide adequate PPE • Child and forced labors are not allowed for any form of activities • Site(s) shall be secured by fencing and manned at entry points	Contractor, PMU, DPHE
Labor Issues	• Use of labors for various construction activities.	• Awareness building about prevention of child abuse, child marriage, GBV, sexual harassment, trafficking of women and children as well as illegal drug trade. • Ensure uses of PPE during the construction activities. • Adequate facilities ensuring COVID-19 protocols (PPE etc.) and adequate training on COVID-19 issues • Treated water will be made available at site for labor drinking purpose. • Evacuation facilities for symptomatic labors.	Contractor, PMU, DPHE
Occupational Health and Safety of the Workers and Construction Site	▪ .Lack of proper housing, water supply and sanitation facilities may cause health hazards of the workers. ▪ Improper liquid and solid wastes management cause environmental pollution ▪ Potential disease transmission like water borne diseases, dengue, and others	▪ Consider the location of construction camps away from communities (at least 500 m) in order to avoid social conflicts; ▪ Create awareness among the camp users on health and safety requirements to be maintained and code of conduct. ▪ Adequate housing for all workers should be provided avoiding over crowing, proving with Safe and reliable water supply; Hygienic sanitary facilities and sewerage system. ▪ Ensure proper collection and disposal of solid wastes within the construction camps. ▪ Provide adequate health care and sanitation facilities within the construction sites.	Contractor, PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
	▪ Construction works may cause health risks (injuries, accidents, death) to workers and site visitors, if not properly instructed. ▪ Lack of First Aids and Health care facilities.	▪ Train all construction workers in basic sanitation and health care issues and safety matters and on the specific hazards of their work. ▪ Regular mosquito repellant spraying during monsoon periods. ▪ Provide appropriate PPE for workers, such as safety boots, helmets, masks, gloves, protective clothing, goggles, full-face eye shields and ear protection; ▪ Maintain the PPE properly by cleaning dirty ones and replacing them with the damaged ones; ▪ Provide health care facilities and first aid facilities are readily available; ▪ Document and report occupational accidents, diseases, and incidents and actions taken.	
Community Health and Safety	▪ Noise and dust pollution; ▪ Communicable diseases can spread among the local community.	▪ Prior to start the construction activities, the contractor will be informed the local community; ▪ Regular health checkup of the workers and awareness training about the communicable diseases; ▪ Proper lighting at the project site during the night time; ▪ Avoid unnecessary noise pollution; ▪ Spraying water in the dry surface to reduce the dust pollution ▪ Provide proper access control to the project site and unauthorized entry to the project site will be controlled.	Contractor, PMU, DPHE
Beneficial impact on employment generation	▪ Create opportunity for jobs of the local people.	▪ Employ local people in the project activities as much as possible. ▪ Give priority to poor people living in the villages within project area in subproject related works (for example, excavation and other works, which do not require skilled manpower).	Contractor, PMU, DPHE
Sub-project specific impacts during the Construction phase and corresponding mitigation measures			
Setting up and operation of drilling rig and drilling for installation of DTW	▪ Air and noise pollution affecting nearby settlements. ▪ Stock-pilling of earth.	▪ Consider use of noise attenuator in drilling rigs ▪ Remove stock-piled earth after completion of works.	Contractor, PMU, DPHE
Pump House construction and Electrical works	▪ Air and noise pollution affecting nearby settlements	▪ Ensure adequate number of portable toilets	Contractor, PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
	▪ Water pollution from temporary labor shed toilets		
Construction of water distribution network	▪ Air and noise pollution affecting nearby settlements ▪ Water pollution from temporary labor shed toilets ▪ Ecological impacts including destruction of aquatic habitat	• Ensure adequate number of portable toilets in the construction sites. ▪ Prevent discharge of leachate, chemicals, and faecal sludge into surface waters. ▪ Preventing entry of sediments into the water bodies. ▪ Keep noise level (from equipment) to a minimum level, as certain fauna are very sensitive to loud noise.	Contractor, PMU, DPHE
During Operation of the Sub-projects			
Odors and pollution caused by leaking latrines and faecal sludge impacting surrounding water bodies, flora and fauna.	▪ Leaching of faecal materials from toilets.	▪ Ensure preventative maintenance schedule is followed ▪ Regular inspections of potential leaking points	WATSAN Committee, DPHE
Withdrawal of groundwater	▪ Excessive withdrawal may cause depletion of the GW table.	▪ Monitoring of extraction rates	WATSAN Committee, DPHE
Community Health	▪ Human health safety problems may occurs during operational activities of TW, Faecal Sludge management and others.	▪ Proper design and method should be practiced while install the tube well in terms of depth of water extraction. Water sample should test (Arsenic, iron, salinity, TC and FC, E.coli and other parameters) at a regular interval. ▪ The basement of the tube-well and sanitary latrine should be placed in an elevated land so that it would not be inundated during flood and heavy rainfall. ▪ Proper training should be provided to the community about the proper use of the sanitary facilities and tube wells. ▪ Adequate facility for safe containment of the faecal sludge and ensure proper emptying of the containments, transport, treatment, and safe end use or disposal of fecal sludge. ▪ Any hole or trench should be backfilled to avoid water logging and harassment of the community.	WATSAN Committee, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
Accessibility to Equitable Water and Sanitation Services	▪ Decrease the incidents of water borne diseases in the community.	• Improve water supply and sanitation facilities by providing adequate safe water supply and safe containments of faecal sludge even during seasonal flood and heavy rainfall. • Community awareness building program shall be undertaken for use of the facilities, hygiene behaviors and hand washing practices of the community people. • Ensure proper operation and maintenance of the facilities.	DPHE
Operation of Pump House and DTW	▪ Increase in noise level	▪ Install noise attenuator and ensure proper maintenance of pump and motor	DPHE

8. Implementation Modalities

8.1 Introduction

The project My Village My Town is implemented through two government institutes: DPHE and LGED. DPHE is implementing the village water supply and sanitation part of the project. PMU of DPHE will be responsible for the implementation of village water supply and sanitation part of the project. After implementation, it will be handed over to the local community (have to be formed if not existing yet) or Union Parishad for operation and maintenance of the water supply and sanitation system. The local body (Union Parishad) needs to be strengthening through training and providing technical manpower for the maintenance and repair of water supply and sanitation system after handover.

8.2 Institutional Arrangement

In Bangladesh, the institutional arrangement for water supply and sanitation is provided below.

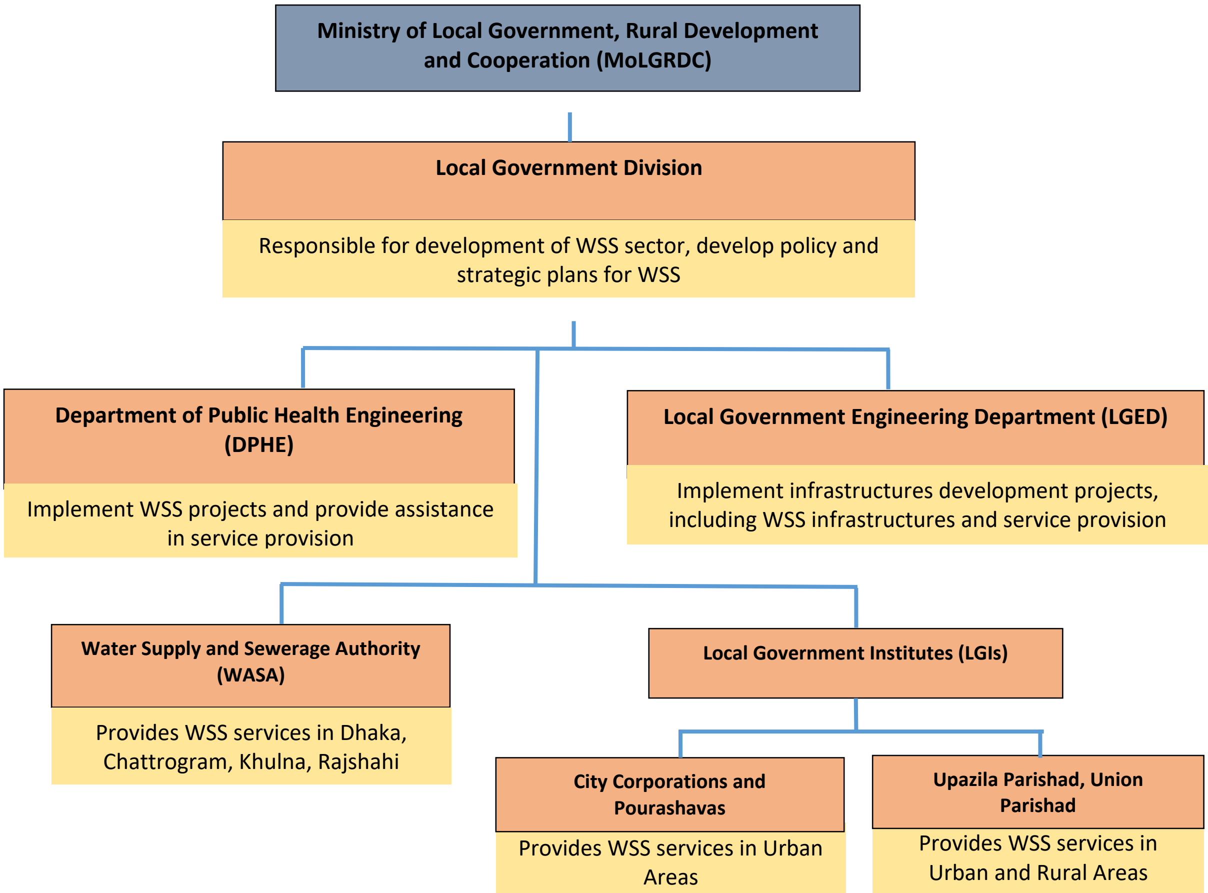


Figure 8.1: Institutional Framework of water supply and sanitation in Bangladesh.

Ministry of Local Government, Rural Development, and Cooperatives (MoLGRDC)

MoLGRDC is in charge of housing and construction, regional and rural policy, municipal and city administration and finances, and election administration. It contains two divisions. Local Government Division (LGD) is one of them. Within the LGD, a special unit called the Policy Support Unit (PSU) is responsible for developing water supply policy and strategies. Major activities of LGD on sanitation and water supply are-

- Deal with drinking water issues
- Development of water supply, sanitation, drainage and sewage disposal in rural and urban areas. The structures of the management of sanitation, including drainage and waste vary between rural and urban areas.

Local Government Division (LGD): The primary agency in charge of sanitation in Bangladesh is the Local Government Division (LGD), which is a division of the Ministry of Local Government, Rural Development, and Cooperatives (MoLGRDC). The structures of the management of sanitation, including drainage and waste vary between rural and urban areas.

I. ***Rural Water* Supply *and Sanitation:*** Zila parishads, upzila parishads, and union parishads are the three types of rural governmental bodies. Their functions are-

- coordinating the delivery of sanitation services in rural communities
- Union parishads, which are the smallest administrative units, are in charge of FSM services.

II. **Urban *Water Supply and Sanitation***: Pourashavas (urban governments) and City Corporations constitute urban local governance. Their responsibilities are-

- To coordinate the provision of sanitary services in urban contexts
- Management of the FSM and its services

As per Pourashava Act (2009), Pourashavas (municipalities) operate and maintain the water supply system and sanitation. These systems are financed and constructed by the central government through the Department of Public Health and Engineering (DPHE) and the Local Government Engineering Department (LGED).

Department of Public Health Engineering (DPHE): The MoLGRDC regulates DPHE, the national lead government agency responsible for both urban and rural water supply and sanitation services and waste management in the country except Dhaka, Narayanganj, Khulna, Rajshahi and Chittagong cities where WASAs operate. DPHE is active in both urban and rural areas, offering both hardware (such as pit latrines and shared latrines) and software (e.g., social mobilization and hygiene behavior training). By 2022, DPHE will have provided gender-segregated WASH-block latrines in all primary schools, working collaboratively with the Ministry of Primary and Mass Education (MoPME). Additionally, MoPME is putting programs in place to meet the students' WASH needs. The Ministry of Education (MoE) is in charge of WASH in secondary schools, and it contributes to ensuring gender-separated better sanitation facilities in secondary schools. Their main functions are divided into two categories.

I. Rural Water Supply and Sanitation:

For rural locations, DPHE offers water supply options include hand pumps, shallow and deep tube wells, natural spring development, infiltration galleries, deep set pumps, ring wells, etc. The DPHE is also entrusted with the maintenance of tube-wells and other water delivery infrastructure. It also ensures rural sanitation through the production and distribution of water seal latrines as well as through health promotion initiatives.

II. Urban Water Supply and Sanitation

Except WASA areas, all district and sub-divisional towns are covered by DPHE activities in the urban sector. DPHE implements urban piped water supply system, which includes treatment facilities, production wells, water distribution network, storage reservoirs, and pumping installations. The municipality typically takes on the maintenance role.

Local Government Institutions (LGIs)

The Local Government Institutions (LGIs) include a three-tiered rural local government system made up of 64 zila (district) parishads, 492 upazila (sub-district) parishads, 4,573 union parishads, and three hill district parishads. Single-tier urban authorities are made up of 11 City Corporations and 329 municipalities (Pourashavas).

I. ***Zila parishads, upzila parishads, and union parishads:*** Zila parishads, upzila parishads, and union parishads are the three types of rural governmental bodies. The LGIs in the Zila Parishads, Upazila Parishads, and Union Parishads are in charge of coordinating the delivery of sanitation services in rural communities. Union parishads, which are the smallest administrative units, are responsible for FSM services.

   Each Union Parishad (UP) is divided into nine wards, with water and sanitation (WATSAN) committees participating in village-level decision-making for WASH. According to a GoB Circular from 2007, Union-level WATSAN committees are responsible for a range of WASH activities including supporting and participating in DPHE activities for awareness raising, coordinating the activities of different stakeholders in the WASH sector, implementing WASH projects, and participating in data collection activities for WASH sector (IRF-FSM 2017, p.5).

II. ***Pourashavas and city corporations:*** Pourashavas (urban governments) and city corporations constitute urban local governance. The coordination of the provision of sanitary services in urban contexts is the responsibility of both Pourashavas and city corporations. The management of the FSM and its services is the joint responsibility of Pourashavas and city corporations. Dhaka, Chittagong, Khulna, and Rajshahi Water Supply and Sewerage Authorities (WASAs) are in charge of providing water and treating sewage in four City Corporations.

8.3 Overall Project Management and Implementation

The organizational arrangement for the project management and implementation of My Village My Town project is shown in Figure 02.

Project Steering Committee (PSC)

For the successful implementation of the project, a project steering committee (PSC) can be established at the national level in the Local Government Department (LGD) under MoLGRD&C, chaired by the Secretary of the LGD to provide the overall guidance and policy direction. The PSC will consist of the representative from LGED and DPHE, the financial Institutions Division and the Economic Relations Division under the Ministry of Finance, the Planning Commission, Ministry of Environment Forests and Climate change and Ministry of Water Resources. The PSC will meet at regular intervals to oversee the progress of the project and the corrective measures, if necessary

Project Management Unit (PMU)

At the management level, a Project Management Unit (PMU) at LGED/DPHE headquarters, headed by the Project Director will be formed. The Project Director (PD) will be overall responsible for the management of the project components. Other responsibilities include among others communication and coordination with donor, approval of payments to Consultant and (future) Contractors, and approval of reports and other documents. PMU is assisted by Design, Management and Supervision Consultant (DMS) to be appointed during the project implementation.

Design, Management and Supervision (DMS) Consultant

The DMS consultant will work under the PD and be responsible for preparing the design of the project components (WASH facilities) according to national guidelines and standards and shall responsible for the overall management and monitoring of the project activities. The DMS Consultant will supervise all civil works, ensuring compliance with all design parameters including quality requirements. The Consultant will also responsible for monitoring the Contractor's activities and to ensure the implementation of the project components/activities as per plan schedule. The DMS Consultant also responsible for the quality control and quality assurance of the construction of the infrastructures (WASH), monitoring and reporting the safety issues during the construction of the project and also ensure the implementation of ESMP for the project. Also the Consultant will recommend to the PMU to take action on any non-compliance issues related to construction and ESMP and submit monthly report on the progress of implementation works of the project and compliance and non-compliance of ESMP of this project by the Contractor.

The DMS consultant will support the local PIU in implementation of the project activities and construction of the infrastructures for WASH, quality assurance of the construction and also construction materials.

