Local Government Engineering Department

Government of the People's Republic of Bangladesh

'My Village-MY Town' Technical Assistance Project

Study - 7

Feasibility Study on Water Supply and Sanitation in Disaster Prone 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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Acknowledgments

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Executive Summary

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 rural areas was designated as "***Study-7,"*** which covers eight villages of disaster prone areas.

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.

Some key findings are presented here to comprehend the proposed study better. The survey includes 51.28% males and 48.72% females. The percentage of married household heads in the survey area was approximately 90% (total number of households 7,238). The average income of the people was 14,434 BDT. Moreover, the survey revealed 7.48% of households with disabled members.

Regarding the availability of water supply in the disaster prone area, the survey covered 7,238 families. Among those 85% use tube wells as their primary source of safe drinking water and ponds, and river/canal water has been used for wash and cooking in some villages. The survey indicates that water adequacy (87%), water accessibility, and water quality is quite good (83%) in disaster prone area. Approximately 32% of bad water quality is mostly iron. In many villages, the filtering and settlement process is used for water purification. The pipe water supply system is not good in most villages.

The analysis also demonstrates the sanitation condition of the study area. Toilet facilities and toilet conditions are not up to mark in most villages. Of the 7,238 households, 71% have access to toilets. Pit latrines are the most common toilet type. Vip latrines are also there but in a minimum range.

In terms of hygiene practice and awareness, the study indicates that hand washing is prevalent among 51% of the 7,238 households. Interviews during the survey agreed about practicing hand washing with soap after using toilets. Different local NGOs are involved in the public awareness activities conducted in the study area.

According to hydro-geological research conducted as a study component, the entire region is categorized into four categories. Four villages Fulchari, Pathordubi, Datinakhali and Bagaiya out of eight villages of disaster prone area, lie in the “Good aquifer within 300ft” category, and Induria, Charsharat, Tipna and Shimulbank lies in the “Deep aquifer” category.

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, rural 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.

Water availability has been estimated from the data collected from the field survey regarding water volume. Data on pond usage has been analyzed, and it observed that 47% of total ponds had been used for only fish. The computation result of potential ponds shows that the total ponds have very little or low potentiality in eight pilot villages of disaster prone area.

The current demand for general water use per person-day has been assessed based on data from eight disaster prone villages. After the completion of the project, a 25-year demand forecast was carried out using a linear regression model for both water supply and sanitation.

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.

The current demand for overall water use per person-day has been assessed based on data from eight disaster prone villages. After the completion of the project, a 25-year demand forecast was carried out using a linear regression model for both water supply and sanitation.

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 return rate of 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
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 others from selected areas, 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:

- Rural Road Connectivity
- Rural Growth Center and Hat Bazars
- Rural Water Supply and Sanitation
- Rural Waste Management
- Community Space and Recreation
- Upazila Physical Plan/Master Plan

Among above mentioned six components, the Center for Environmental and Geographic Information Services (CEGIS) has engaged only in the feasibility and review study of *"Rural Water Supply and Sanitation."* Accordingly, the study will follow 8 sub-study areas 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
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 rural areas.

1.2 The setting of the Study Area

Bangladesh is a flood-prone country. Floods influence the groundwater and surface water. Aside from that, the coastal zone is vulnerable to cyclones and storm surge. So, there is a huge possibility of saline water intrusion into groundwater and surface water. These criteria threaten the possibility of safe drinking water for people. Sustainable access to freshwater is a major issue for the rural areas of our country. For these reasons, a thorough investigation is required to assess the water source criteria and conditions in nearby villages vulnerable to flood, storm surge, and cyclone. Among all of these villages, eight are selected to examine the water availability, quality, and sanitation conditions. These are given in the **Table 1.1**.

Table 1.1: Selected Disaster Prone areas

Village	Union	Upazila	District
Fulchari	Fulchari	Fulchari	Gaibandha
Pathordubi	Pathordubi	Bhurungamari	Kurigram
Tipna	Khurnia	Dumuria	Khulna
Datinakhali	Labsa	Shyamnagar	Satkhira
Induria	Memania	Hijla	Barishal
Shimulbank	Shimulbank	Dakkhin Sunamganj	Sunamganj
Bagaiya	Rustimpur	Gowainghat	Sylhet
Charsharat	Ichakhali	Mirsarai	Chattogram

From the above table, Tipna, Datinakhali, Charsharat, and Induria are cyclone-prone areas. Fulchari, Shimulbank, Bagaiya, and Pathordubi are flood prone areas. So, groundwater and surface water are easily contaminated here. That’s why these areas are selected to assess water supply conditions, drinking water quality, sanitation conditions, and hygiene conditions.

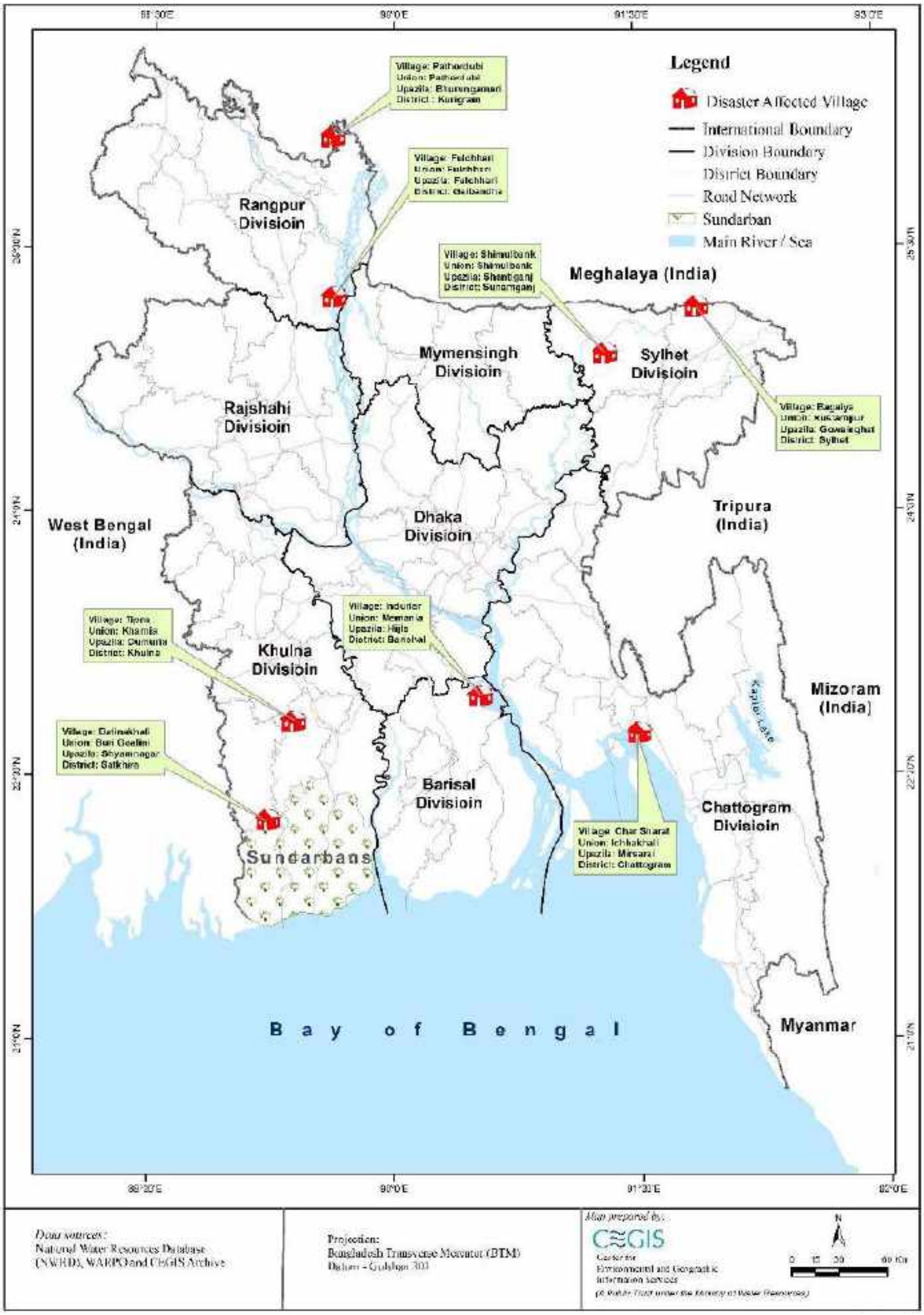


Figure 1.1: Location of the Study Villages

Description of Study Village

Induria Village

Induria village is located in Memania Union of Hijla Upazila of Barisal 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 south-central coastal and cyclone prone criteria. According to BBS, the village's total area is about 338 hectares.

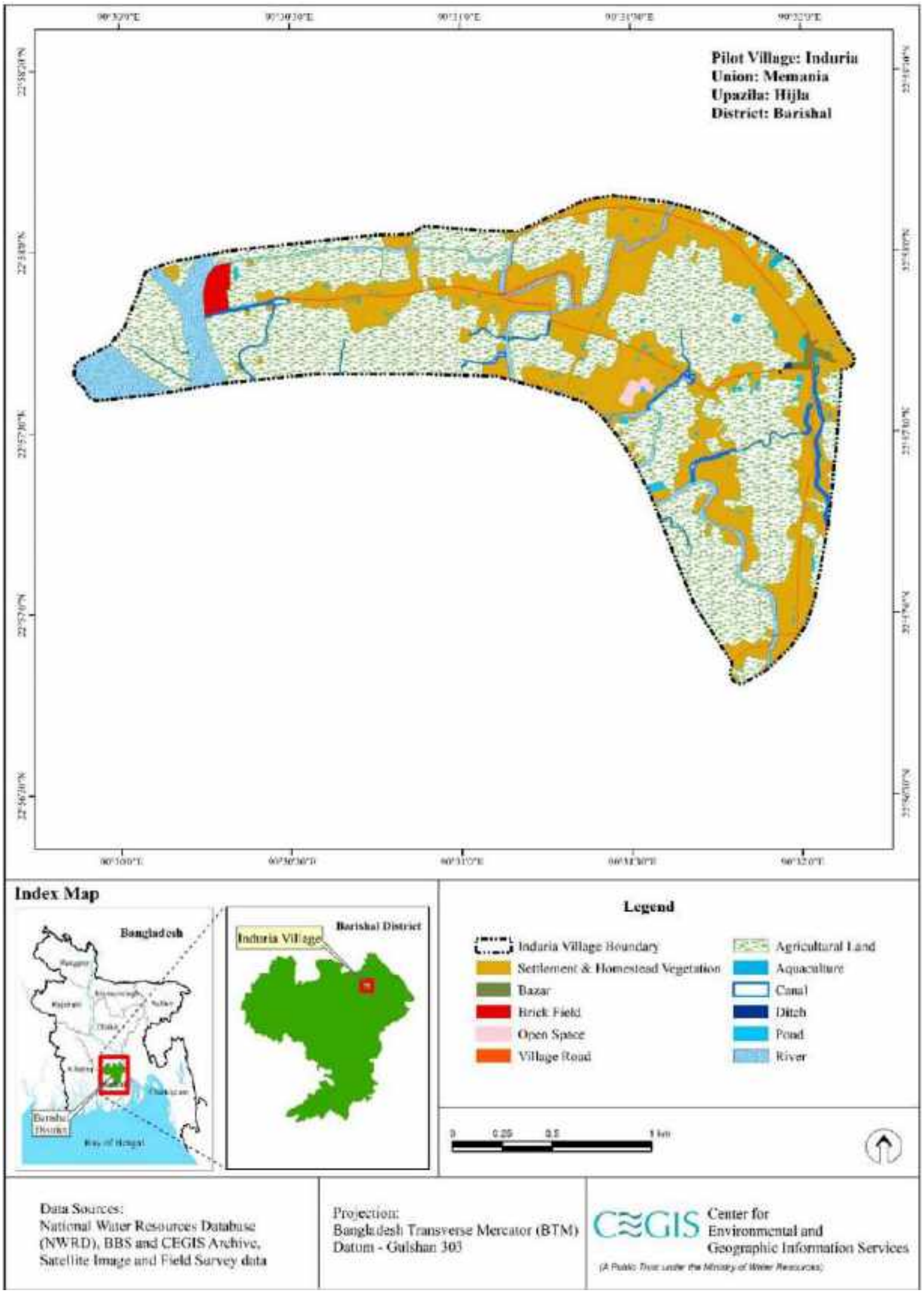


Figure 1.2: Land use map of Induria village

Fulchari Village

Fulchari village is located in Fulchari Union of Fulchari Upazila of Gaibandha 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 flood-prone area and char area criteria. According to BBS, the village's total area is about 331 hectares.

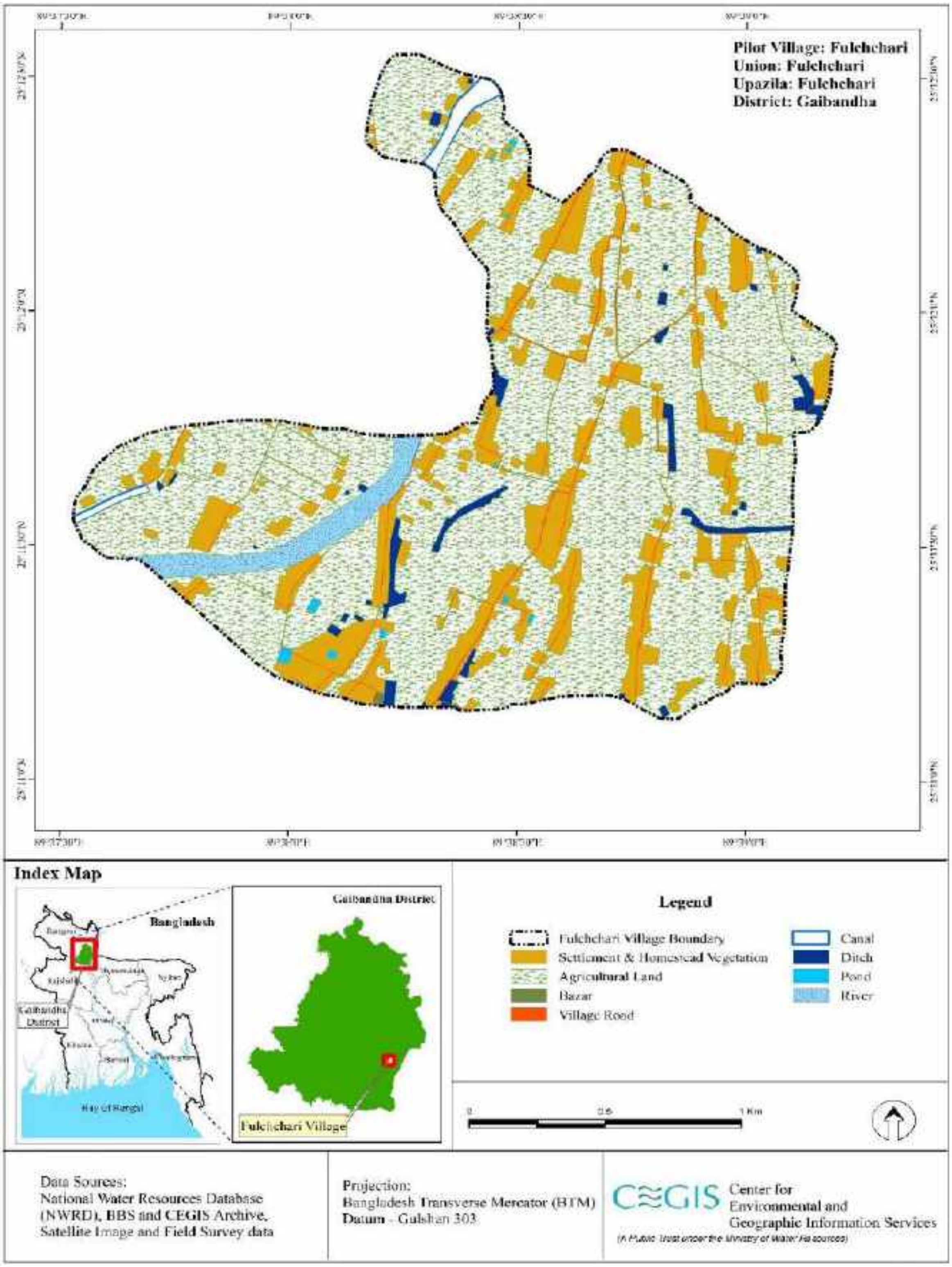


Figure 1.3: Land use map of Fulchari village

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 the 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 village's total area is about 236 hectares.

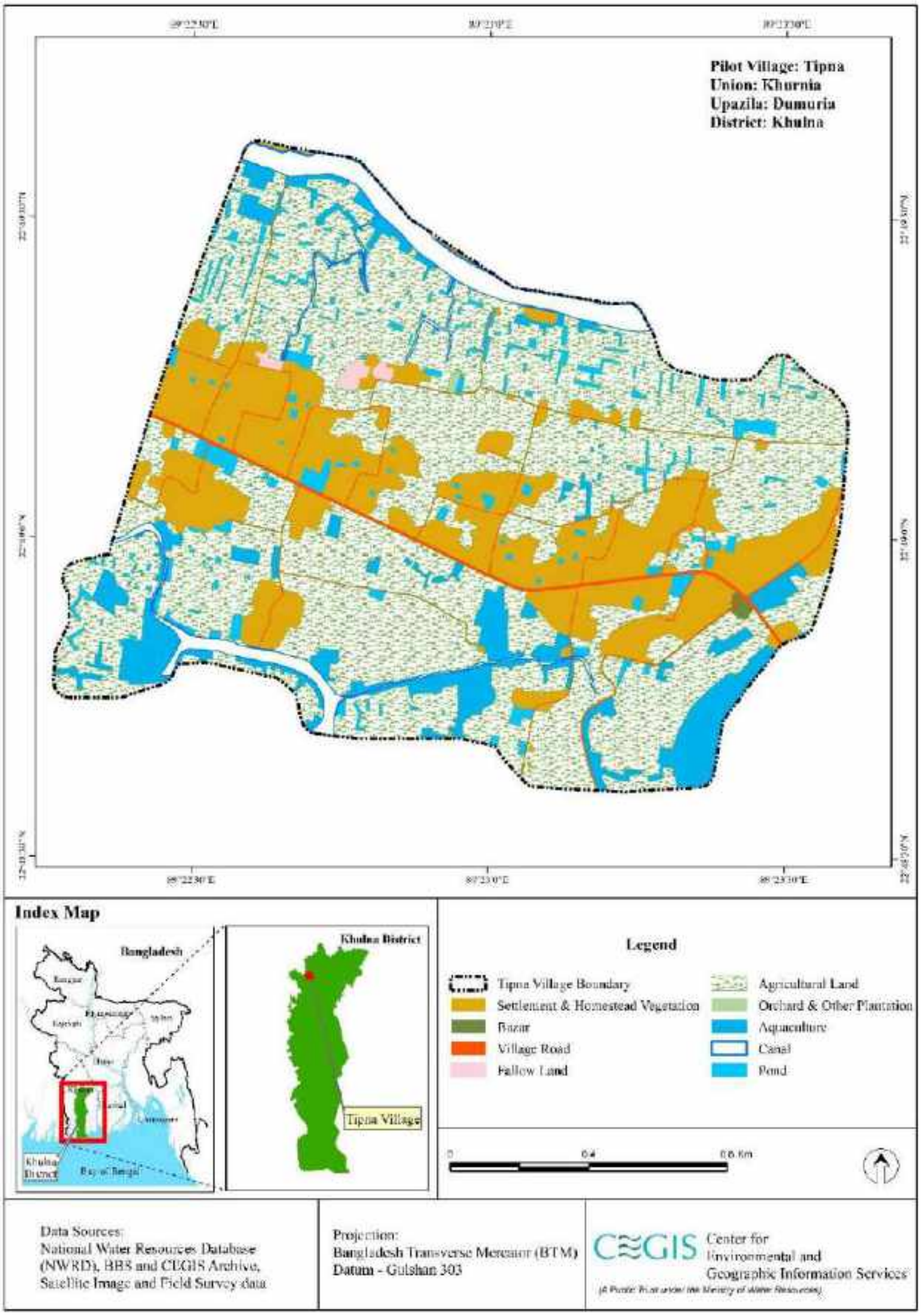


Figure 1.4: Land Use map of Tipna village

Pathordubi Village

Pathordubi village is located in the Pathordubi Union of Bhurungamari Upazila of Kurigram 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 disaster prone criterion. According to BBS, the village's total area is about 819 hectares (the village area will be verified during the census).