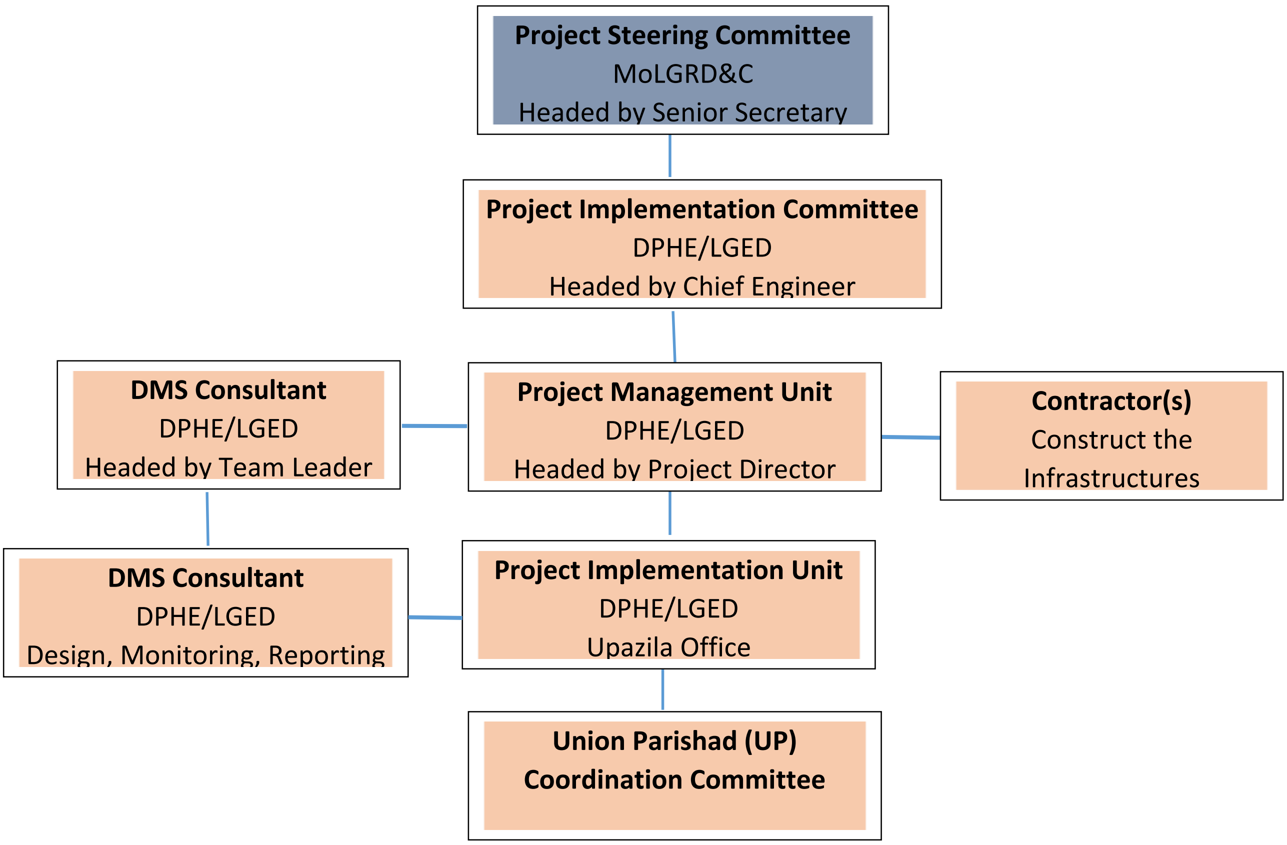


Figure 8.2:. Organizational arrangement for project implementation of My Village My Town.

Project Implementation Unit (PIU)

- Project Management, co-ordination and technical support for implementation of of the project in village level.
- Ensuring the optimal technical quality in project implementation and service delivery.
- Monitoring of project progress in co-ordination with other department including UP and PMU, and DMS consultant.
- Verify the project progress reports by DMS Consultant.
- Staying abreast with latest development in the area of expertise and facilitate transfer of relevant information and best practices to staff for use in Nagar Nigam functioning.
- The PIU shall report to PMU and discuss day to day issues proactively.

Union Parishad (UP)

Engaging the UP is central to the project's success. Enhancing the capacity of UPs to plan, deliver, and manage WASH services is a top priority. The project intends to achieve this through clarifying the roles of UPs in WASH service delivery in policy documents and training responsible UP officials. DPHE shall provide technical support to UPs in WASH and training on O&M issues.

Coordination Committee.

A WASH Coordination Committee will be formed at each UP with representatives from the DPHE, Ward Councilor/Member and one representative from the Civil Society. The committees will be led by the UPs to facilitate local level coordination needed for project implementation. The committee members will meet regularly to plan and coordinate the WASH related project activities within the UP and prepare the quarterly progress report for submission to Upazilla DPHE.

Contractor(s)

The Contractor(s) will be appointed through local bidding process by DPHE for the implementation of the development works of the projects. The main responsibilities of contractors during the implementation of the projects include new construction (pipe line, deep TW, latrine and wash block), rehabilitation and maintenance of existing WASH facilities in accordance with the bidding documents. The Contractor is required to complete the construction works as per schedule and also to fulfill the commitments and requirements of ESMP, which will be prepared during IEE/ESIA studies. The contractors will be responsible for implementing community and occupational health and safety measures.

8.4 Operation, Maintenance and Monitoring of WASH Facilities

The operation and maintenance of WASH facilities depends on types, whether community based or individual household level. In case of community based water supply like PSF, AIRP, piped water supply system and public toilets, the user's community will be unable to undertake the O&M operations. In such case, a WATSAN committee will be formed from UP, DPHE, local ward members and users, and this committee in support from local DPHE will be responsible for overall operation and maintenance of the WASH systems. The community based water supply system can also be leased out to private operator(s) by the WATSAN committee. In case of community latrine, a committee can be formed to operate and maintenance of the toilet. The committee will maintain the facility clean and useable by collecting the users' fee or may be lease out to private operator. The development partners or government will need to provide financial support for O&M of the community based WASH facilities.

For individual WASH facilities like TW, latrines and other, the user/household will undertake the routine O&M of the system. In such cases, the user/HH will contract the local technician for the necessary repair and maintenance works.

The roles and responsibility of the stakeholders in operation and maintenance of WASH facilities are given in Table 3.

Table 8.1. Roles and responsibly of the stakeholders for O&M works of WASH facilities

Stakeholder	Roles and Responsibility for O&M Works
PMU	Develop the Guidelines for the O&M process for the Village water supply and sanitation interventions provided by the project. Development of the Training materials on O&M for local technicians, UP and local DPHE and conduct the training on O&M.
Local DPHE	Development of contingent budget for O&M works of the facility. Training of the local technicians and UP for capacity building in O&M Prepare the checklist for operation, supervision, and maintenance in the periodic visit plan of the facility Undertake periodic visit of the facility, make financial support required for average annual O&M expenditures and seeking budget for annual O&M works. Monitoring the water quality of the water supply facility and reporting to DPHE.
UP	Coordinate with local DPHE for technical support for O&M of the community based facilities. Regular monitoring of the WASH facilities and also water quality of the water supply facility with technical support from DPHE.
Local Technicians	User Group or individual (in case of household toilet and TW) will contact the local technicians for both minor and major repairs and cleaning of the facility Support for minor and major repair and maintenance works of the facility. Make available of the tools, spare parts and other materials required for repairs and maintenance.
WATSAN Committee	Coordinating with local DPHE and UP for O&M operation for community based facility and fund for such repair and maintenance works Collect fund from user's fees for routine O&M works and cleaning of public/community toilets. Maintenance of records and details of materials/tool/equipment purchased like date of purchase, manufacturer details, cost of purchase, warranty, dates for part replacement etc.
Household/User	Proper and careful use of the facility Undertake minor repairs and maintain of the system.

9. Conclusion

The goal of this study was to build up a frame work to enhance the facility of the villagers related to water supply and sanitation in relation to the sustainability of WASH interventions in four arsenic-contaminated villages. The water supply and availability, as well as the sanitation conditions, of the selected arsenic-contaminated areas, Tipna (Khulna), Datinakhali (Satkhira), Shimulbank (Sunamganj), and Saikchail, were examined in this study (Cumilla). A survey was conducted by CEGIS and a group of team members to analyze the conditions. During the survey, some water samples were collected. People's opinions and laboratory results of water sample testing were used to assess the problem. Some technologies have been chosen to solve problems based on the problems. Some designs for technology implementation have been developed. Water is a basic human requirement. People in arsenic contaminated area, on the other hand, are deprived due to their geological location. People in this area do not have access to adequate water and sanitation all year. This study will help them meet their water needs and improve their sanitation.

Some recommendations are

Trust and Unity: Building trust among community members and providing interventions that are consistent with local resources and intervention users' financial capacity will support locally driven collaborative projects. Communities receiving WASH interventions should be encouraged to participate in design, construction, and maintenance activities under constant supervision and support. According to the interviews of participants, most communities have members with communication and construction skills. These people could be good candidates for supporting water supply technologies, building and updating latrines, and delivering health education messages. Future research, programs, or investments may benefit from an examination of community-based participatory approaches to sustaining WASH interventions.

Financial support: Establishing effective inter-agency relationships with local organizations to provide a consistent supply of funds for reparations and technical support will improve the committee's ability to:

1. perform routine maintenance of water supply and sanitation systems;
2. collaborate with local providers to ensure the availability of construction materials and disinfection products for water treatment; and
3. Respond to infrastructure damage caused by weather events in a timely and efficient manner.

It is recommended that more research be conducted on the barriers to and strategies for improving participation in local government institutions.

4. **Equity**: Participants reported feelings of vulnerability, discomfort, lack of awareness, and irresponsible behaviour as a result of unequal distribution of resources and access to educational opportunities. Local governments, stakeholders, bilateral and multilateral organizations, water committees, local associations, NGOs, and other groups involved in water, sanitation, and health education will need to gain a thorough understanding of the reasons underlying these inequalities.
5. **Leadership**: Committee members must be carefully selected and trained in order for communities to accept increases in water fees and to create a sense of support and local representation. Water fees that are adjusted to community expenses and individual

circumstances will allow for the maintenance of savings accounts for emergencies and timely repairs, thereby increasing user satisfaction. More research is needed to determine the best strategies for selecting, training, and sustaining dependable water committees.

6. **Adequacy:** To ensure the adequacy of the interventions provided to the people of the arsenic-contaminated village, assessment tools encompassing sociocultural, technical, health, environmental, institutional, and financial factors are required. To effectively address community needs, additional assessments of viability for selecting sustainable sanitation technologies and drinking water supplies may be useful.

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Appendix I

I.1 Need Assessment

At the beginning of the work, consultation meetings were organized with relevant professionals and officials of LGED and DPHE to understand the project's requirements, including data and information needs, expected outputs from the project, and the monitoring process. However, the need assessment task followed different sub-activities such as (i) literature review and data. (ii) Water quality, and arsenic contamination-related data and information, for a specific district, available in DPHE's Groundwater Circle, previous and other running projects, and other NGO reports, (iii) individual expert consultation for selection of sampling methodology, (iv) identification of data and information with their sources; (v) data collection format/questionnaire, (vi) identification of the content of the inception report including the implementation plan (vii) organize consultation meeting to identify the overall need assessment of the proposed project.

I.2 Review of literature and information

The selected literature, data, and information directly or indirectly related to village water supply technology, water quality, current hygiene and sanitation practices, hydrogeological settings, arsenic concentration, etc., were collected from DPHE, different published papers, and as well as from other relevant organizations. Data sources were identified in a consultation meeting during the need assessment. Government long-term plans and commitments for attaining the targets of Vision -2041 have also been collected and reviewed.

I.3 Demographic Information of Project Area

The project area comprises plain land, hills, haor, char/beel, coast, barind and economic zone area. Following the BBS population information, the demographic profile maps have been prepared. Further, satellite images from CEGIS and other sources were used to prepare the study area base map. CEGIS has substantial spatial/GIS data under the National Water Resources Database (NWRD), Mouza Database, Roads and infrastructure data, historical satellite images, different types of maps (e.g., base map, road and infrastructure map, settlement map, land use maps, utilities & facilities map, etc.). For strategic planning of services and facilities of the rural people, the base map with the demographic profile is highly essential.

I.4 Development and testing of data collection tools

Developing data collection and testing of tools is one of the essential activities, accomplished through several tasks, some of which are:

- **a)** Development of draft questionnaires,
- **b)** Development of data collection tools, and
- **c)** Field testing and finalization of questionnaires.

The brief descriptions of these subtasks are mentioned below:

<u>Development of draft questionnaires</u>

After thorough research on previous similar data and inquiries, the questionnaire was prepared. A structured questionnaire was designed in this regard. The DPHE officials validated the questionnaire, and after that, it was tested at the field level. In the field test, the enumerators used the prepared and validated questionnaire to conduct a test survey. The questionnaire has been streamlined and implemented with the test result. The questionnaire has several parts, such as:

- **i)** General Information of the Household,
- **ii)** Water Supply System,
- **iii)** Sanitation, and
- **iv)** Awareness and Cleanliness.

Household Questionnaire

Comprehensive household data, including financial and expenditure information, etc. analyzed in this survey. The questionnaire (Figure 3.2) design keeps the interrelated pace of the questions along with the purpose of the study. The questionnaire collects information about the respondent's identity, geographical location, household information, household head's information, main occupation, number of family members, source of monthly household income, and expenditure. It also mentions the number of adult men, women, and children in the household—the number of children receiving education, their cost, etc.

Water Supply System Questionnaire

The Water supply system questionnaire gives us information about the primary source of drinking water, water quality from the source, purification of water before drinking, and if the amount of water available at home is sufficient for drinking and cooking. Moreover, the cost of water source maintenance, water scarcity, causes of water shortage, recommendations for improvement, and the cost of improving the water supply system are vividly expressed in the questionnaire.

Sanitation Questionnaire

Questionnaires about sanitation are more important in data collection. People are still not aware of sanitation in our country. So, the questions were arranged so that the correct answers could be collected. The queries are related to the availability of the toilet, types of toilets, facilities available in the toilet depicting the hygiene situation, number of community toilets (if available), types of containment, condition of containment, etc.

Awareness and Cleanliness Questionnaire

There are many questions about cleanliness and awareness in the questionnaire. It included household and nearby environmental situations, hygiene habits, disadvantages/constraints associated with poor sanitation, public awareness activities (*vaccination, corona, cyclone, strike, World Water Day, World Handwashing Day, World Environment Day, Sanitation Month, and World Toilet Day*), etc. There are other awareness questions, i.e., the availability of TV programs or advertisements people watch—for example, the immunization program for children, diarrhea, awareness about sanitary napkins, etc.

Development of data collection tools

After developing the questionnaire, "KoboToolbox" was used for its digital version. This tool has two versions.

- **I.** Web-version and
- **II.** Mobile version.

For the convenience of collecting data in the field, a mobile version of the questionnaire was used. The app on the mobile for KoboToolbox is named “KoboCollect.”

<u>Field testing and finalization of Questionnaires</u>

After developing the digital questionnaire in the KoboCollect App, a reconnaissance field visit satisfied the understanding of the project activities, tested and assessed the field questionnaire/tools, and identified other relevant problems and issues that could arise during the survey. During the reconnaissance survey, the CEGIS team discussed the parameters of the questionnaire and tools and other WATSAN-related matters with the DPHE officials. The reconnaissance field visit contributed to refining the existing tools and preparing additional assessments of the tools.

Figure I.1: Data Collection during Reconnaissance Field Visit

I.5 Development of Sampling Methodology

Sample Frame

The survey universe (also called sample frame) consisted of 35 communities (also referred to as villages) spread across all 15 districts in 8 regions of the country. These regions are Plain land, hilly area, coastal areas, cyclone prone, arsenic contaminated, haor areas, bill/char areas, and barind areas. The total population comes to approximately 58,043 (Fifty-Eight thousand and Forty-Three), and the number of households is about 12,684 (Twelve Thousand six hundred and eighty-four). The scope of analysis for the study is the “household” in targeted communities.

Sample Size Determination

Sample size estimation looked at two aspects,

1. The number of households in the pilot village.
2. The number of households in the sample village.

There are **15 pilot villages** in this survey. All the households were surveyed in pilot villages, and data was processed comprehensively. In the other **20 sample villages**, 10% of households were surveyed. This 10% of the total households is selected in such a way that it represents the whole village.