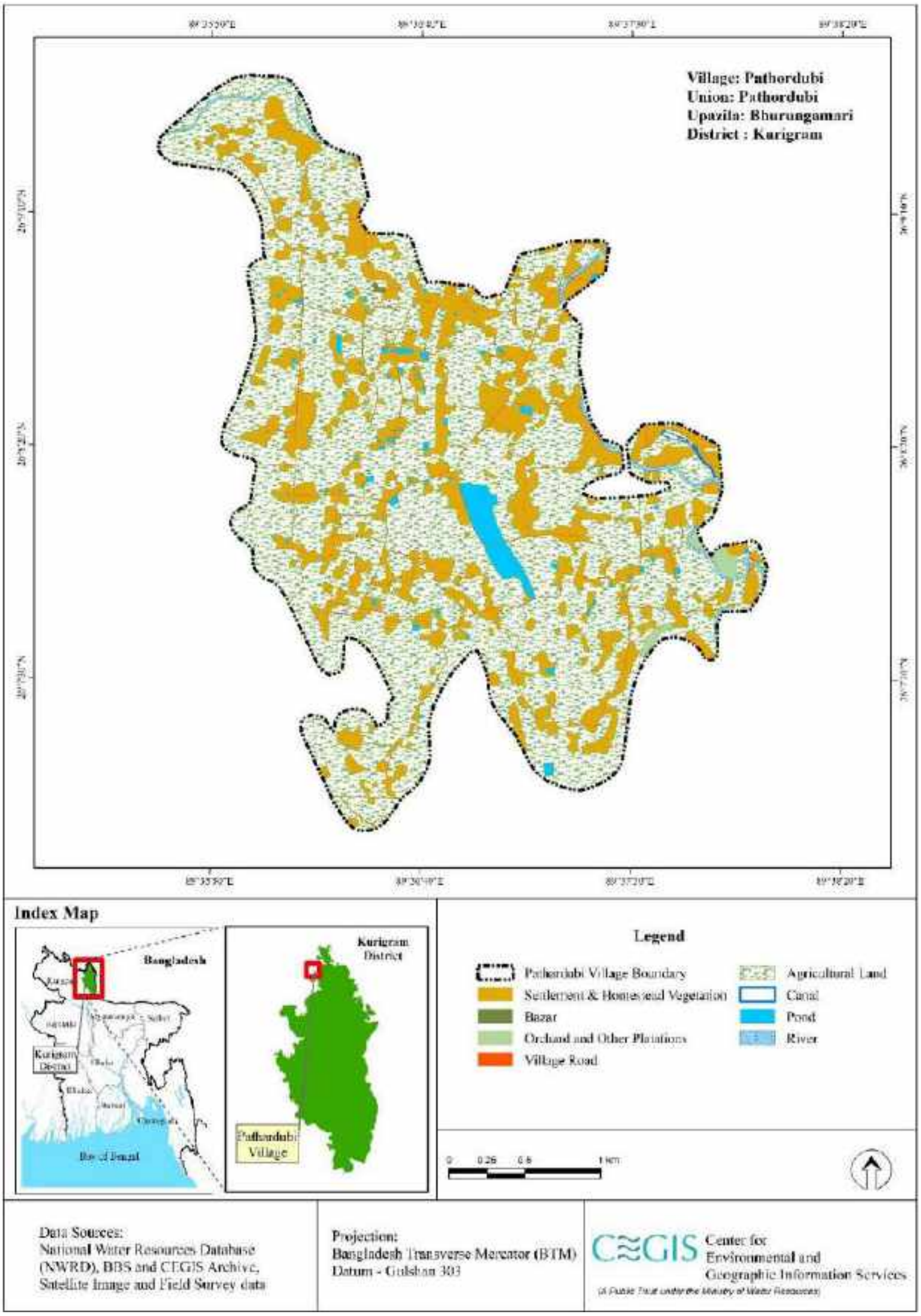


Figure 1.5: Land Use map of Pathordubi village

Datinakhali 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 the 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 village's total area is about 164 hectares.

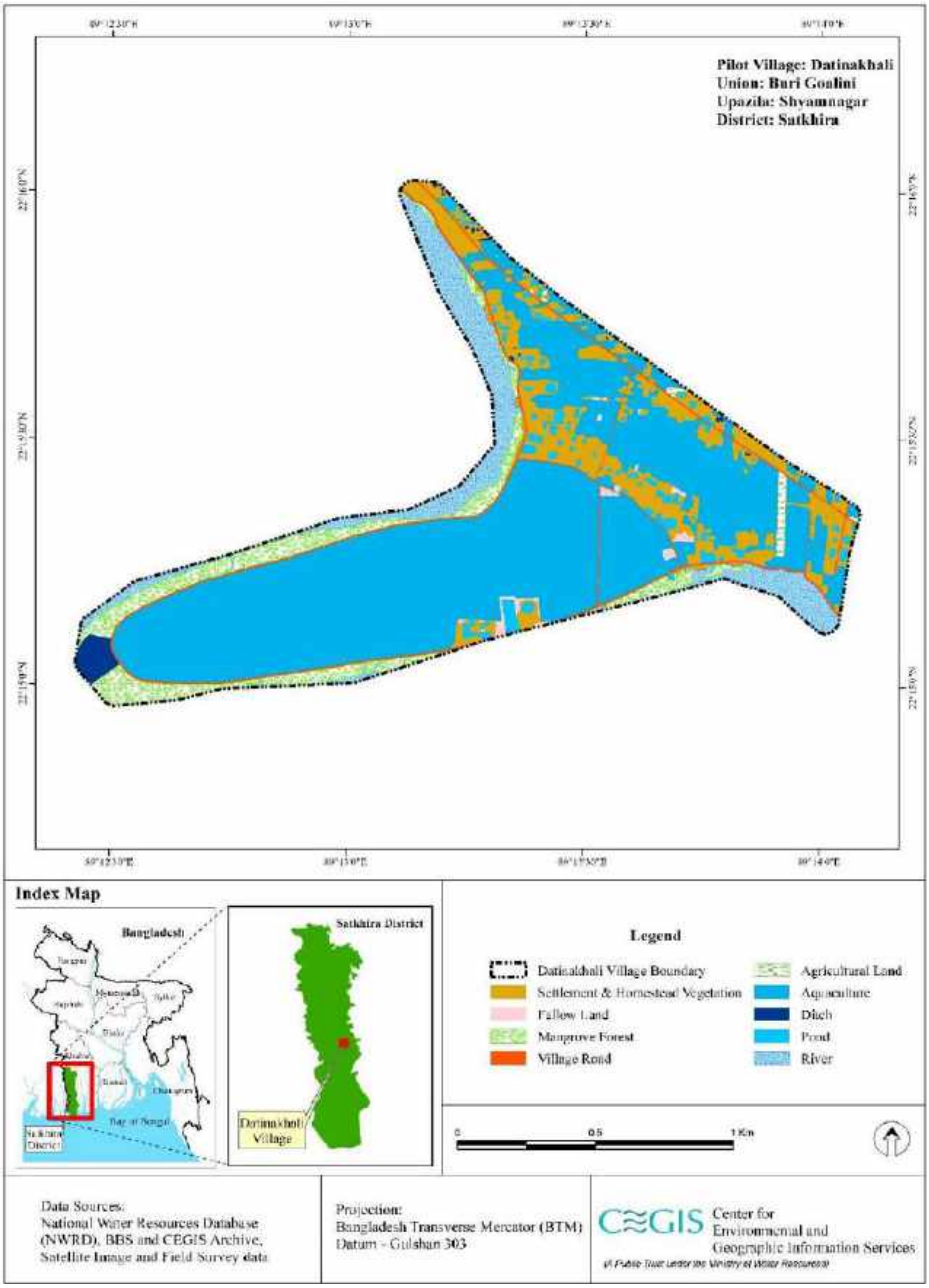


Figure 1.6: Land Use map of Datinakhali Village

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 the 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 village’s total area is about 218 hectares and about 2791 peoples in 665 households live in this village.

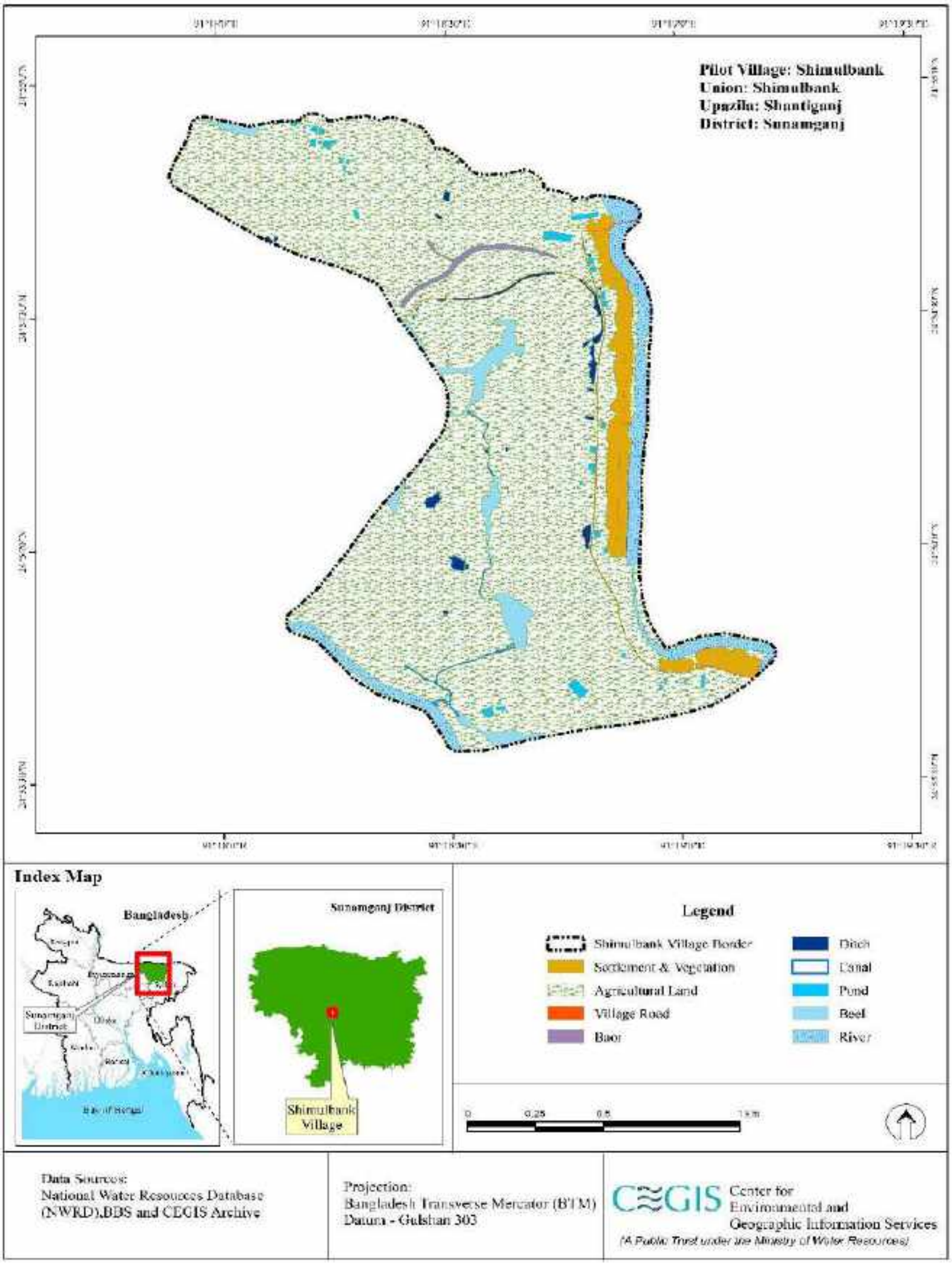


Figure 1.7: Land Use map of Shimulbank village

Bagaiya Village

Bagaiya village is located in Rustimpur Union of Gowainghat Upazila of Sylhet 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 Haor area criterion. According to BBS, the village’s total area is about 166 hectares .