Table I.1: Sampling Size Determination

Number of Households	12,684
Total estimated population	58,043
Average Household size	5 persons/household
Margin of error	10%
Confidence level	90%
Number of Villages to survey	35

Sample Distribution

The sample distribution of arsenic contaminated areas represents in the below table.

Table I.2: Sample Distribution

District	Upazila	Union	Village	Total Household (apprx.)	Surveyed Household
Cumilla	Monoharganj	Bipulshar	Saikchail *	1652	1652
Khulna	Dumuria	Khurnia	Tipna *	772	772
Satkhira	Shyamnagar	Burigoalini	Datinakhali *	568	568
Sunamganj	Dakkhin Sunamganj (Shantiganj)	Shimulbank	Shimulbank *	462	462

The * marked village names are pilot villages that were entirely surveyed like enumeration. However, others are sample villages where only 10% of the total households have been studied.

I.6 Baseline Data Collection through Field Survey

The collection of union-wise data using the developed format/questionnaire from target communities, Union Parishad, NGOs, and other stakeholders is the main activity, which has been carried out through several tasks are:

a) Field team formation,

b) Training the field team,

c) Mobilization of the field team, and

d) Collection of union-wise data using the developed questionnaires.

Field team formation

Field team formation is crucial in ensuring the collection of primary data on which the project output depends. Quality survey teams were recruited based on their educational background and professional qualification and trained in collecting field data. Each team consisted of nine to ten members, one of whom was the team leader to lead the team and had previous experience /skills in related work.

The field supervisor trained the staff to monitor water supply and sanitation facilities. Sessions have been taken separately on Map, Monitoring of Sanitation, checking the water point and water quality testing by field test kit, using a digital camera and GPS, etc.

Figure I.2: GPS used for collection of the geographic location of HHs

Training of the Field Staff

After developing the digital questionnaire in the KoboCollect App, 60 enumerators conduct the field survey of 40 villages. 5 among them were supervisors. The questionnaire included latrine-related terms and other water supply sources. The 60 enumerators divided into 3 groups. A two-day training program from 20 - 21 June 2022 was arranged to scrutinize the questionnaire and describe the terminology and other potentially confusing parts.

Figure I.3: Field Staff Training

Mobilization of the field team

Teams were mobilized to the field after the survey set-up according to the field plan. LGED and CEGIS issued a letter to the team for possible help from government/non-government organizations and individuals. The field team members extended the necessary financial and other logistic support.

Collection of village-wise data using the developed questionnaires

After team mobilization, the field data collection process follows a systematic approach. Using a developed questionnaire, information on water and sanitation coverage, identifying potential freshwater sources, small and piped water supply schemes, water quality, and current hygiene practices collected carefully from the target communities, Union Parishad, NGOs, and other stakeholders. Following the village-wise data collection plan, the team leader monitored the progress of the data collection.

I.7 Real-Time Verification of Data collection

The field surveyor collects data in *kobocollect* (Mobile version), which is stored in *kobotoolbox* (Web version). Here the data is checked and appropriately corrected by cross-checking or calling the responder directly. Verified and approved information will be processed for further analysis.

Figure I.4: Verification of Field Data at in-House

I.8 Data Management and Analysis

As per DPHE and CEGIS officials' guidance, the consultant uses the “KoboCollect App” and “KoboToolbox web version” for data management. “Kobo” is a platform for data collection. Collected data accordingly and converted it to an Excel file. Finally, the analyzed findings were visualized through synchronized use of the Excel file.

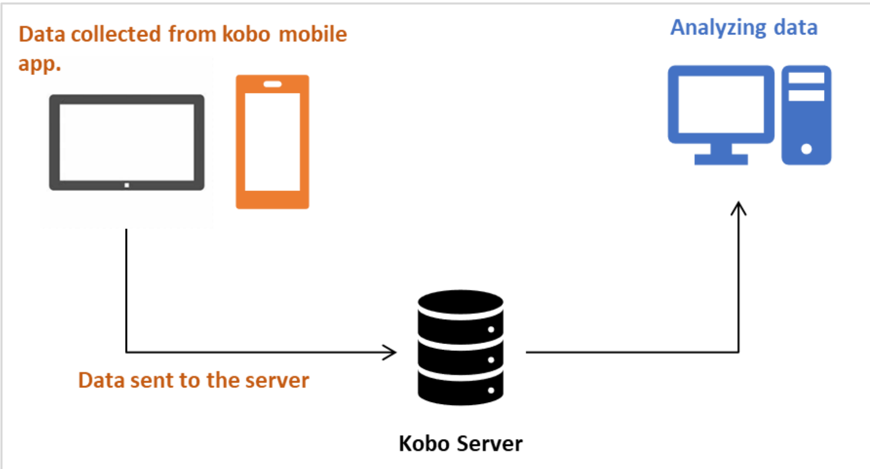

Figure I.5: Data Collection and Management

Upon completion of fieldwork, the data was shifted to MS Excel for cleaning and analysis. The raw datasets were thoroughly checked and cleaned for aspects such as faulty response options, wrong information, and the resulting missing data, specifying ‘others’ data where required, etc. Alongside excel, Python was also used to analyze data. The image sorting, sorting, distributing data among the consultants, etc., were efficiently conducted using Excel and Python coding.

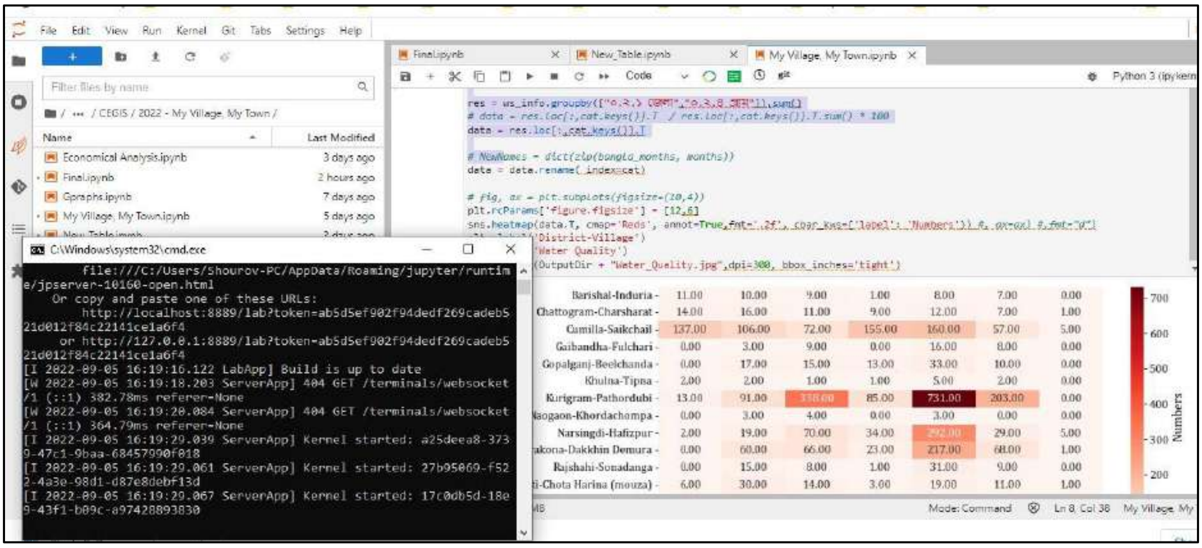

Figure I.6: Data Analysis

I.9 Limitations and Constraints

The project followed proper guidelines and monitoring by the DPHE officials and consultants. Even though utmost precautions and measurements against inaccurate data and cleaning unnecessary data, some errors and limitations remain. Some regions were disaster-affected, and enumerators couldn't reach to get the perfect sample. Some areas are out of reach as the locals didn't cooperate. Moreover, the diverse religious beliefs of the residents also made the enumerators unable to acquire unerring data.

Appendix II

Table II.1: Investment cost (BDT in Lac)

District	Upazila	Union	Village	Number of Household (HH)	water supply	sanitation	Financial Cost (BDT in Lac)
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	136	180.5	316.5
Khulna	Dumuria	Khurnia	Tipna	772	17	132.5	149.5
Satkhira	Shyamnagar	Labsa	Datinakhli	568	250	181	431
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank	462	210	91.5	301.5
Base cost							1198.5
Physical contingency							59.925
Price contingency							59.925
Total							**1318.35**

Table II.2: O&M cost (BDT in Lac)

District	Upazila	Union	Village	Number of Households (HH)	Number of Residents (approx.)	Average water source maintenance cost per year	Avg. cost (BDT) for operating and maintaining Community Toilet	Total Maintenance Cost	Total Maintenance Cost (in Lac)
						BDT	**BDT**	**BDT**	**BDT in Lac**
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	6528	357.35	0	583195	6
Khulna	Dumuria	Khurnia	Tipna	772	3088	175.72	0	135656	1
Satkhira	Shyamnagar	Labsa	Datinakhli	568	2272	118.28	0	67183	1
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank	462	1848	211.13	600	374742	4
Total									**12**

Table II.3: Time saved benefit of water supply (BDT in Lac)

						Without Project			With Project			Net Benefit
District	Upazila	Union	Village	Number of Household (HH)	Number of Residents (apprx)	Total Time Required for Access to Water	Value of Time per Person	Value of Time Required for Access to Water	Total Time Required for Access to Water	Value of Time per Person	Value of Time Required for Access to Water	Total Value of Time Saved Benefit of Intervenion
						Hour	Tk/hour	BDT	Hour	Tk/hour	BDT	BDT
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	6528	0.17	62.5	6205000	0.083333333	62.5	3102500	31
Khulna	Dumuria	Khurnia	Tipna	772	3088	0.20	62.5	3522250	0.1	62.5	1761125	18
Satkhira	Shyamnagar	Labsa	Datinakhli	568	2272	0.25	62.5	3239375	0.125	62.5	1619687.5	16
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank	462	1848	0.25	62.5	2634844	0.125	62.5	1317421.88	13
Total												**78**

Table II.4: Time saved benefit of sanitation (BDT in Lac)

						Without Project			With Project			Net Benefit
District	Upazila	Union	Village	Number of Household (HH)	Number of Residents (apprx)	Total Time Required for Access to Community Toilet	Value of Time per Person	Value of Time Saved Benefit of Intervention (Sanitation)	Total Time Required for Access to Community Toilet	Value of Time per Person	Value of Time Saved Benefit of Intervention (Sanitation)	Total Value of Time Saved Benefit of Intervention
						Hour	Tk/hour	BDT	Hour	Tk/hour	BDT	BDT
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	6528	0.333	62.50	12410000	0.166666667	62.5	6205000	62
Khulna	Dumuria	Khurnia	Tipna	772	3088	0.250	62.50	4402813	0.125	62.5	2201406.25	22
Satkhira	Shyamnagar	Labsa	Datinakhli	568	2272	0.333	62.50	4319167	0.166666667	62.5	2159583.33	22

						Without Project			With Project			Net Benefit
District	**Upazila**	**Union**	**Village**	**Number of Household (HH)**	**Number of Residents (apprx)**	**Total Time Required for Access to Community Toilet**	**Value of Time per Person**	**Value of Time Saved Benefit of Intervention (Sanitation)**	**Total Time Required for Access to Community Toilet**	**Value of Time per Person**	**Value of Time Saved Benefit of Intervention (Sanitation)**	**Total Value of Time Saved Benefit of Intervention**
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank	462	1848	0.250	62.50	2634844	0.125	62.5	1317421.88	13
Total												**119**

Table II.5: Health benefit (BDT in Lac)

Without Project											
District	**Upazila**	**Union**	**Village**	**Number of Household (HH)**	**Number of Residents (apprx)**	**Annual Cost of Healthcare**	**Rate of Water-borne Disease**	**Total Expenditure on Healthcare Due to Water-borne Disease**	**Number of Days Absent from Productive Activities Due to Water-borne Disease**	**Value of Productive Time**	**Total Cost of Missing Productive Work Due to Water-borne Disease**
						BDT	**%**	**BDT in Lac (rounded)**	**Days**	**BDT/Day**	**BDT in Lac (rounded)**
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	6528	6000	20%	98	73	500	149
Khulna	Dumuria	Khurnia	Tipna	772	3088	6000	20%	46	73	500	70
Satkhira	Shyamnagar	Labsa	Datinakhli	568	2272	6000	20%	34	73	500	52
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank	462	1848	6000	20%	28	73	500	42
Total								**206**			**313**

With project											
District	**Upazila**	**Union**	**Village**	**Number of Household (HH)**	**Number of Residents (apprx)**	**Cost of Healthcare**	**Rate of Water-borne Disease after Intervention (Decrease)**	**Total Expenditure on Healthcare after Intervention**	**Number of Days Absent from Productive Activities after Intervention Decrease)**	**Value of Productive Time**	**Total Cost of Missing Productive Work after Intervention**
						BDT	**%**	**BDT in Lac (rounded)**	**Days**	**BDT/Day**	**BDT in Lac (rounded)**
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	6528	1200	4%	20	15	500	30
Khulna	Dumuria	Khurnia	Tipna	772	3088	1200	4%	9			
Satkhira	Shyamnagar	Labsa	Datinakhli	568	2272	1200	4%	7	15	500	10
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulbank	462	1848	1200	4%	6	15	500	8
Total								**41**			**49**

Incremental Benefits											
District	**Upazila**	**Union**	**Village**	**Number of Household (HH)**	**Number of Residents (apprx)**	**Cost of Healthcare**	**Rate of Water-borne Disease after Intervention (Decrease)**	**Total Expenditure on Healthcare after Intervention**	**Number of Days Absent from Productive Activities after Intervention Decrease)**	**Value of Productive Time**	**Total Cost of Missing Productive Work after Intervention**
						BDT	**%**	**BDT in Lac (rounded)**	**Days**	**BDT/Day**	**BDT in Lac (rounded)**
Cumilla	Monohorganj	Bipulshar	Shekchail	1632	6528	4800	16%	78	58.40	500	119
Khulna	Dumuria	Khurnia	Tipna	772	3088	4800	16%	37	73.00	500	70

Incremental Benefits											
District	**Upazila**	**Union**	**Village**	**Number of Household (HH)**	**Number of Residents (apprx)**	**Cost of Healthcare**	**Rate of Water-borne Disease after Intervention (Decrease)**	**Total Expenditure on Healthcare after Intervention**	**Number of Days Absent from Productive Activities after Intervention Decrease)**	**Value of Productive Time**	**Total Cost of Missing Productive Work after Intervention**
						BDT	**%**	**BDT in Lac (rounded)**	**Days**	**BDT/Day**	**BDT in Lac (rounded)**
Satkhira	Shyamnagar	Labsa	Datinakhli	568	2272	4800	16%	27	58.40	500	41
Sunamganj	Dakkhin Sunamganj (Santiganj)	Shimulbank	Shimulban k	462	1848	4800	16%	22	58.40	500	34
Total								**165**			**265**

Table II.6: Financial analysis (BDT in Lac)

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit of water supply	Time saved benefit of sanitation	Health benefit	Total Benefit	
1	359.55		360				0	-359.55
2	479.4		479				0	-479.4
3	479.4		479				0	-479.4
4		12	12	78	119	430	626	615
5		12	12	78	119	430	626	615
6		12	12	78	119	430	626	615
7		12	12	78	119	430	626	615
8		12	12	78	119	430	626	615
9		12	12	78	119	430	626	615

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit of water supply	Time saved benefit of sanitation	Health benefit	Total Benefit	
10		12	12	78	119	430	626	615
11		12	12	78	119	430	626	615
12		12	12	78	119	430	626	615
13		12	12	78	119	430	626	615
14		12	12	78	119	430	626	615
15		12	12	78	119	430	626	615
16		12	12	78	119	430	626	615
17		12	12	78	119	430	626	615
18		12	12	78	119	430	626	615
19		12	12	78	119	430	626	615
20		12	12	78	119	430	626	615
Total			**1,103.25**				**3,174.58**	**2,071.33**
Financial Net Present Value (FNPV)								**2,071.33**
Financial Benefit Cost Ratio (FBCR)								**2.877471243**
Financial Internal Rate of Return (FIRR)								**34%**

Table II.7: Financial sensitivity analysis (BDT in Lac)