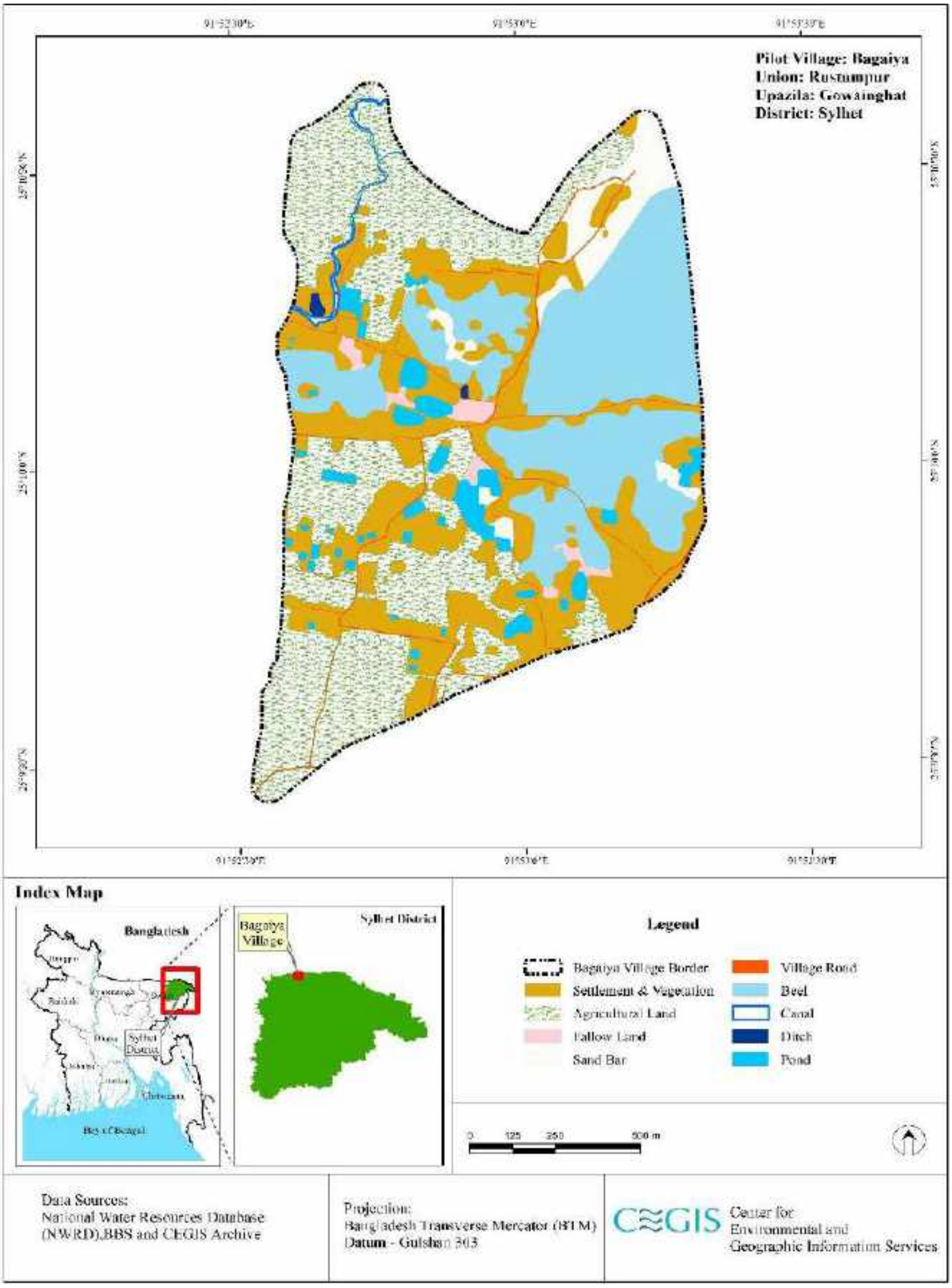


Figure 1.8: Land Use map of Bagaiya village

Charsharat Village

Charsharat village is located in Ichakhali Union of Mirsarai Upazila of Chattogram 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 south-east coastal criterion. According to BBS, the village's total area is about 967 hectares.

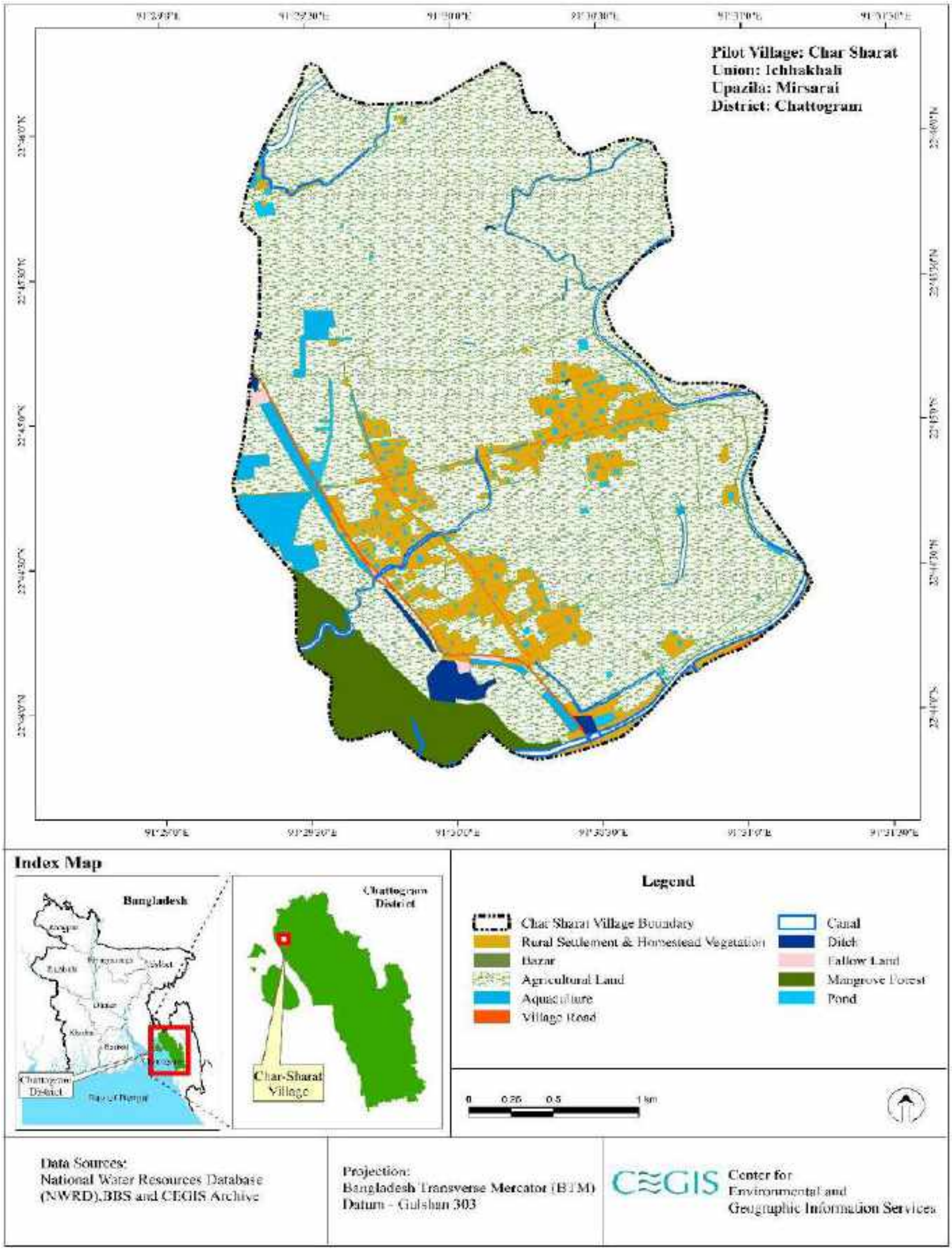


Figure 1.9: Land Use map of Charsharat village

1.3 The objective of the Project

The main objectives of conducting this feasibility study are to prepare access to safe piped water supply and sanitation services in select villages as follows: 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.**

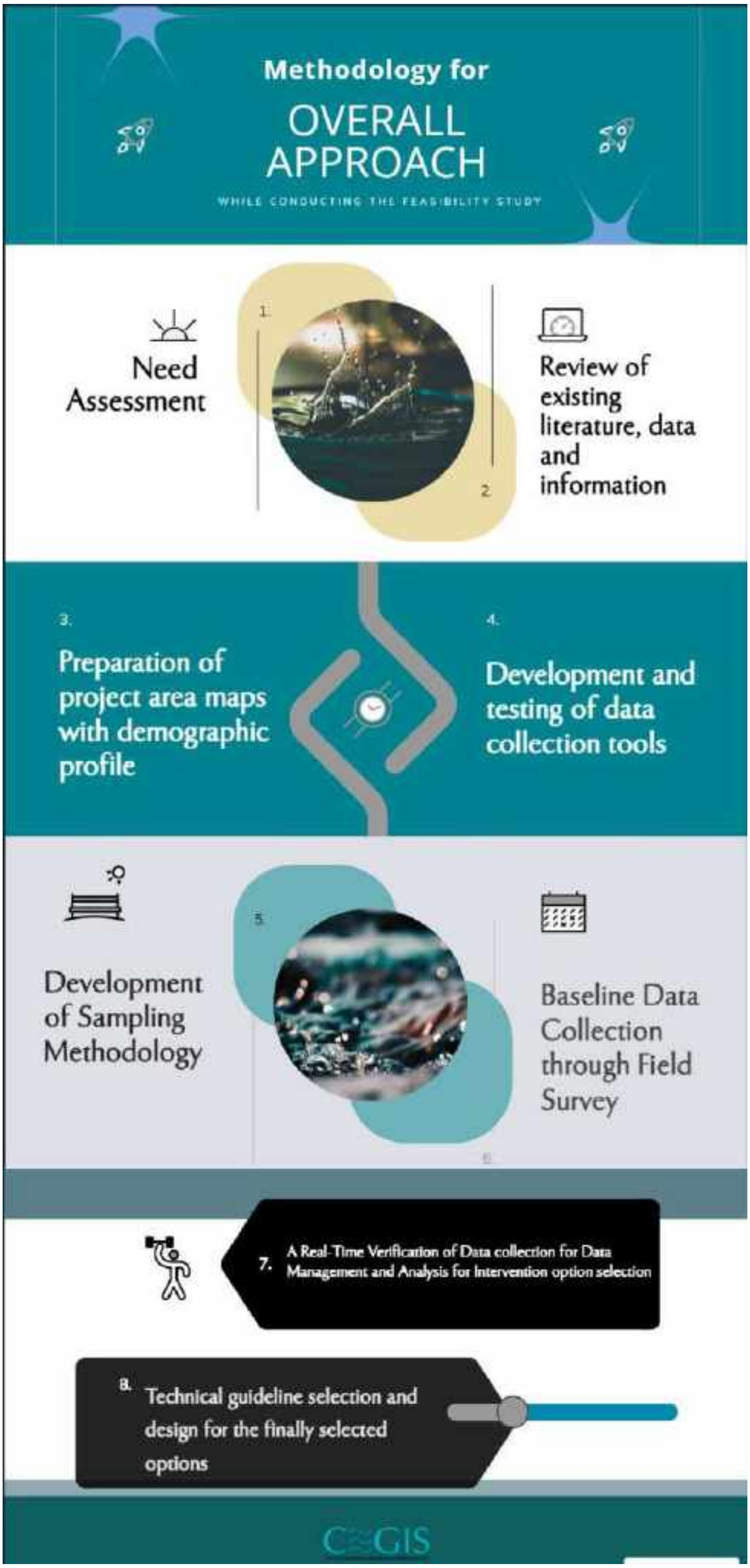


Figure 1.10: Flow diagram of the methodology

2. Existing WASH Status

2.1 WASH Analysis of Disater-prone Areas

Bangladesh is one of the most disaster-prone countries. Bangladesh is particularly vulnerable to several natural hazards, such as floods, droughts, cyclones, and earthquakes, due to its flat topography, low-lying environment, and socioeconomic environment. Every three years, the country is hit by a severe tropical cyclone, and about a quarter of the country is inundated with floodwaters. Bangladesh has made major efforts to lessen its vulnerability to natural disasters. Despite these attempts, climate change is making the coastal population more vulnerable. Besides, coastal zones are always deprived of many facilities because of their communication difficulties. The communication system in the study area is very poor. Water logging is a common occurrence here during the rainy season. In flood-prone areas, during a flood, water fully sinks the road. As a result, travel by road has been difficult. The only means of communication is through waterways, then. Some areas are still without power. Hence, these areas become detached from other areas and are deprived of many types of facilities. So, it is difficult to get clean drinking water for them. People are forced to live in unsanitary conditions due to a lack of drinking water, particularly during the pre-monsoon season, which hastens the deterioration of sanitation conditions. Moreover, most of the people are illiterate here. So they have less knowledge about sanitation and hygiene. For all these reasons, water supply, sanitation, and hygiene problems are common here. A comprehensive household survey is used to evaluate the current condition.

2.1.1 Water Supply

For the assessment of the water supply condition, some questions have been set. The following criteria have been discussed below:

Water sources in the Induria, Fulchari, Tipna, Pathordubi, and Datinakhali villages have been assessed qualitatively by the inventory survey through a questionnaire. For the assessment of the water sources in the villages, some specific criteria were defined in the questionnaire. The surveyors noted down the appropriate answer after consultation with the local people during the survey.

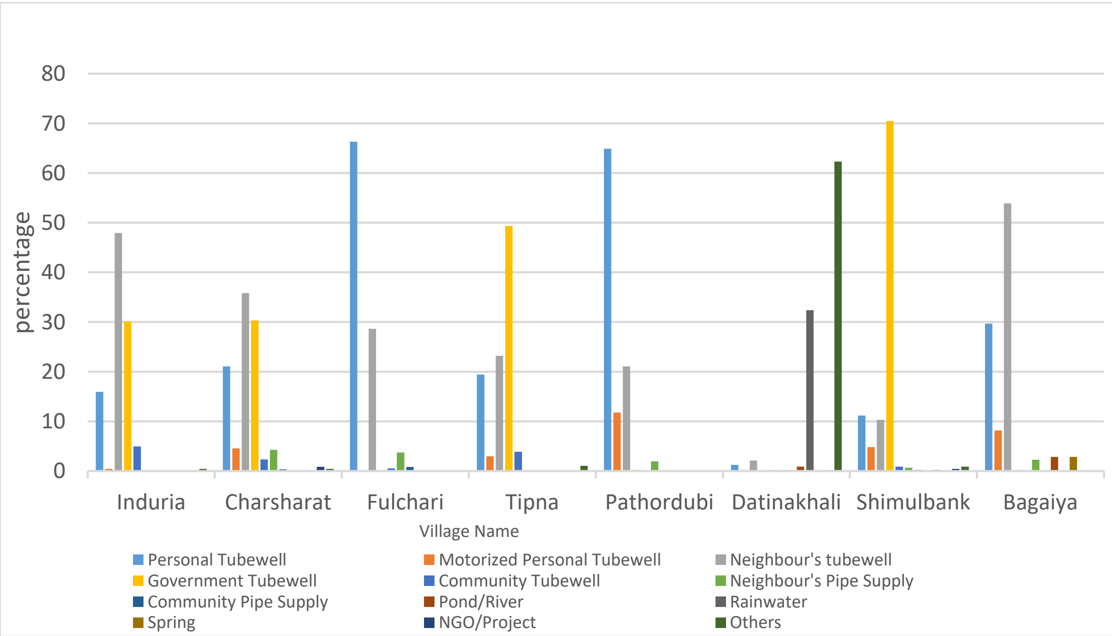


Figure 2.1: Percentage of water supply source percentage

Figure 2.1 shows that in Induria, most of the people use neighbor's tubewell. 47.94% of people use the tubewells of their neighbors. Apart from that, 30.08% of the people use government tubewell, and only 15.93% use personal tubewell. 0.41% use motorized personal tubewell. The use of community tubewell is 4.95%. Only 0.14% use community pipe supply and neighbor's pipe supply as a water source. 0.41% of people buy water for personal use. Tubewell is the main source of water at Induria. On the other hand, most of the people in Fulchari use personal tubewell. 66.31% people use personal tubewell in Fulchari. 25% of the people use neighbor's tubewell. There is no government tubewell here. 0.53% use community tubewell. 3.71% of the people manage their water from neighbor's pipe supply and 0.8% manage their water from community pipe supply. Tubewell is the main source of water here too. But the maximum tubewell is personal tubewell. Most of the people at Tipna use government tubewell. 49.35% use government tubewell in Tipna. 23.19% rely on a neighbor's tubewell. Only 19.43% use personal tubewell. 2.98% of the people use motorized personal tubewell. 3.89% of the people use community tubewell. 1.04% of the people buys water for drinking. Like Fulchari, most of the people at Pthordubi use personal tubewell. 64.88% use a personal tubewell. 21.06% rely on a neighbor's tubewell. In this case, the use of motorized personal tubewell water is notable. 11.79% of the people use motorized personal tubewell. 0.24% use government tubewell. 1.94% of people get their water from their neighbor's pipe supply. Very few people use pond or river water. In Datinakhali most of the people use other options, such as buying water bottles for drinking, taking water from NGO's, etc. Only 1.23% use personal tubewell. Motorized tubewells are extremely uncommon in Induria. Only 0.18% use motorized personal tubewell. 2.11% use neighbor's tubewell. 0.185% use government tubewell, community tubewell and community pipe supply. 88% of the people uses pond water. Rainwater use is noteworthy here. 32.39% use rainwater. At Shimulbank maximum water source is a government tubewell. About 70.46% of the people use government tubewell. Personal and neighbor tubewell are less important as a primary water source. At Bagaiya, the maximum water source is the neighbors' tubewell and the next noticeable water source is the personal tubewell. However, most people in Charsarat use their neighbors' tubewells as well as the government tubewell. Around 21.06% of the people uses personal tubewell.

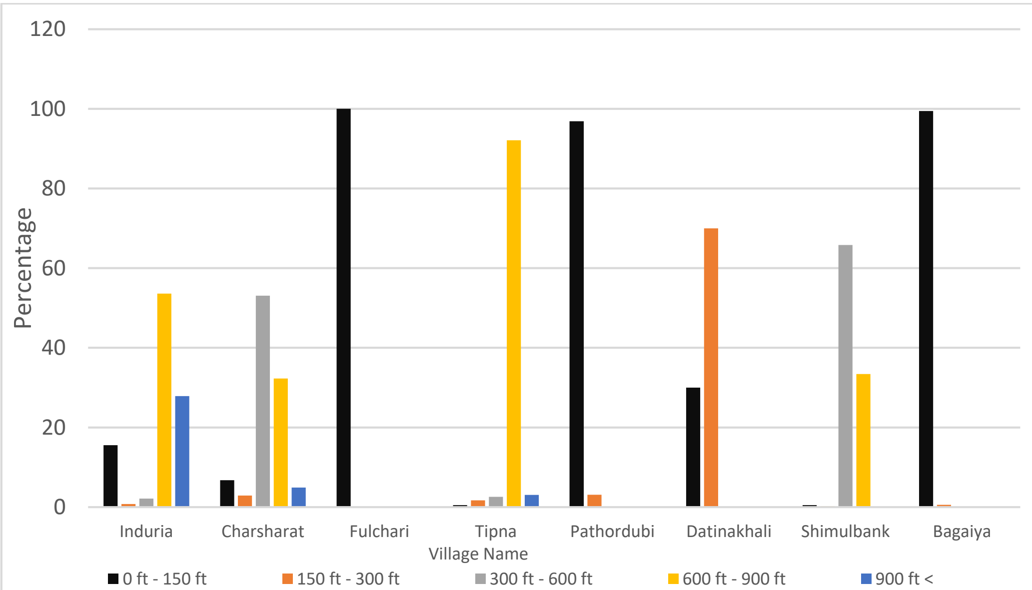


Figure 2.2: Percentage of depth of tubewell assessment

Figure 2.2 shows that most of the tubewell depth is in the range of 600–900 ft at Induria. This range contains 53.62% tubewell. 27.88% tubewell depth is over 900 ft. 15.55% tubwell lies between 0-150 ft. So, at Induria, the maximum tubewell is a deep tubewell, and a small portion is a shallow tubewell.