Year	Benefit decreased by 10%			Total cost increased by 10%			Best Case			Worst Case		
	Reduced benefit	Total cost	Cash flow	Benefits	Increased Total cost	Cash flow	Benefit Increased by 10%	Total cost decreased by 10%	Cash flow	Benefit decreased by 10%	Total cost increased by 10%	Cash flow
	0.9				1.1		1.1	0.9		0.9	1.1	
1	0	360	-360	0	396	-396	0	327	-327	0	396	-396
2	0	479	-479	0	527	-527	0	436	-436	0	527	-527
3	0	479	-479	0	527	-527	0	436	-436	0	527	-527
4	569	12	558	626	13	614	689	11	679	569	13	557
5	569	12	558	626	13	614	689	11	679	569	13	557
6	569	12	558	626	13	614	689	11	679	569	13	557
7	569	12	558	626	13	614	689	11	679	569	13	557
8	569	12	558	626	13	614	689	11	679	569	13	557
9	569	12	558	626	13	614	689	11	679	569	13	557
10	569	12	558	626	13	614	689	11	679	569	13	557
11	569	12	558	626	13	614	689	11	679	569	13	557
12	569	12	558	626	13	614	689	11	679	569	13	557
13	569	12	558	626	13	614	689	11	679	569	13	557
14	569	12	558	626	13	614	689	11	679	569	13	557
15	569	12	558	626	13	614	689	11	679	569	13	557
16	569	12	558	626	13	614	689	11	679	569	13	557
17	569	12	558	626	13	614	689	11	679	569	13	557
18	569	12	558	626	13	614	689	11	679	569	13	557
19	569	12	558	626	13	614	689	11	679	569	13	557
20	569	12	558	626	13	614	689	11	679	569	13	557
	2886	**1103**	**1783**	**3175**	**1214**	**1961**	**3492**	**1003**	**2489**	**2886**	**1214**	**1672**
	FBCR		**2.62**	FBCR		**2.62**	FBCR		**3.48**	FBCR		**2.38**
	FNPV		**1783**	FNPV		**1961**	FNPV		**2489**	FNPV		**1672**
	FIRR		**32%**	FIRR		**32%**	FIRR		**40%**	FIRR		**29%**

Table II.8: Economic analysis (BDT in Lac)

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Economic Benefit	Total Benefit	
1	252		252.4				0	-252.4
2	337		336.5				0	-336.5
3	337		336.5				0	-336.5
4		10	10.5	70.4	107.2	387.5	565.1	554.6
5		10	10.5	70.4	107.2	387.5	565.1	554.6
6		10	10.5	70.4	107.2	387.5	565.1	554.6
7		10	10.5	70.4	107.2	387.5	565.1	554.6
8		10	10.5	70.4	107.2	387.5	565.1	554.6
9		10	10.5	70.4	107.2	387.5	565.1	554.6
10		10	10.5	70.4	107.2	387.5	565.1	554.6
11		10	10.5	70.4	107.2	387.5	565.1	554.6
12		10	10.5	70.4	107.2	387.5	565.1	554.6
13		10	10.5	70.4	107.2	387.5	565.1	554.6
14		10	10.5	70.4	107.2	387.5	565.1	554.6
15		10	10.5	70.4	107.2	387.5	565.1	554.6
16		10	10.5	70.4	107.2	387.5	565.1	554.6
17		10	10.5	70.4	107.2	387.5	565.1	554.6
18		10	10.5	70.4	107.2	387.5	565.1	554.6
19		10	10.5	70.4	107.2	387.5	565.1	554.6
20		10	10.5	70.4	107.2	387.5	565.1	554.6
Total			**786**				**2,863**	**2,077**

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Economic Benefit	Total Benefit	
Economic Net Present Value (ENPV)								**2,077**
Economic Benefit Cost Ratio (EBCR)								**3.641941007**
Economic Internal Rate of Return (EIRR)								**42%**

Table II.9: Economic sensitivity analysis (BDT in Lac)

Year	Benefit decreased by 10%			Total cost increased by 10%			Best Case			Worst Case		
	Reduced benefit	Total cost	Cash flow	Benefits	Increased Total cost	Cash flow	Benefit Increased by 10%	Total cost decreased by 10%	Cash flow	Benefit decreased by 10%	Total cost increased by 10%	Cash flow
	0.9				1.1		1.1	0.9		0.9	1.1	
1	0	252	-252	0	278	-278	0	229	-229	0	278	-278
2	0	337	-337	0	370	-370	0	306	-306	0	370	-370
3	0	337	-337	0	370	-370	0	306	-306	0	370	-370
4	514	10	503	565	12	554	622	10	612	514	12	502
5	514	10	503	565	12	554	622	10	612	514	12	502
6	514	10	503	565	12	554	622	10	612	514	12	502

Year	Benefit decreased by 10%			Total cost increased by 10%			Best Case			Worst Case		
	Reduced benefit	**Total cost**	**Cash flow**	**Benefits**	**Increased Total cost**	**Cash flow**	**Benefit Increased by 10%**	**Total cost decreased by 10%**	**Cash flow**	**Benefit decreased by 10%**	**Total cost increased by 10%**	**Cash flow**
7	514	10	503	565	12	554	622	10	612	514	12	502
8	514	10	503	565	12	554	622	10	612	514	12	502
9	514	10	503	565	12	554	622	10	612	514	12	502
10	514	10	503	565	12	554	622	10	612	514	12	502
11	514	10	503	565	12	554	622	10	612	514	12	502
12	514	10	503	565	12	554	622	10	612	514	12	502
13	514	10	503	565	12	554	622	10	612	514	12	502
14	514	10	503	565	12	554	622	10	612	514	12	502
15	514	10	503	565	12	554	622	10	612	514	12	502
16	514	10	503	565	12	554	622	10	612	514	12	502
17	514	10	503	565	12	554	622	10	612	514	12	502
18	514	10	503	565	12	554	622	10	612	514	12	502
19	514	10	503	565	12	554	622	10	612	514	12	502
20	514	10	503	565	12	554	622	10	612	514	12	502
	2603	**786**	**1817**	**2863**	**865**	**1999**	**3150**	**715**	**2435**	**2603**	**865**	**1738**
	EBCR		**3.31**	EBCR		**3.31**	EBCR		**4.41**	EBCR		**3.01**
	ENPV		**1817**	ENPV		**1999**	ENPV		**2435**	ENPV		**1738**
	EIRR		**39%**	EIRR		**39%**	EIRR		**48%**	EIRR		**36%**

Appendix III

Demand Analysis

Before designing the intervention related to water supply, the demand of water has been analysed. The demand analysis of water supply system design is given below.

a. Demand Analysis: Identify the need for public investments by assessing:

i. Current demand

Current demand for drinking water has been assessed based on data derived from field survey of pilot villages. Previous two years (2021 and 2020) data are related with the population growth[10] rate.

Table III.1: Current Demand for Drinking Water (Litre)

Pilot villages with Districts		Average daily water demand (L)	Average monthly water demand (L)	Year		
				2022	2021	2020
District	Village			Avg. yearly water demand (L)	Avg. yearly water demand (L)	Avg. yearly water demand (L)
1	2	3	4	5	6	7
Cumilla	Saikchail	13	376	4517	4459	4401
Khulna	Tipna	15	455	5455	5385	5316
Satkhira	Datinakhali	15	445	5334	5266	5198
Sunamganj	Shimulbank	15	451	5412	5343	5274
Average				**5179.5**	**5113.25**	**5047.25**

Based on population growth rate, demand for drinking water forecasted through end of the project, has been made. Demand has been forecasted for a period of 20-year, Linear Regression model is used for used for the purpose.

Table III.2: Prior project Implementation Drinking Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	5047	Estimated
2021	5113	Estimated
2022	5180	Survey data
2023	5246	Based on population growth rate forecasted through end of the project, has been made.
2024	5312	
2025	5378	

[10] BBS, Statistical Pocketbook, 2021, chapter II.

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2026	5444	
2027	5510	
2028	5576	
2029	5643	
2030	5709	
2031	5775	
2032	5841	
2033	5907	
2034	5973	
2035	6039	
2036	6106	
2037	6172	
2038	6238	
2039	6304	
2040	6370	
2041	6436	
2042	6502	
2043	6569	
2044	6635	
2045	6701	

Data have been presented in the following **Figure 0.16**

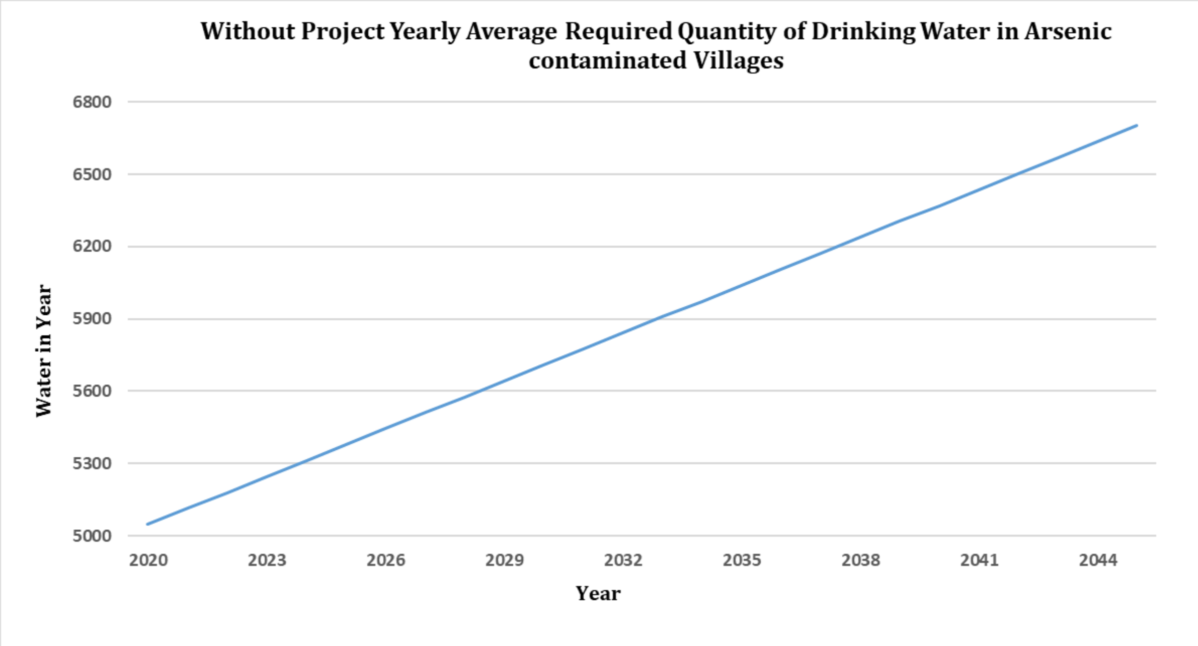

Figure III.1: Prior Project Implementation Yearly Average Required Quantity of Drinking Water in arsenic contaminated Villages

ii. Future demand

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in water likely to be used due better living condition.

Table III.3: Projected Drinking Water Demand after project implementation

Year	Avg. yearly Drinking water demand (Litre)	Assumption increases in 30%
2020	4693	Estimated
2021	5047	Estimated
2022	5113	Survey
2023	5180	Business as usual
2024	5246	
2025	5312	
2026	5378	Forecasted through end of the project
2027	7163	
2028	7249	
2029	7335	
2030	7421	
2031	7507	

Year	Avg. yearly Drinking water demand (Litre)	Assumption increases in 30%
2032	7593	
2033	7679	
2034	7765	
2035	7851	
2036	7937	
2037	8023	
2038	8109	
2039	8195	
2040	8281	
2041	8367	
2042	8453	
2043	8539	
2044	8625	
2045	8711	

Based on projected data in with-project condition, a chart has been prepared, and presented below in **figure 0.17**:

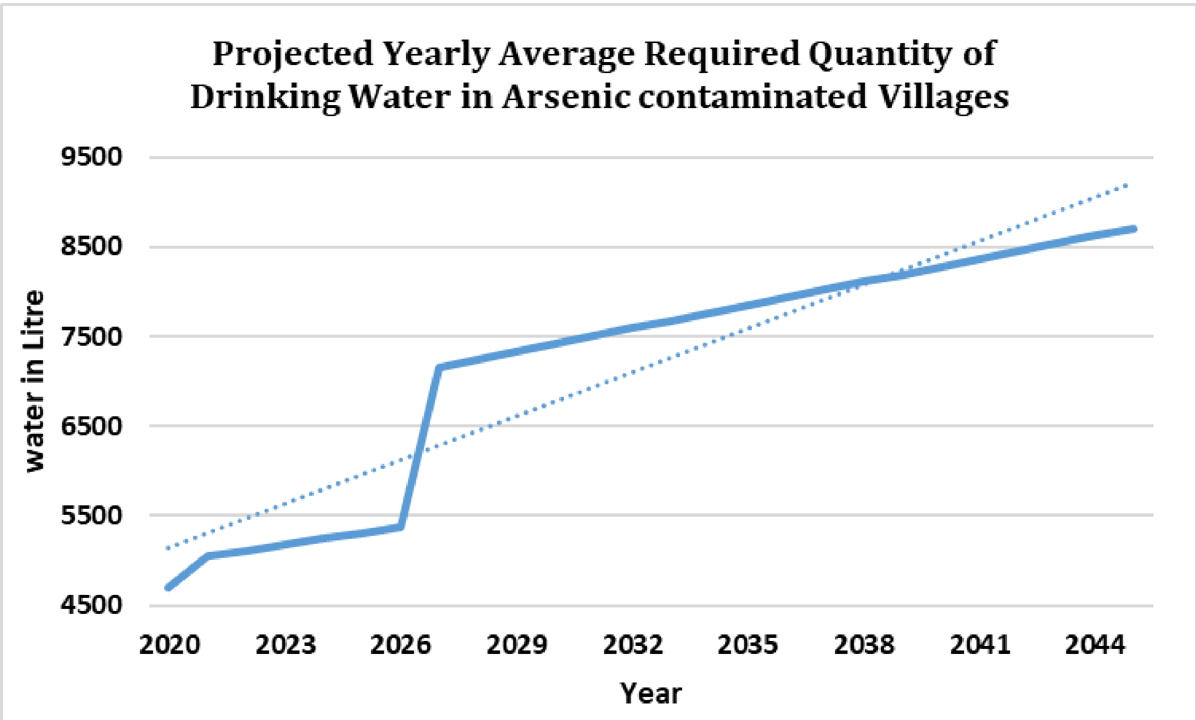

Figure III.2: Projected Yearly Average Required Quantity of Drinking Water in Arsenic contaminated Villages after project implementation.

iii. Various constrains and means to meet the demand including government regulations, technological developments etc.

On the existing physical settings, proper planning and implementation of the project, and proper management and O&M of the project are likely to be means to meet demand for water.

Water Supply Demand

a. Demand Analysis: Identify the need for public investments by assessing:
   i. Current demand

Current demand for overall water use per person-day has been assessed based on data available[11] of arsenic contaminated pilot villages. Previous two years (2021 and 2020) data are related with the population growth[12] rate.

Table III.4: Current Demand for Overall Water Use before project implementation (Liter) in Saikchail.

District	Village	Number of household (HH)	Avg. HH size	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Cumilla	Saikchail	1652	5.4	8921	624456	18733680	2248	2219	2191
Total				**8,921**	**624,456**	**43,711,920**	**2,248**	**2,219**	**2,191**

Source: BBS, Statistical Pocketbook, 2021, (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%).

Based on population growth rate, demand for drinking water forecasted through end of the project, has been made. Based on 2020, 2021, and 2022 years' overall water use data (estimated), overall water demand has been forecasted for a period of 20-year. In this case, Linear Regression model is used for projection. As population increases in the pilot villages, demand for water has been estimated at an increasing trend over the years. There three observations in the analysis, past water use, business as usual projection for a period, and forecasted for a period of 20-year. These are shown in the following Table.

Table III.5: Before Project Implementation Overall Water Demand and Projection

Year	Yearly Overall water demand (Lac Litre)	Remarks
2020	2191	Estimated quantity of water is based on 70 litre per person per day
2021	2219	
2022	2248	
2023	2277	Business as usual Projection
2024	2305	
2025	2334	

[11] DPHE report about 70 litre/person/day.
[12] BBS, Statistical Pocketbook, 2021, chapter II.