However, in Fulchari, all of the tubewells are between 0 and 150 feet deep. So groundwater can easily overflow here. The maximum tubewell is a shallow tubewell. In Tipna, 92.12% of the tubewell is located between 600 and 900 feet underground. So the maximum tubewell is a deep tubewell here. In Pathordubi, 96.89% of the tubewells are between 0 and 150 feet deep. Almost all the tubewells are shallow tubewells. Ground water has the potential to overflow. The 30% tubewell depth range at Datinakhali is 0-150 ft., and the 70% tubewell depth range is 150-300 ft. Two-thirds of the tubewells in this area are in the midrange, and one-third are shallow. The depth of the tubewell at Shimulbank ranges from 300 to 600 feet. So the maximum tubewell is deep tubewell. At Bagaiya, almost all tubewells are shallow tubewells. The depth varies from 0 to 150 ft. Ground water can easily leak out here. The maximum tubewell depth (53.1%) at Charsarat varies between 300 and 600 feet. Between 150 and 300 feet is the depth of 32.3% of tubewells. The maximum tubewell is in the intermediate range. A deep tubewell is also impressive.

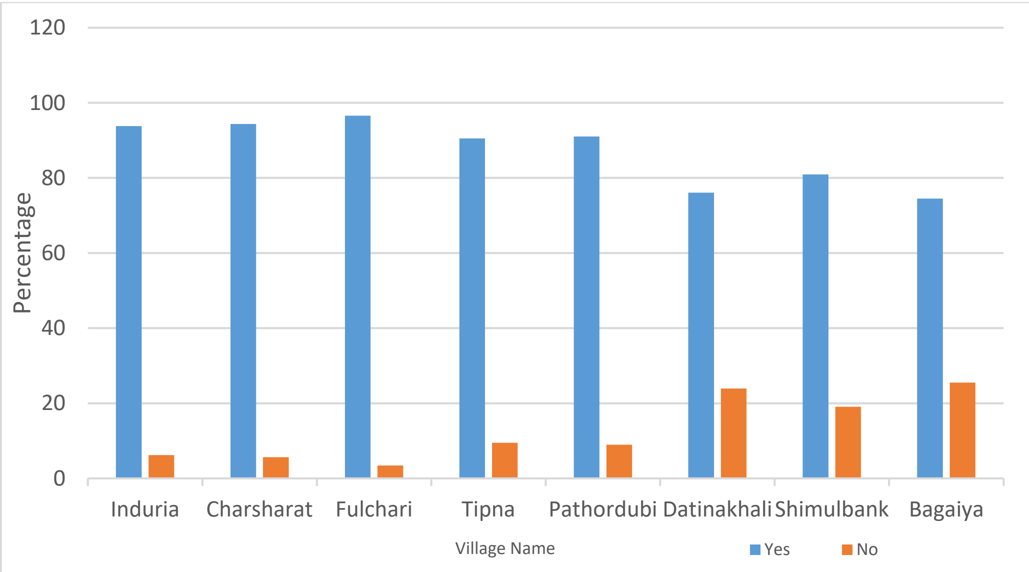


Figure 2.3: Percentage of water availability assessment

Figure 2.3 shows that most of the people in the villages agree that there is sufficient water available at the source. Among those villages, Datinakhali, Shimulbank, and Bagaiya have to face a comparatively high scarcity of water. Around 23.94% of Datinakhali, 19.05% of Shimulbank, and 25.52% of Bagaiya have to face a little bit of a water scarcity problem. Among these villages, Fulchari has the lowest level of water scarcity.

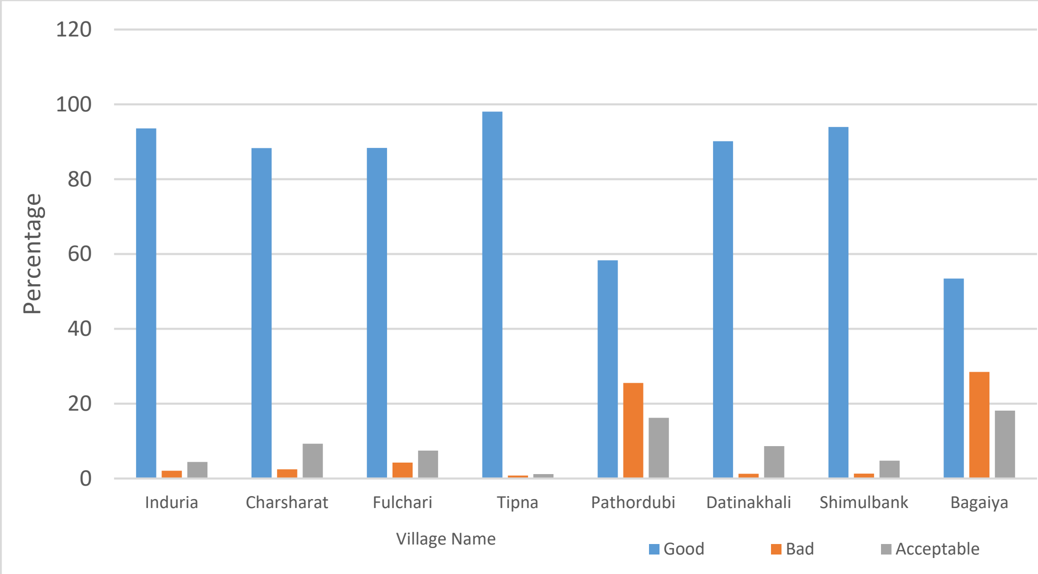


Figure 2.4: Percentage of water quality assessment

Figure 2.4 shows that in India, 93.54% of people believe the quality of water at the source is good, 2.06% believe it is poor, and 4.4% believe it is acceptable. As a result, the majority of people have favorable opinions. In Fulchari, 88.35% of the people agree that water quality is good, 4.24% say the water source is bad, and 7.43% say it is acceptable. In Tipna, 98.06% of the people say the water quality is good. Only 0.78% say it's bad, and 1.17 say it's acceptable. Pathordubi has a low percentage of high-quality water. 58.28% of the people agree that the water quality is good. 25.52% say the water quality is bad, while 16.2% say it is acceptable. But in Datinakhali, 90.14% say the water quality is good. 1.23% say it's bad, and 8.63% say it's acceptable. Most people in Shimulbank agree that the water quality is good. But at Bagaiya, only 53.42% of the people say the quality is good. A surprising number of people agreed that the quality was poor. As per the people's opinion, maximum water quality is good at Charsharat. Among these villages, a comparatively high percentage of bad-quality water has been found in Bagaiya and Pathordubi.

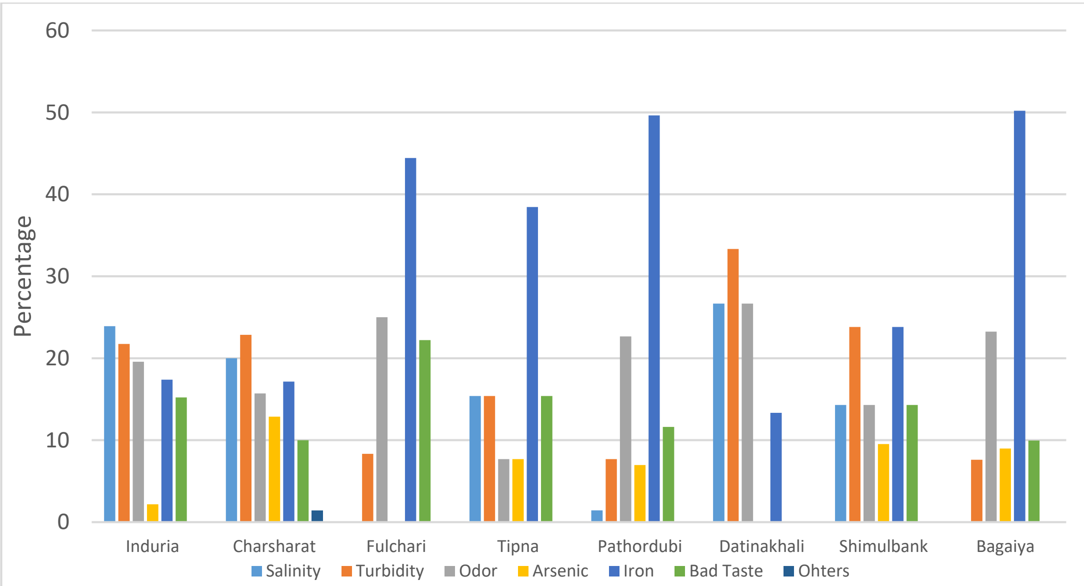


Figure 2.5: Water quality problem assessment

From the **Figure 2.5** it has been assessed that in Induria, various reasons are responsible for quality problems. Salinity, turbidity, odor, iron, and bad taste are the reasons behind this. Salinity issues are among the most serious. At Charsharat, the water is turbid and saline. Iron deficiency is another factor that contributes to poor water quality. But at Fulchari, the iron problem is severe. Odor has also found this remarkable. Water has a bad taste because of the presence of iron. At Tipna, the iron problem is severe, like in Fulchari. The iron problem is more serious at Pathordubi and Bagaiya too. The presence of iron at Bagaiya and Pathordubi has been attributed to approximately 50% of the reasons for the poor water quality. However, the main causes of poor water quality in Tipna are turbidity, salinity, and odor. Whereas at Shimulbank, the main reasons are turbidity and iron.

Water Supply (Tubewell) Coverage

Table 2.1: Village wise water coverage information for disaster prone areas

District	Village	Total HH	Total Population	Tubewell	Tubewell per person	Required Tubewell	Tubewell Demand	% of Demand	Coverage
Barishal	Induria	728	3392	119	28.50	339.2	220.2	65	35
Chattogram	Charsharat	941	4573	241	18.98	457.3	216.3	47	53
Gaibandha	Fulchari	377	1583	250	6.33	158.3	0.0	0	100
Khulna	Tipna	772	3270	173	18.90	327	154.0	47	53
Kurigram	Pathordubi	2469	10038	1893	5.30	1003.8	0.0	0	100
Satkhira	Datinakhali	568	2256	8	282.00	225.6	217.6	96	4
Sunamganj	Shimulbank	462	2629	73	36.01	262.9	189.9	72	28
Sylhet	Bagaiya	921	5399	348	15.51	539.9	191.9	36	64

The water coverage has been analyzed based on the present condition assessment of the disaster-prone area. According to **Figure 2-6**, the maximum water coverage is found at Fulchari and Pathordubi. They have 100% coverage, which indicates good water coverage. Water coverage is not good in other villages. The lowest water coverage has been found at Datinakhali, which is 4%. So, water coverage is very poor at Datinakhali.