Year	Yearly Overall water demand (Lac Litre)	Remarks
2026	2363	Forecasted through end of the project
2027	2391	
2028	2420	
2029	2449	
2030	2478	
2031	2506	
2032	2535	
2033	2564	
2034	2592	
2035	2621	
2036	2650	
2037	2679	
2038	2707	
2039	2736	
2040	2765	
2041	2793	
2042	2822	
2043	2851	
2044	2879	
2045	2908	

Data have been presented in the following chart. A linear trend with upward direction is seen in the chart. It shows, before implementation, future overall water demand in the pilot villages will vary between 2150 Lac to 2900 Lac litres for the period.

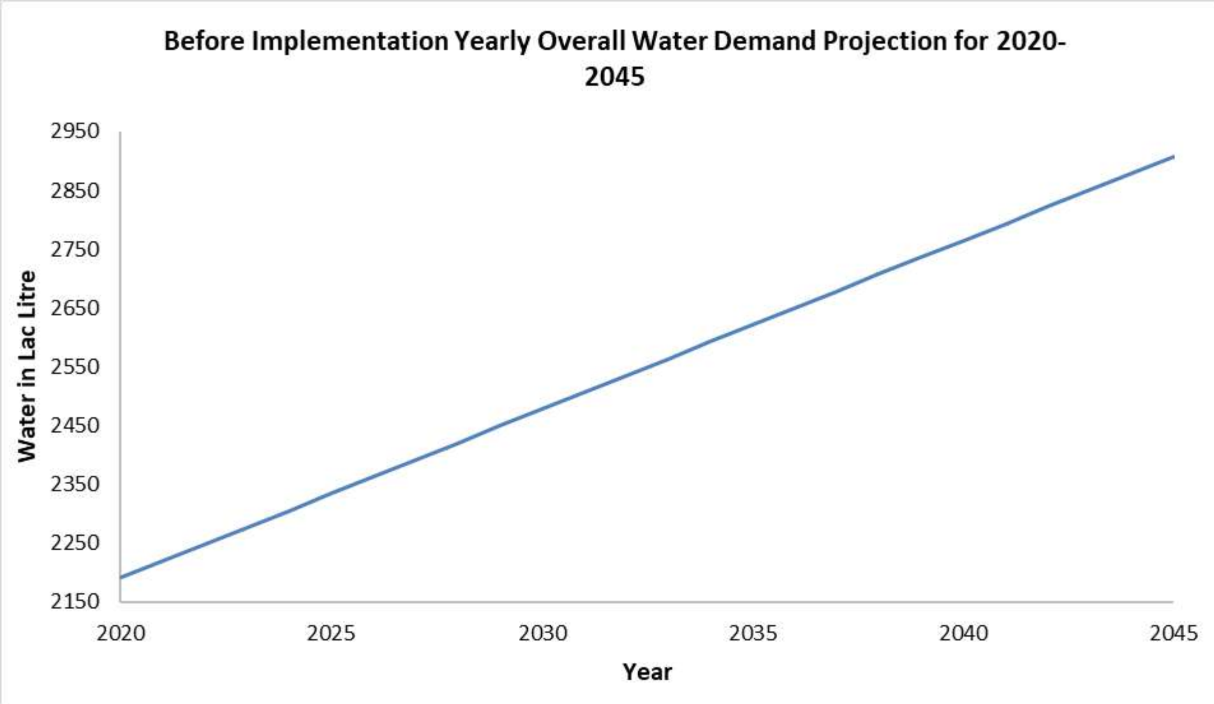

Figure III.3: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045.

ii. Future demand

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in water likely to be used due to better living condition in upper middle income and at the beginning of higher income country.

Table III.6: After Implementation Overall Water Demand and Projection

Year	Yearly overall water demand (Lac Litre)	Assumptions
2020	2191	Estimated based on 70 litres per person per day.
2021	2219	
2022	2248	
2023	2277	Business as usual Projection
2024	2305	
2025	2334	
2026	3072	Forecasted through end of the project with the assumption of increased water use about 30% of water use before implementation. This for better living condition in the future.
2027	3109	
2028	3146	
2029	3184	
2030	3221	

Year	Yearly overall water demand (Lac Litre)	Assumptions
2031	3258	
2032	3295	
2033	3333	
2034	3370	
2035	3407	
2036	3445	
2037	3482	
2038	3519	
2039	3557	
2040	3594	
2041	3631	
2042	3669	
2043	3706	
2044	3743	
2045	3781	

Based on projected data, after implementation, a chart has been prepared, and presented below:

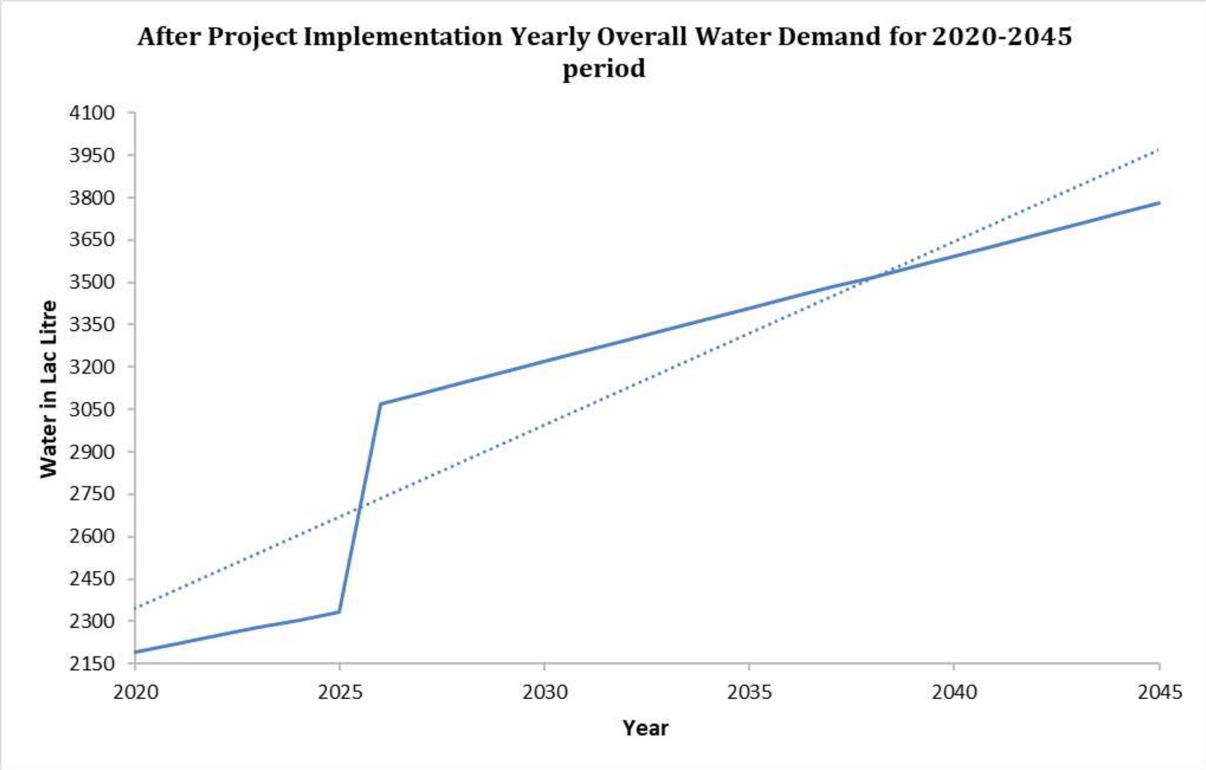

Figure III.4: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 2150 Lac to 3800 Lac litres over the period. The trend is upward.

iii. Current demand

Current demand for overall water use per person-day has been assessed based on data available[13] of arsenic contaminated pilot villages. Previous two years (2021 and 2020) data are related with the population growth[14] rate.

Table III.7: Current Demand for Overall Water Use before project implementation (Liter) in Tipna.

District	Village	Number of household (HH)	Avg. HH size	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Khulna	Tipna	772	4.2	3273	229130	6873888	825	814	804
Total				**3,273**	**229,130**	**16,039,072**	**825**	**814**	**804**

Source: BBS, Statistical Pocketbook, 2021, (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%).

[13] DPHE report about 70 litre/person/day.
[14] BBS, Statistical Pocketbook, 2021, chapter II.

Based on population growth rate, demand for drinking water forecasted through end of the project, has been made. Based on 2020, 2021, and 2022 years' overall water use data (estimated), overall water demand has been forecasted for a period of 20-year. In this case, Linear Regression model is used for projection. As population increases in the pilot villages, demand for water has been estimated at an increasing trend over the years. There three observations in the analysis, past water use, business as usual projection for a period, and forecasted for a period of 20-year. These are shown in the following Table.

Table III.8: Before Project Implementation Overall Water Demand and Projection

Year	Yearly Overall water demand (Lac Litre)	Remarks
2020	804	Estimated quantity of water is based on 70 litre per person per day
2021	814	
2022	825	
2023	835	Business as usual Projection
2024	846	
2025	856	
2026	867	Forecasted through end of the project
2027	877	
2028	888	
2029	899	
2030	909	
2031	920	
2032	930	
2033	941	
2034	951	
2035	962	
2036	972	
2037	983	
2038	993	
2039	1004	
2040	1014	
2041	1025	
2042	1035	
2043	1046	

Year	Yearly Overall water demand (Lac Litre)	Remarks
2044	1057	
2045	1067	

Data have been presented in the following chart. A linear trend with upward direction is seen in the chart. It shows, before implementation, future overall water demand in the pilot villages will vary between 800 Lac to 1100 Lac litres for the period.

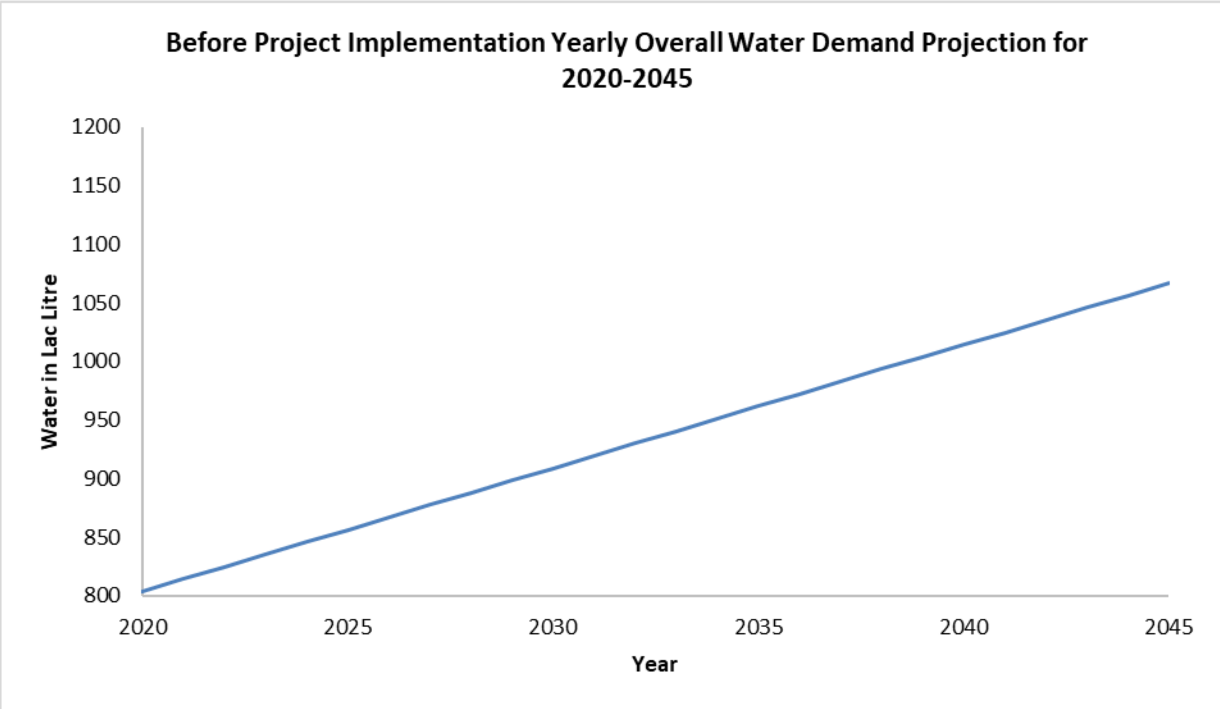

Figure III.5: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045.

iv. Future demand

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in water likely to be used due to better living condition in upper middle income and at the beginning of higher income country.

Table III.9: After Implementation Overall Water Demand and Projection

Year	Yearly overall water demand (Lac Litre)	Assumptions
2020	804	Estimated based on 70 litres per person per day.
2021	814	
2022	825	
2023	835	Business as usual Projection
2024	846	

Year	Yearly overall water demand (Lac Litre)	Assumptions
2025	856	
2026	1127	Forecasted through end of the project with the assumption of increased water use about 30% of water use before implementation. This for better living condition in the future.
2027	1141	
2028	1154	
2029	1168	
2030	1182	
2031	1196	
2032	1209	
2033	1223	
2034	1237	
2035	1250	
2036	1264	
2037	1278	
2038	1291	
2039	1305	
2040	1319	
2041	1332	
2042	1346	
2043	1360	
2044	1373	
2045	1387	

Based on projected data, after implementation, a chart has been prepared, and presented below:

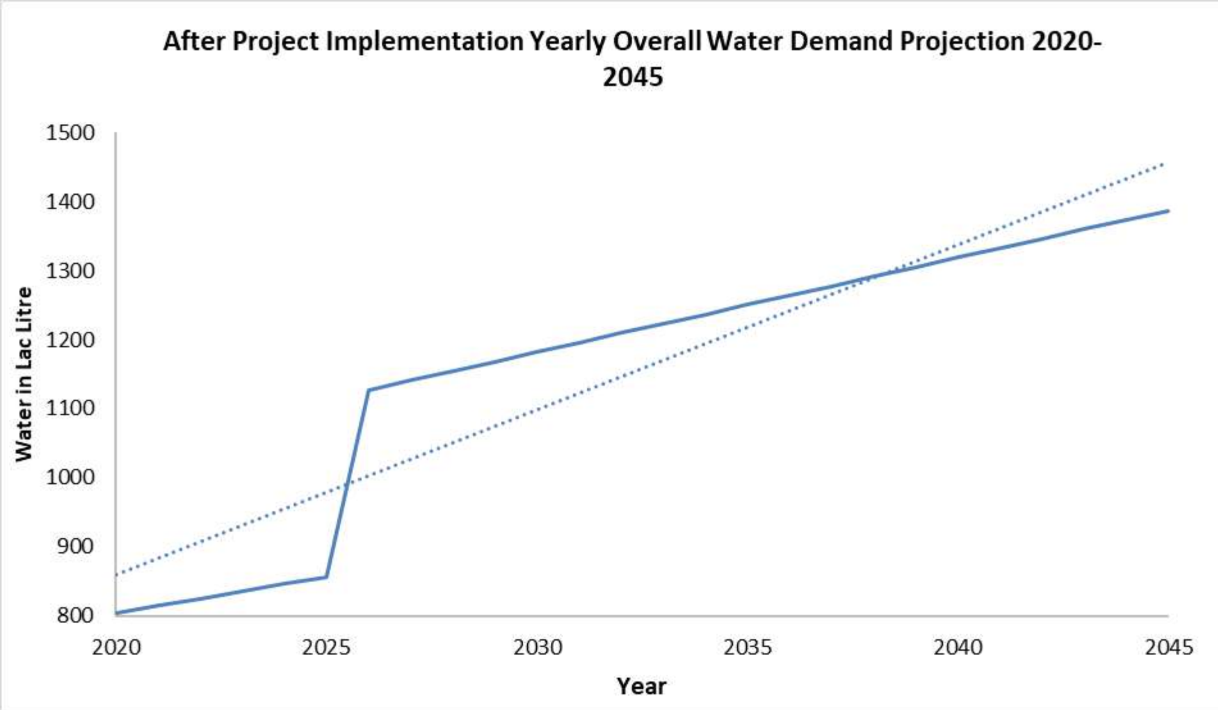

Figure III.6: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 800 Lac to 1400 Lac litres over the period. The trend is upward.

v. Current demand

Current demand for overall water use per person-day has been assessed based on data available[15] of arsenic contaminated pilot villages. Previous two years (2021 and 2020) data are related with the population growth[16] rate.

Table III.10: Current Demand for Overall Water Use before project implementation (Liter) in Datinakhali.

District	Village	Number of household (HH)	Avg. HH size	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Cumilla	Datinakhali	568	4.0	2255	157847	4735416	568	561	554
Total				**2,255**	**157,847**	**11,049,304**	**568**	**561**	**554**

Source: BBS, Statistical Pocketbook, 2021, (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%).

Based on population growth rate, demand for drinking water forecasted through end of the project, has been made. Based on 2020, 2021, and 2022 years' overall water use data (estimated), overall water demand has been forecasted for a period of 20-year. In this case, Linear Regression model is

[15] DPHE report about 70 litre/person/day.
[16] BBS, Statistical Pocketbook, 2021, chapter II.

used for projection. As population increases in the pilot villages, demand for water has been estimated at an increasing trend over the years. There three observations in the analysis, past water use, business as usual projection for a period, and forecasted for a period of 20-year. These are shown in the following Table.

Table III.11: Before Project Implementation Overall Water Demand and Projection

Year	Yearly Overall water demand (Lac Litre)	Remarks
2020	554	Estimated quantity of water is based on 70 litre per person per day
2021	561	
2022	568	
2023	575	Business as usual Projection
2024	583	
2025	590	
2026	597	Forecasted through end of the project
2027	605	
2028	612	
2029	619	
2030	626	
2031	634	
2032	641	
2033	648	
2034	655	
2035	663	
2036	670	
2037	677	
2038	684	
2039	692	
2040	699	
2041	706	
2042	713	
2043	721	
2044	728	
2045	735	

Data have been presented in the following chart. A linear trend with upward direction is seen in the chart. It shows, before implementation, future overall water demand in the pilot villages will vary between 2150 Lac to 2900 Lac litres for the period.

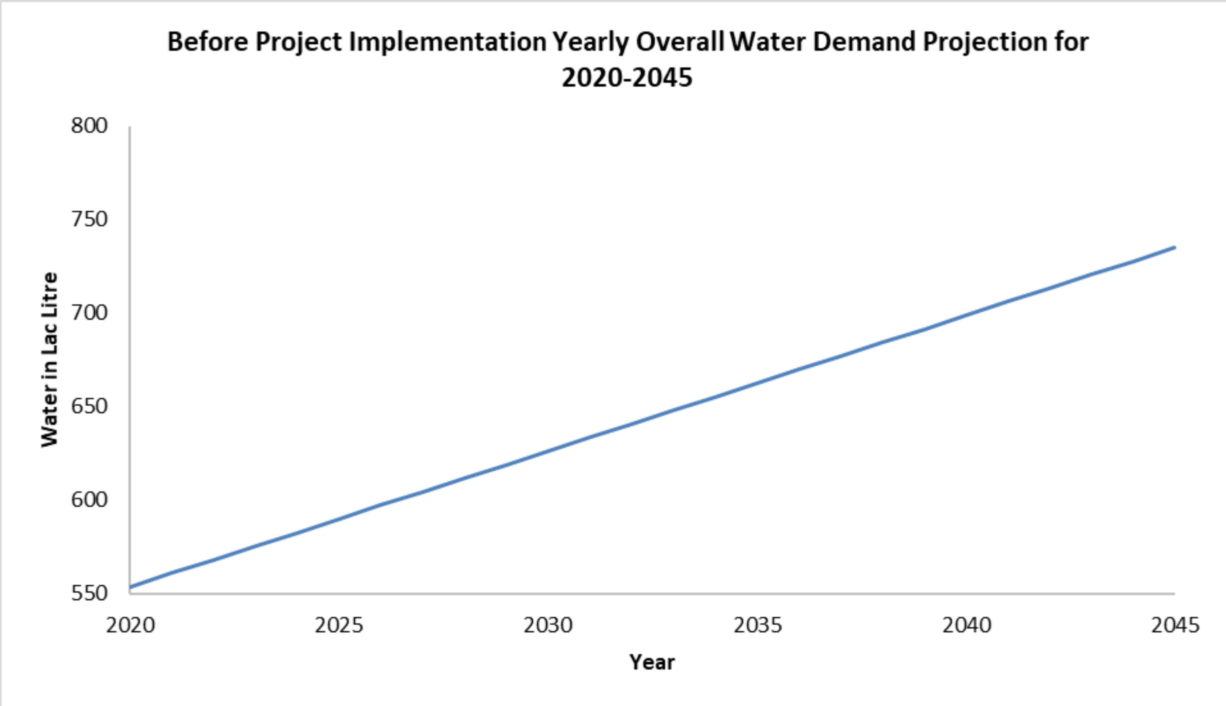

Figure III.7: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045.

vi. Future demand

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in water likely to be used due to better living condition in upper middle income and at the beginning of higher income country.

Table III.12: After Implementation Overall Water Demand and Projection

Year	Yearly overall water demand (Lac Litre)	Assumptions
2020	554	Estimated based on 70 litres per person per day.
2021	561	
2022	568	
2023	575	Business as usual Projection
2024	583	
2025	590	
2026	776	Forecasted through end of the project with the assumption of increased water use about 30% of water use before
2027	786	
2028	795	

Year	Yearly overall water demand (Lac Litre)	Assumptions
2029	805	implementation. This for better living condition in the future.
2030	814	
2031	824	
2032	833	
2033	842	
2034	852	
2035	861	
2036	871	
2037	880	
2038	890	
2039	899	
2040	908	
2041	918	
2042	927	
2043	937	
2044	946	
2045	956	

Based on projected data, after implementation, a chart has been prepared, and presented below:

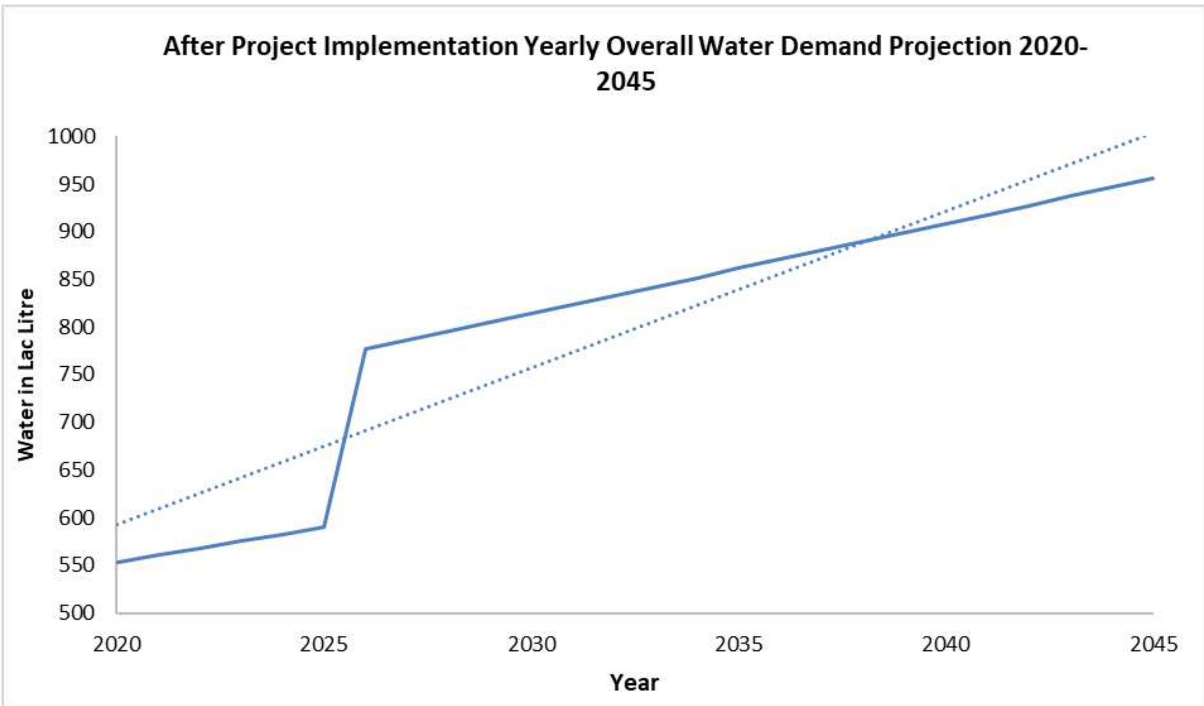

Figure III.8: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 550 Lac to 1000 Lac litres over the period. The trend is upward.

vii. Current demand

Current demand for overall water use per person-day has been assessed based on data available[17] of arsenic contaminated pilot villages. Previous two years (2021 and 2020) data are related with the population growth[18] rate.

Table III.13: Current Demand for Overall Water Use before project implementation (Liter) in Shimulbank.

District	Village	Number of household (HH)	Avg. HH size	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Cumilla	Shimulbank	462	5.7	2629	184015	5520438	662	654	646
Total				**2,629**	**184,015**	**12,881,022**	**662**	**654**	**646**

Source: BBS, Statistical Pocketbook, 2021, (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%).

Based on population growth rate, demand for drinking water forecasted through end of the project, has been made. Based on 2020, 2021, and 2022 years' overall water use data (estimated), overall water demand has been forecasted for a period of 20-year. In this case, Linear Regression model is

[17] DPHE report about 70 litre/person/day.
[18] BBS, Statistical Pocketbook, 2021, chapter II.

used for projection. As population increases in the pilot villages, demand for water has been estimated at an increasing trend over the years. There three observations in the analysis, past water use, business as usual projection for a period, and forecasted for a period of 20-year. These are shown in the following Table.

Table III.14: Before Project Implementation Overall Water Demand and Projection

Year	Yearly Overall water demand (Lac Litre)	Remarks
2020	646	Estimated quantity of water is based on 70 litre per person per day
2021	654	
2022	662	
2023	671	Business as usual Projection
2024	679	
2025	688	
2026	696	Forecasted through end of the project
2027	705	
2028	713	
2029	722	
2030	730	
2031	739	
2032	747	
2033	755	
2034	764	
2035	772	
2036	781	
2037	789	
2038	798	
2039	806	
2040	815	
2041	823	
2042	832	
2043	840	
2044	849	
2045	857	

Data have been presented in the following chart. A linear trend with upward direction is seen in the chart. It shows, before implementation, future overall water demand in the pilot villages will vary between 2150 Lac to 2900 Lac litres for the period.

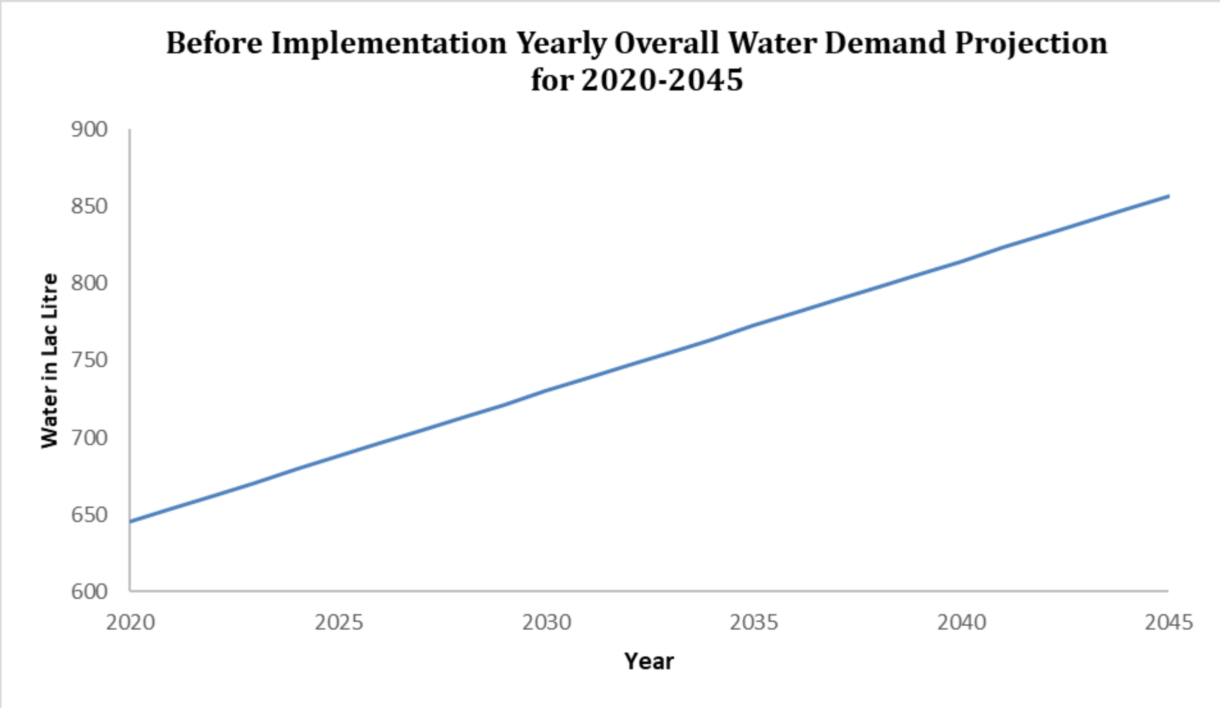

Figure III.9: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045.

viii. Future demand

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in water likely to be used due to better living condition in upper middle income and at the beginning of higher income country.

Table III.15: After Implementation Overall Water Demand and Projection

Year	Yearly overall water demand (Lac Litre)	Assumptions
2020	646	Estimated based on 70 litres per person per day.
2021	654	
2022	662	
2023	671	Business as usual Projection
2024	679	
2025	688	
2026	905	Forecasted through end of the project with the assumption of increased water use about 30% of water use before
2027	916	
2028	927	

Year	Yearly overall water demand (Lac Litre)	Assumptions
2029	938	implementation. This for better living condition in the future.
2030	949	
2031	960	
2032	971	
2033	982	
2034	993	
2035	1004	
2036	1015	
2037	1026	
2038	1037	
2039	1048	
2040	1059	
2041	1070	
2042	1081	
2043	1092	
2044	1103	
2045	1114	

Based on projected data, after implementation, a chart has been prepared, and presented below:

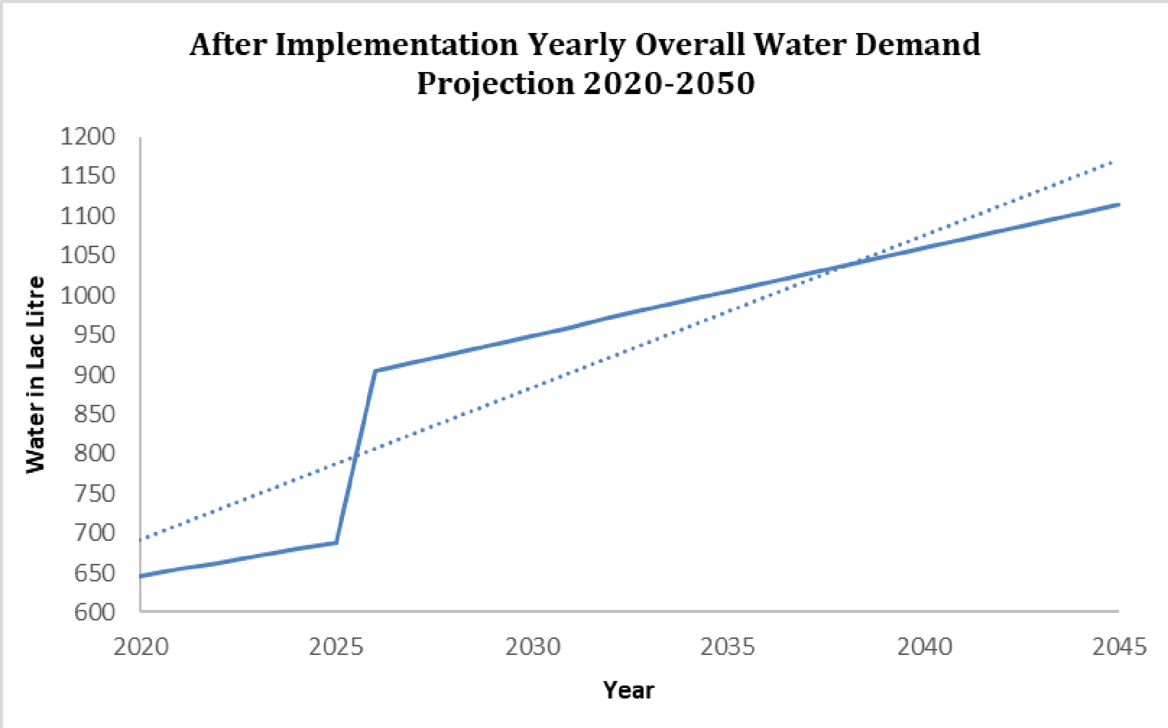

Figure III.10: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 600 Lac to 1150 Lac litres over the period. The trend is upward.

ix. Various constrains and means to meet the demand including government regulations, technological developments etc.