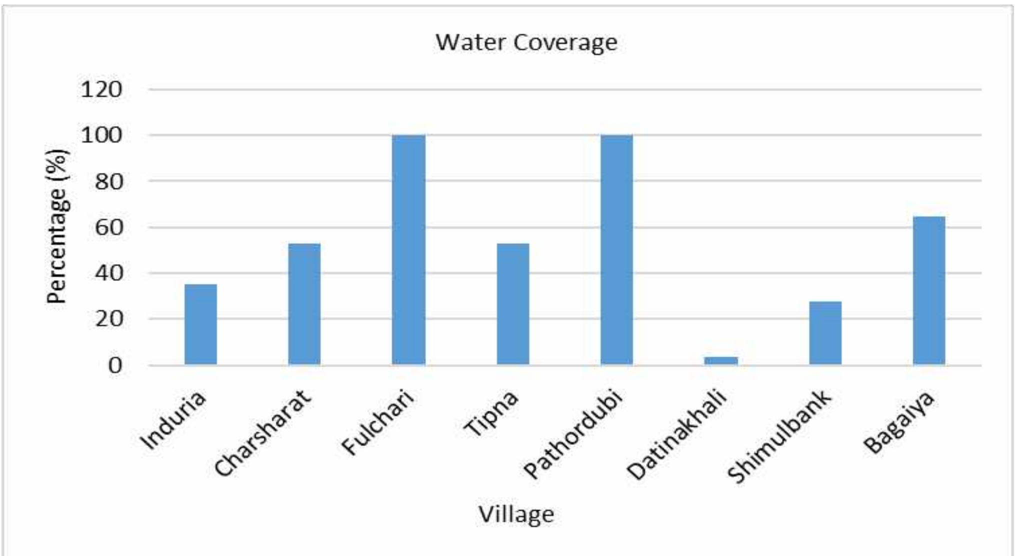


Figure 2.6: Water Supply Coverage of Disaster-Prone Area

2.1.2 Quality of Drinking Water

The term "drinking water quality" refers to the standard quality of water that is safe for human consumption. Some of the water quality parameters respond to the human senses of sight (turbidity, colour), taste (salty, offensive), and smell (odor).

For the assessment of drinking water quality, some criteria have been set. The following criteria have been discussed below.

The drinking water quality of the Induria, Fulchari, Tipna, Pathordubi, and Datinakhali villages has been assessed qualitatively by the inventory survey through a questionnaire. For the assessment of the drinking water quality of the villages, some specific criteria were defined in the questionnaire. The surveyors noted down the appropriate answer after consultation with the local people during the survey.

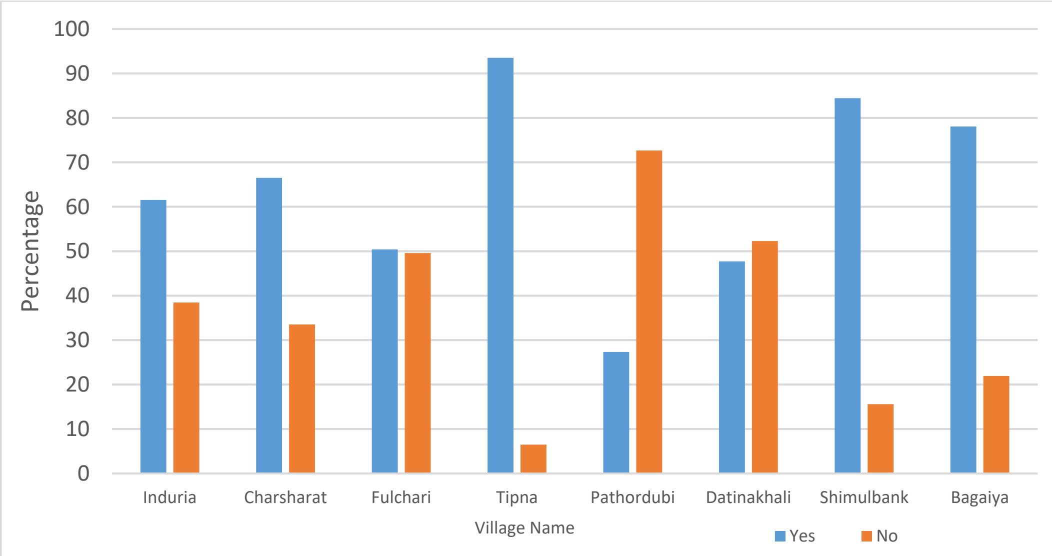


Figure 2.7: Arsenic test assessment

From the **Figure 2.7** it has been assessed that in Induria, 61.54% of the people say the water has an arsenic problem, and 38.46% disagree with the arsenic problem. But in Fulchari, half the people agrees with the arsenic problem and half does not. 50.4% agree with the problem, and 49.6% disagree. On the other hand, the arsenic problem is severe in Tipna. 93.52% of the people say that water has an arsenic problem. Only 6.48% disagree with the arsenic problem. Pathordubi, on the other hand, most people say water has no arsenic problem, which is 72.66%. And 27.34% of the people agree with the arsenic problem. In Datinakhali, 47.71% agree that there is an arsenic problem, while 52.29% disagree. That means there is a severe problem with arsenic here. At Charsharat, a remarkable percentage of arsenic pollution has been seen. But at Shimulbank and Bagaiya, the arsenic problem is moderate. But the arsenic problem has been assessed here..

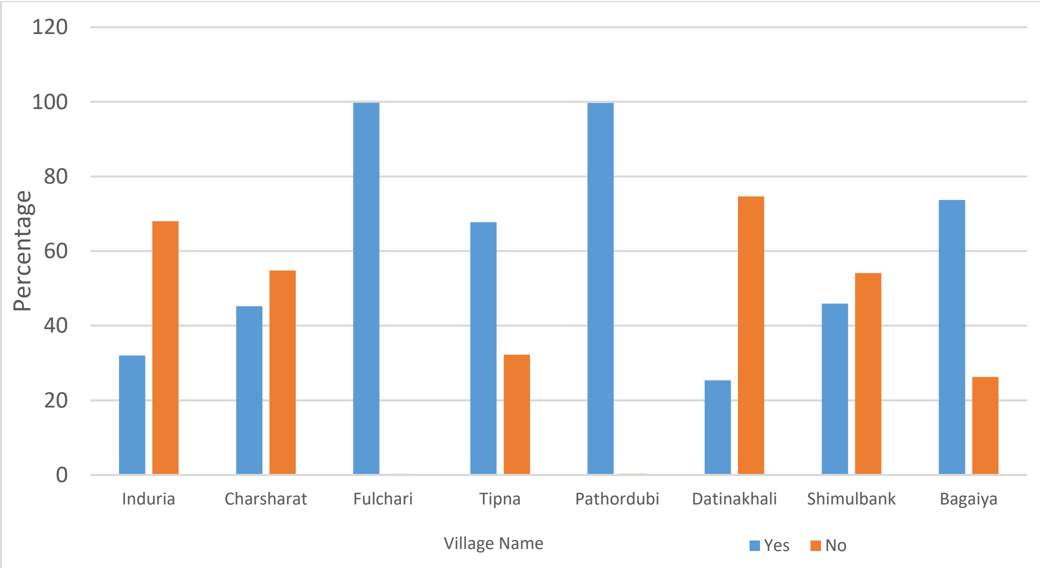


Figure 2.8: Variation in water Source assessment

From the **Figure 2.8** it has been assessed that 32.01% of people in Induria use the same water source for drinking and housework, while 67.99% use a different source. In Fulchari, however, 99.73% of people use the same source for drinking and housework. Only 0.27% of people use a different source. In Tipna, 67.75% use the same source, while 32.25% use a different source. In Pathordubi, 99.68% use the same water source, and 0.32% use a different source. However, in Datinakhali, 25.35 percent use the same source while 74.6 percent use a different source. At Charsharat and Shimulbank, most people use different water sources for drinking and other purposes. However, most people in Bagaiya use the same source. Among these villages, most of the people of Fulchari, Tipna, Bagaiya, and Pathordubi use the same water source for drinking and housework purposes. On the other hand, in Induria, Charsharat, Shimulbank, and Datinakhali, most people use different sources.

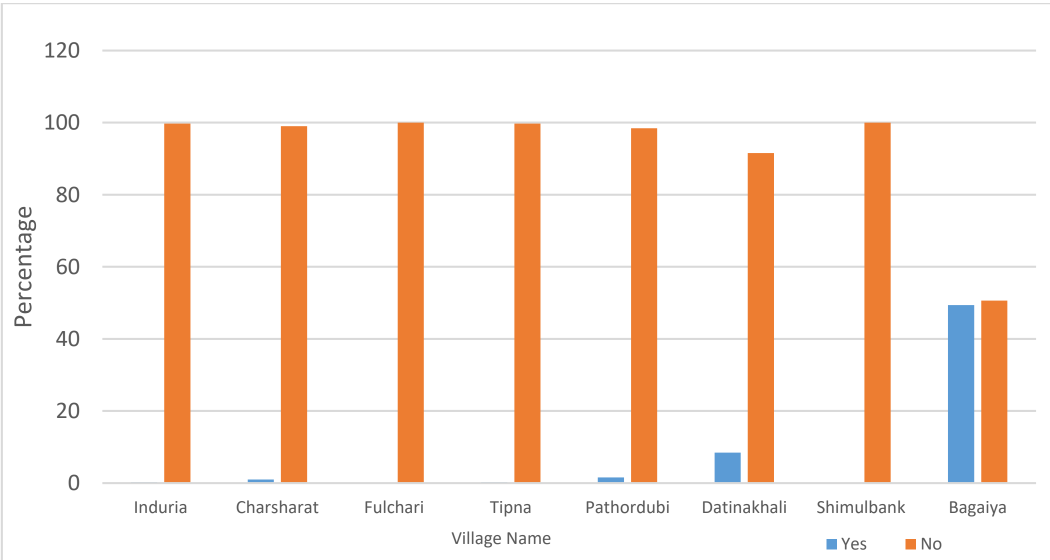


Figure 2.9: Water purification assessment

From **Figure 2.9,** it has been assessed that most of the people do not purify their water in all the villages except Bagaiya. A remarkable percentage has been found to purify their water. The reason could be that the water quality is poor. Around 50% of people need to purify their water.