On the existing physical settings, proper planning and implementation of the project, and proper management and O&M of the project are likely to be means to meet demand for water.

Sanitation Demand

Demand Analysis: Identify the need for public investments by assessing:

i. <u>Current Sanitation Status of Pilot Villages</u>

Sanitation is an important tool for social well-being. It is the provision of facilities and services for the safe disposal of human urine, and feces and maintenance of hygienic conditions, through services such as garbage, collection and wastewater disposal[19]. According to questionnaire survey, latrine types and number identified in the pilot villages. Total of various latrines is calculated at 2488 numbers in households (HHs) of 3454. It indicates that some of the HHs do not have any latrine. About 27% of the HH have not any latrine. In the following Table, pit latrine i.e., single pit appears about 1340 and ventilated improved pit (VIP) stands at 463 number. Pit latrines need more cost for frequent cleaning of feces (waste matter remaining after food has been digested and discharged from bowels) in the pits. These are not environment friendly. The following Table shows the current latrine status in pilot villages.

[19] https://www.researchgate.net/publication/349988876_Sanitation

Table III.16: Current Latrine Types and Number in the Disaster Prone Villages

District	Village	Type of Latrine						
		Pit Latrine	Double Pit Latrine	VIP Latrine	Flash Latrine	Septic Tank Latrine	Open Latrine	Others
Khulna	Tipna	346	21	35	86	107	0	2
Satkhira	Datinak hali	292	7	15	47	18	0	0
Sunamg anj	Shimul bank	116	15	41	33	59	21	1
Cumilla	Saikcha il	586	65	372	176	177	2	1

Source: Questionnaire Survey, 2022.

ii. <u>Current demand</u>

Current demand analysis for investment covers conversion of single pit and construction of twine pit latrine for better sanitation condition specially latrine type (single pit and twine pit). The following Table shows the current number of conversions of single pit latrine to twine pit latrine[20].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[21] rate and behavior of the people in current sanitation with reference to the national economic growth rate. In this regards, economic expansion (GDP growth rate) about 5 percent of FY 2020-2021 have taken for calculation of the previous data. Based on the assumption, gradually improved economic condition, previous number of single pit latrine was drawn down to the current number of single pit latrine to convert in twine pit. On the basis of DPHE data, current latrine type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table III.17: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (HH)	HH size (4.2)	Number of Persons	Conversion Single Pit Latrine by Pilot Village and Adjacent Area			
					Single Pit Latrine	Year 2022	Year 2021	Year 2020
Khulna	Tipna	772	4.2	3242.4	300	300	315	331

Source: BBS, Statistical Pocketbook (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%)

[20] DPHE data for development of sanitation system in the pilot Villages.
[21] BBS, Statistical Pocketbook, 2021, chapter II.

Based on 2020, 2021, and 2022 years' overall water use data (estimated), the investment demand for conversion of single pit to twin pit has been forecasted for a period of 20-year. In this case, Linear Regression model is used for the projection. As population increases slowly (1.3 percent or less) with better economic condition (GDP growth rate more than 5 percent, 7 or 8 percent), single pit will have become down in number. Thus, the demand for conversion is estimated to be decreasing trend over the years. There are for a period of 20-Year. These are shown in the following Table.

Table III.18: Before Project Conversion Number of Single Pit Latrine and Projection.

Year	Single Pit Latrine	Remarks
2020	331	Estimated based on awareness of better future sanitation situation
2021	315	
2022	300	DPHE data on conversion of single pit latrine.
2023	285	Business as usual Projection
2024	269	
2025	254	
2026	239	
2027	223	
2028	208	
2029	193	
2030	177	
2031	162	
2032	147	
2033	132	
2034	116	
2035	101	
2036	86	
2037	70	
2038	55	
2039	40	
2040	24	
2041	9	
2042	0	
2043	0	
2044	0	
2045	0	

The above Table is presented in the following chart. A linear trend with down ward direction is seen in the following chart. It shows, before implementation, future average demand for conversion of single pit to twine pit latrines in the pilot villages and adjacent areas will decrease year by year.

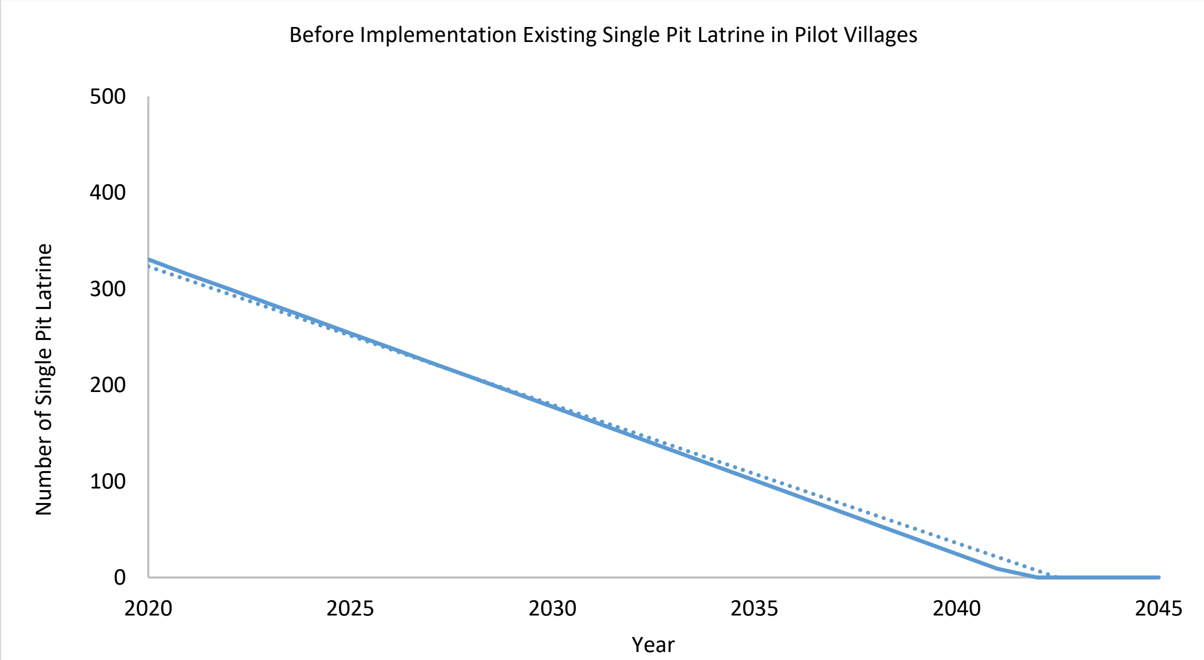

Figure III.11: Before Implementation Existing Single Pit Latrine in Pilot Villages

iii. Future demand

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in new twine pit latrine likely to be used due to better living condition in upper middle income and at the beginning of higher income country. Estimated annual increase in demand for investment in construction of new twine pit latrine and decrease in investment in conversion of single pit are shown in the following Table:

Table III.19: After Implementation Conversion of Single Pit and Construction of Twine Pit Latrine

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2020	331	141	141	Estimated based on population grows and awareness of better sanitation condition
2021	315	143	143	
2022	300	145	145	DPHE data
2023	285	147	147	Business as usual Projection
2024	269	149	149	
2025	254	151	151	
2026	239	198	152	Forecasted through end of the project with increase in 30% twin pit latrine.
2027	223	201	154	
2028	208	203	156	
2029	193	205	158	
2030	177	208	160	
2031	162	210	162	
2032	147	213	163	

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2033	132	215	165	
2034	116	217	167	
2035	101	220	169	
2036	86	222	171	
2037	70	225	173	
2038	55	227	175	
2039	40	229	176	
2040	24	232	178	
2041	9	234	180	
2042	0	237	182	
2043	0	239	184	
2044	0	241	186	
2045	0	244	187	

After implementation of the project, it is estimated that the investment in construction new twin pit latrine varies between 141 numbers in 2020 to 244 over the period. The trend is presented in the following Chart:

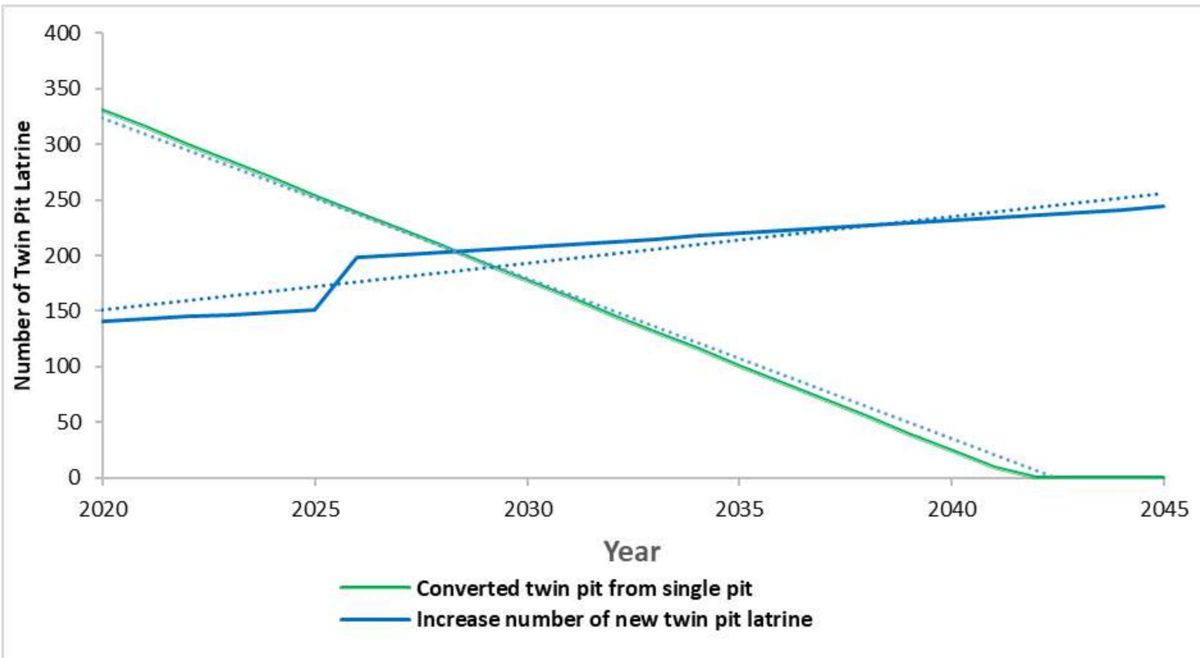

Figure III.12: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

i. Current demand

On the basis of DPHE data, current latrine type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table III.20: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (HH)	HH size (4.2)	Number of Persons	Conversion Single Pit Latrine by Pilot Village and Adjacent Area			
					Single Pit Latrine	Year 2022	Year 2021	Year 2020
Satkhira	Datinakhali	568	4	2272	410	410	430.5	452.025

Source: BBS, Statistical Pocketbook (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%)

Based on 2020, 2021, and 2022 years' overall water use data (estimated), the investment demand for conversion of single pit to twin pit has been forecasted for a period of 20-year. In this case, Linear Regression model is used for the projection. As population increases slowly (1.3 percent or less) with better economic condition (GDP growth rate more than 5 percent, 7 or 8 percent), single pit will have become down in number. Thus, the demand for conversion is estimated to be decreasing trend over the years. There are for a period of 20-Year. These are shown in the following Table.

Table III.21: Before Project Conversion Number of Single Pit Latrine and Projection.

Year	Single Pit Latrine	Remarks
2020	452	Estimated based on awareness of better future sanitation situation
2021	431	
2022	410	DPHE data on conversion of single pit latrine.
2023	389	Business as usual Projection
2024	368	
2025	347	
2026	326	
2027	305	
2028	284	
2029	263	
2030	243	
2031	222	
2032	201	
2033	180	
2034	159	
2035	138	
2036	117	
2037	96	
2038	75	
2039	54	
2040	33	
2041	13	

Year	Single Pit Latrine	Remarks
2042	0	
2043	0	
2044	0	
2045	0	

The above Table is presented in the following chart. A linear trend with down ward direction is seen in the following chart. It shows, before implementation, future average demand for conversion of single pit to twine pit latrines in the pilot villages and adjacent areas will decrease year by year.

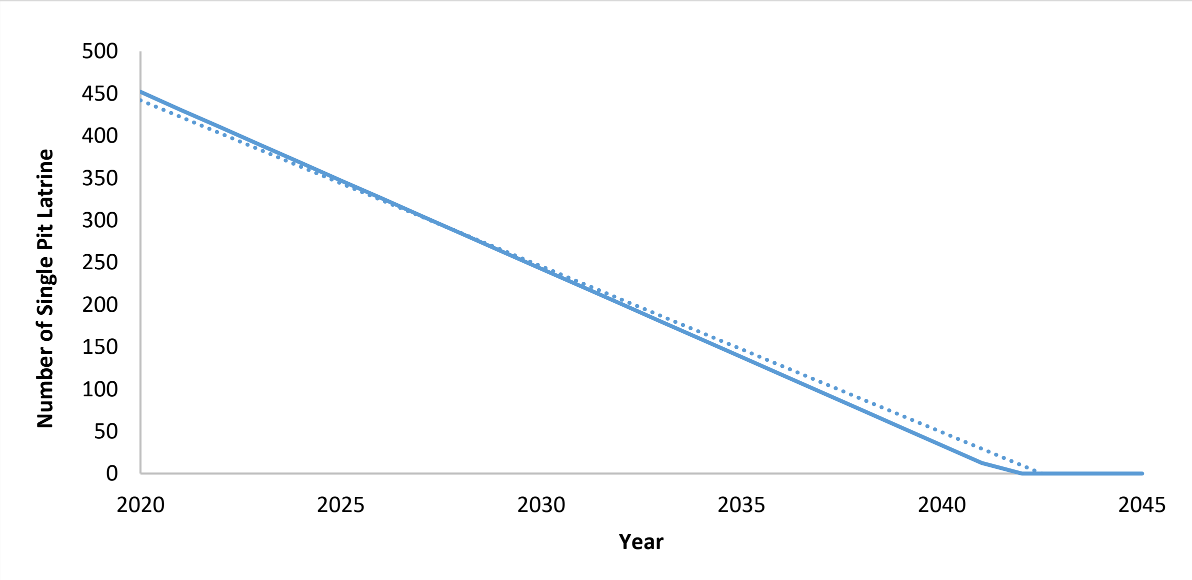

Figure III.13: Before Implementation Existing Single Pit Latrine in Pilot Villages

ii. <u>Future demand</u>

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in new twine pit latrine likely to be used due to better living condition in upper middle income and at the beginning of higher income country. Estimated annual increase in demand for investment in construction of new twine pit latrine and decrease in investment in conversion of single pit are shown in the following Table:

Table III.22: After Implementation Conversion of Single Pit and Construction of Twine Pit Latrine

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine
2020	452	193	193
2021	431	195	195
2022	410	198	198
2023	389	201	201
2024	368	203	203
2025	347	206	206
2026	326	271	208

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine
2027	305	274	211
2028	284	277	213
2029	263	280	216
2030	243	284	218
2031	222	287	221
2032	201	290	223
2033	180	293	226
2034	159	297	228
2035	138	300	231
2036	117	303	233
2037	96	307	236
2038	75	310	238
2039	54	313	241
2040	33	316	243
2041	13	320	246
2042	0	323	248
2043	0	326	251
2044	0	330	253
2045	0	333	256

After implementation of the project, it is estimated that the investment in construction new twin pit latrine varies between 193 numbers in 2020 to 333 over the period. The trend is presented in the following Chart:

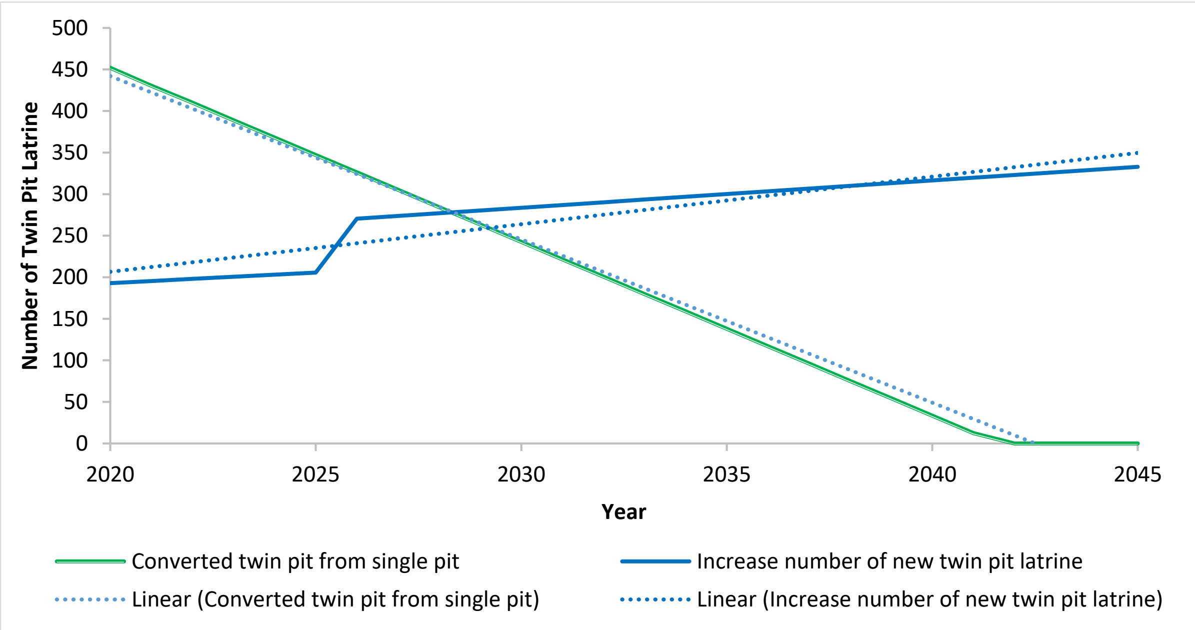

Figure III.14: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

i. <u>Current demand</u>

On the basis of DPHE data, current latrine type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table III.23: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (HH)	HH size (4.2)	Number of Persons	Conversion Single Pit Latrine by Pilot Village and Adjacent Area			
					Single Pit Latrine	Year 2022	Year 2021	Year 2020
Sunamganj	Shimulbank	462	5.7	2633.4	195	195	204.75	214.9875

Source: BBS, Statistical Pocketbook (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%)

Based on 2020, 2021, and 2022 years' overall water use data (estimated), the investment demand for conversion of single pit to twin pit has been forecasted for a period of 20-year. In this case, Linear Regression model is used for the projection. As population increases slowly (1.3 percent or less) with better economic condition (GDP growth rate more than 5 percent, 7 or 8 percent), single pit will have become down in number. Thus, the demand for conversion is estimated to be decreasing trend over the years. There are for a period of 20-Year. These are shown in the following Table.

Table III.24: Before Project Conversion Number of Single Pit Latrine and Projection.

Year	Single Pit Latrine	Remarks
2020	215	Estimated based on awareness of better future sanitation situation
2021	205	
2022	195	DPHE data on conversion of single pit latrine.
2023	185	Business as usual Projection
2024	175	
2025	165	
2026	155	
2027	145	
2028	135	
2029	125	
2030	115	
2031	105	
2032	95	
2033	86	
2034	76	
2035	66	
2036	56	
2037	46	
2038	36	
2039	26	

Year	Single Pit Latrine	Remarks
2040	16	
2041	6	
2042	0	
2043	0	
2044	0	
2045	0	

The above Table is presented in the following chart. A linear trend with down ward direction is seen in the following chart. It shows, before implementation, future average demand for conversion of single pit to twine pit latrines in the pilot villages and adjacent areas will decrease year by year.

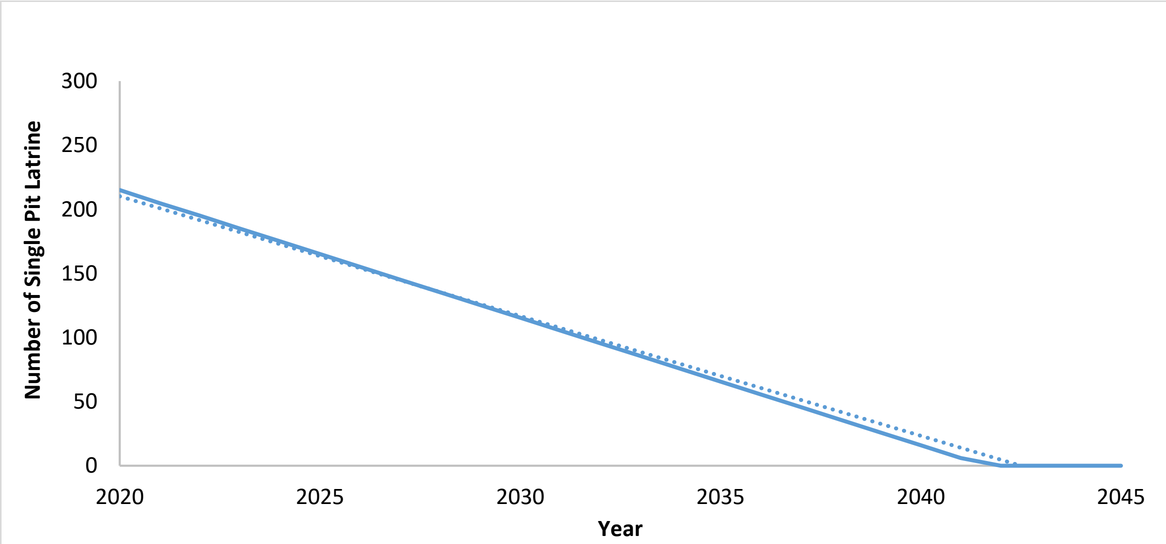

Figure III.15: Before Implementation Existing Single Pit Latrine in Pilot Villages

ii. <u>Future demand</u>

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in new twine pit latrine likely to be used due to better living condition in upper middle income and at the beginning of higher income country. Estimated annual increase in demand for investment in construction of new twine pit latrine and decrease in investment in conversion of single pit are shown in the following Table:

Table III.25: After Implementation Conversion of Single Pit and Construction of Twine Pit Latrine

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine
2020	215	102	102
2021	205	104	104
2022	195	105	105
2023	185	106	106
2024	175	108	108

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine
2025	165	109	109
2026	155	143	110
2027	145	145	112
2028	135	147	113
2029	125	149	114
2030	115	150	116
2031	105	152	117
2032	95	154	118
2033	86	156	120
2034	76	157	121
2035	66	159	122
2036	56	161	124
2037	46	163	125
2038	36	164	126
2039	26	166	128
2040	16	168	129
2041	6	170	130
2042	0	171	132
2043	0	173	133
2044	0	175	134
2045	0	176	136

After implementation of the project, it is estimated that the investment in construction new twin pit latrine varies between 102 numbers in 2020 to 176 over the period. The trend is presented in the following Chart:

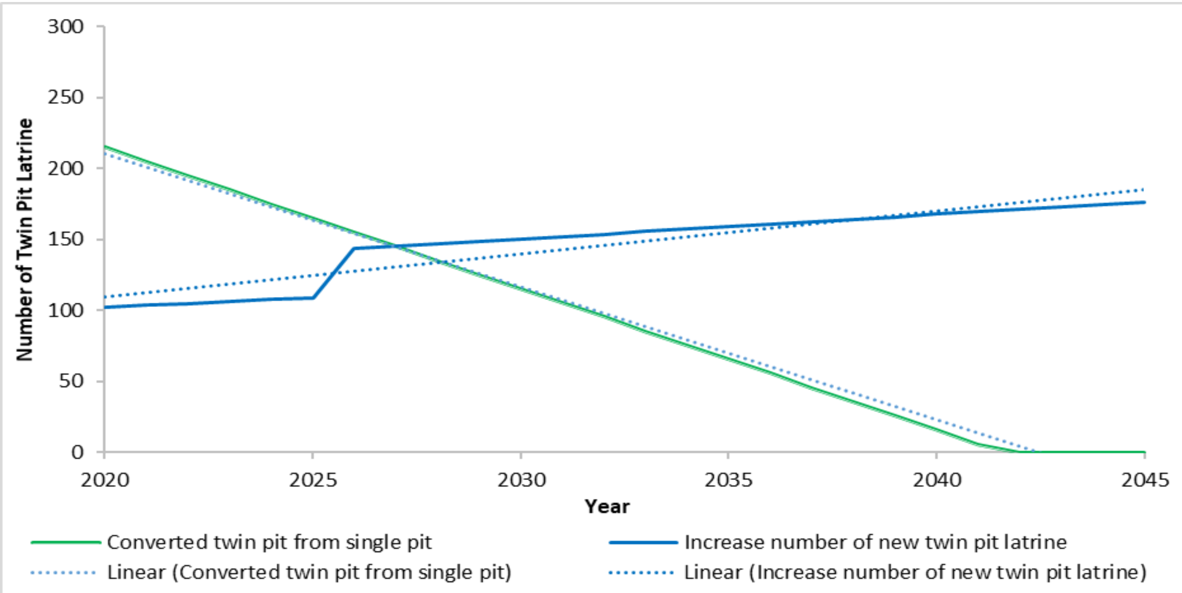

Figure III.16: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

i. Current demand

On the basis of DPHE data, current latrine type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table III.26: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (HH)	HH size (4.2)	Number of Persons	Conversion Single Pit Latrine by Pilot Village and Adjacent Area			
					Single Pit Latrine	Year 2022	Year 2021	Year 2020
Cumilla	Saikchail	1652	5.4	8921	390	390	410	430

Source: BBS, Statistical Pocketbook (Household size taken from household survey)
Note: Average water demand is estimated considering natural growth rate of population (1.3%)

Based on 2020, 2021, and 2022 years' overall water use data (estimated), the investment demand for conversion of single pit to twin pit has been forecasted for a period of 20-year. In this case, Linear Regression model is used for the projection. As population increases slowly (1.3 percent or less) with better economic condition (GDP growth rate more than 5 percent, 7 or 8 percent), single pit will have become down in number. Thus, the demand for conversion is estimated to be decreasing trend over the years. There are for a period of 20-Year. These are shown in the following Table.

Table III.27: Before Project Conversion Number of Single Pit Latrine and Projection.

Year	Single Pit Latrine	Remarks
2020	430	Estimated based on awareness of better future sanitation situation
2021	410	
2022	390	DPHE data on conversion of single pit latrine.
2023	370	Business as usual Projection
2024	350	
2025	330	
2026	310	
2027	290	
2028	271	
2029	251	
2030	231	
2031	211	
2032	191	
2033	171	

Year	Single Pit Latrine	Remarks
2034	151	
2035	131	
2036	111	
2037	91	
2038	72	
2039	52	
2040	32	
2041	12	
2042	0	
2043	0	
2044	0	
2045	0	

The above Table is presented in the following chart. A linear trend with down ward direction is seen in the following chart. It shows, before implementation, future average demand for conversion of single pit to twine pit latrines in the pilot villages and adjacent areas will decrease year by year.

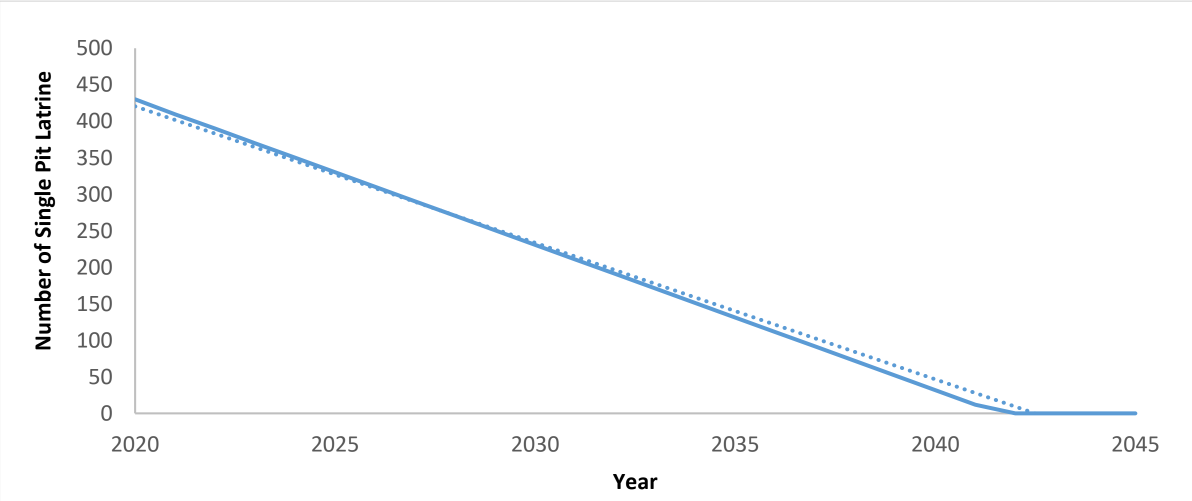

Figure III.17: Before Implementation Existing Single Pit Latrine in Pilot Villages

ii. <u>Future demand</u>

After completion of the project, a 20-year demand forecast has been carried out using linear regression model. It is assumed that about 30% increase in new twine pit latrine likely to be used due to better living condition in upper middle income and at the beginning of higher income country. Estimated annual increase in demand for investment in construction of new twine pit latrine and decrease in investment in conversion of single pit are shown in the following Table:

Table III.28: After Implementation Conversion of Single Pit and Construction of Twine Pit Latrine

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine
2020	430	200	244
2021	410	202	247
2022	390	205	250
2023	370	208	253
2024	350	210	256
2025	330	213	260
2026	310	280	263
2027	290	283	266
2028	271	287	269
2029	251	290	272
2030	231	294	275
2031	211	297	279
2032	191	300	282
2033	171	304	285
2034	151	307	288
2035	131	311	291
2036	111	314	295
2037	91	317	298
2038	72	321	301
2039	52	324	304
2040	32	328	307
2041	12	331	311
2042	0	334	314
2043	0	338	317
2044	0	341	320
2045	0	345	323

After implementation of the project, it is estimated that the investment in construction new twin pit latrine varies between 200 numbers in 2020 to 345 over the period. The trend is presented in the following Chart:

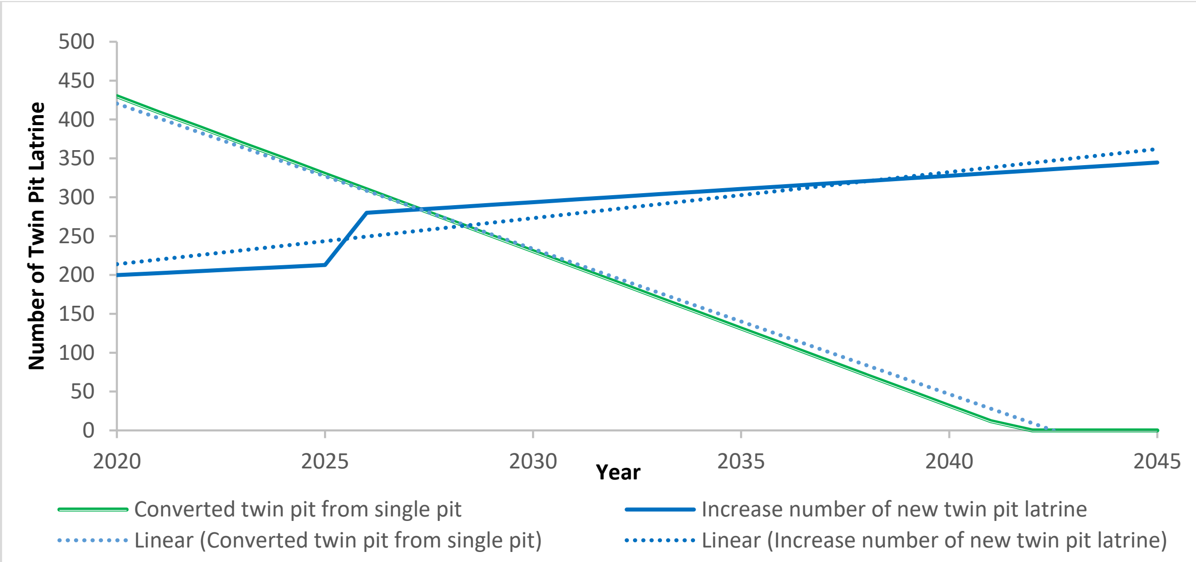

Figure III.18: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

iii. <u>Various constrains and means to meet the demand including government regulations, technological developments etc.</u>

On the existing physical settings, proper planning and implementation of the project, and proper management and O&M of the project are likely to be means to meet demand for water in the project.