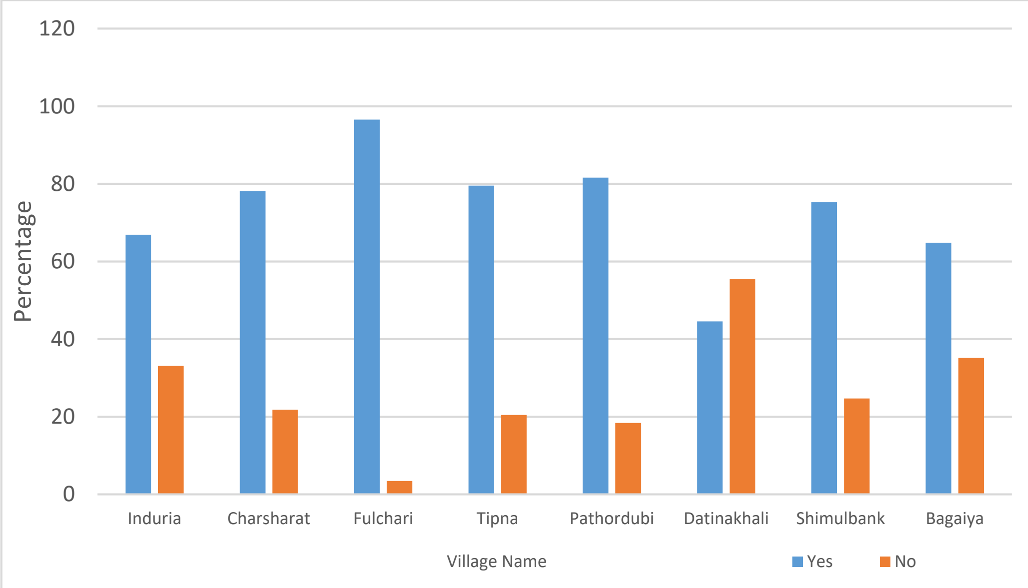


Figure 2.10: Water availability assessment

From the data presented in **Figure 2.10 it has been assessed that** 66.9% of people agree that there is sufficient water available in Induria. 33.1% face scarcity of water. But in Fulchari, 96.55% do not face any scarcity of water, and 3.45% do not get sufficient water. So, the availability of water sources is quite good in Fulchari. In Charsharat, 78% of people have enough water; only 22% do not. In Tipna, 79.53% get enough water, but 20.47% do not get sufficient water. In Pathordubi, 81.61% get sufficient water, but 18.39% do not get sufficient water. But in Datinakhali, there is huge scarcity. Most people do not get sufficient water. 44.54% of the people do not face water scarcity, but 55.46% do not get sufficient water. Among all these villages, Datinakhali has to face a huge scarcity of water. Bagaiya also has a significant water scarcity issue. Around 35% of people do not get sufficient water. Among these villages, there is a huge scarcity problem in Datinakhali, followed by Bagaiya, Induria, and Shimulbank. Fulchari has to face the minimum percentage of water scarcity.

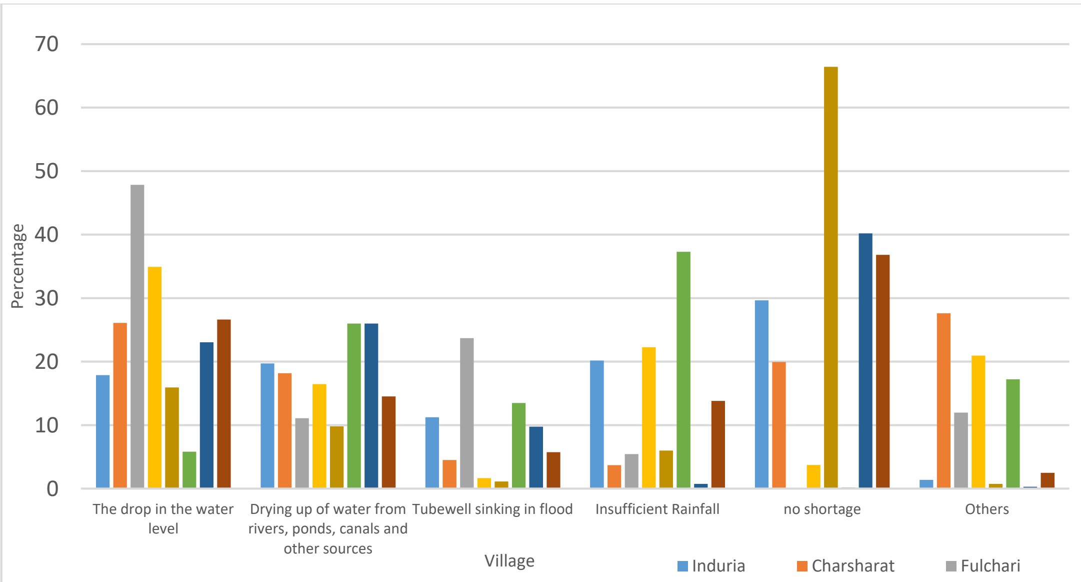


Figure 2.11: Water shortage reason assessment

Figure 2.11 reveals that the causes of water scarcity in rural areas are varied. Reasons for this include a decrease in rainfall and the drying up of water sources such as rivers, ponds, canals, and other bodies of water in the research area. Other reasons have also contributed to the water shortage. The lack of water from their tube wells could have a significant effect on the villagers, especially those who must drink contaminated water at those times. Since the water table drops and the ponds and lakes dry up between February and May, this makes finding potable water in rural areas difficult.

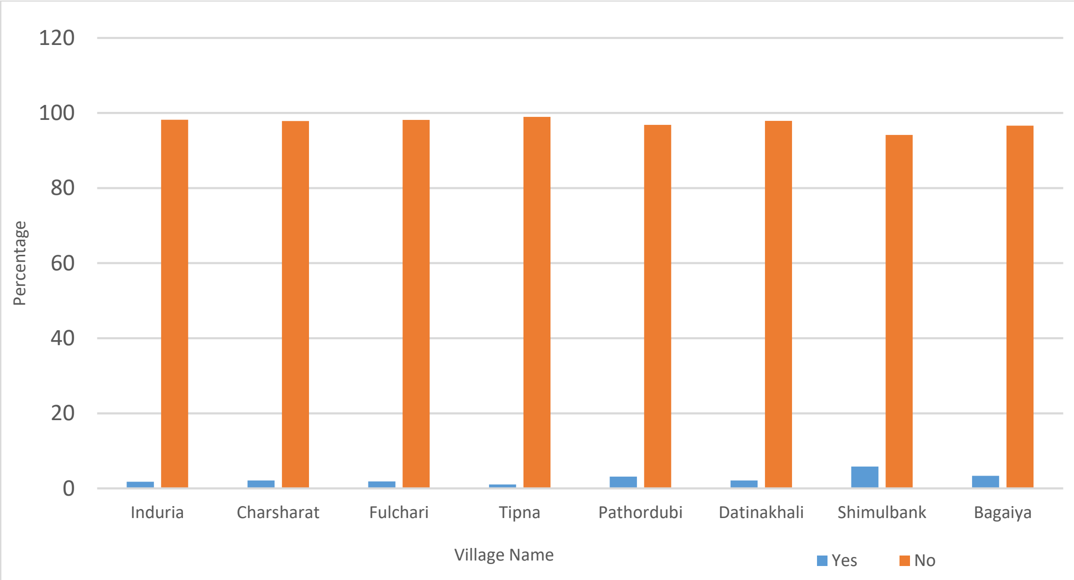


Figure 2.12: Pipe supply availability

Based on the data presented in **Figure 2.12**, it has been determined that the amount of piped water supply that is available here is not particularly exceptional. Piped water is available to only a small percentage of the population. The highest number, 5.84 percent, has been found in Shimulbank; nonetheless, this is still a very small amount. It's possible that there isn't the right facility for the pipe water supply.

The CEGIS team conducted a survey of the eight villages and collected water samples from the GW and SW in each of the surveyed villages. In the environment laboratory here at CEGIS, those water samples have been analyzed. The following table presents the results of a laboratory tasting of drinking water's quality.

Table 2.2: Sample water quality at Bagaiya

Water Quality Perameter	Concentration Present			Bangladeshi Standard
	GW	SW		
	GW 03	SW 01	SW 02	
Arsenic (AS) ppb	50	-	-	50
Iron (Fe) ppm	-	-	-	0.3 -1.0
fluoride (F -) ppm	0.14	-	-	1
Electrical Conductivity (EC) µS/cm	221.2	96.7	34.2	-
Total Dissolved Solid (TDS) mg/L	110.6	47.8	17.1	1000
Dissolved OxyGen (DO) mg/L	6.66	0.97	6.73	6
Salinity, ppt	0.03	0	0	-
pH	7.75	7.27	7.36	6.5 - 8.5
Turbidity (TURB),NTU	4.51	52.3	3.96	10

From the village of Bagaiya three water samples have been collected to test the quality of water.One of them is ground water and other two is surface water. The quality parameters of ground water are found in standard quality. From the **Table 2.2** we can see turbidity has been found in SW 01. Also the Do is very much less than standard value. Do level has been found 0.97 mg/L Most fish and other aerobic aquatic organisms die when DO levels fall below the critical level of 3 mg/L. In this context the survival of fish and other aerobic aquatic biota is not possible. But, no bad quality has been found in other two samples.

Table 2.3: Sample water quality at Charsharat

Water Quality Perameter	Concentration Present		Bangladeshi Standard
	Sw		
	SW 01	SW 02	
Iron (Fe) ppm	-	-	.3 -1.0
fluoride (F -) ppm			1
Electrical Conductivity (EC) µS/cm	1504	982	-
Total Dissolved Solid (TDS) mg/L	752	491	1000
Dissolved OxyGen (DO) mg/L	3.5	4.7	6
Salinity, ppt	0.72	0.43	-
pH	6.8	7.02	6.5 - 8.5

From the following **Table 2.3,** we can see a little bit of salinity has been present in the water and the DO level is less than the standard value. Do level of SW 01 is in a critical condition. Below this range, most fish and other aerobic aquatic organisms die. So the DO level is not at satisfaction level here. The other sample also has the Do level less than standard value. It is difficult for fish and other aerobic aquatic organisms.

Table 2.4: Sample water quality at Fulchari

Water Quality Parameter	Concentration Percent					Bangladeshi Standard
	GW					
	GW 01	GW 02	GW 03	GW 04	GW 05	
Arsenic (AS) ppb	0	0	0	0	0	50
Iron (Fe) ppm	-	-	-	0.5999	-	.3 -1.0
fluoride (F -) ppm	0.3391	0.3729	0.0161	0.2077	0.2788	1
Electrical Conductivity (EC) µS/cm	1441	938	825	729	1094	-
Total Dissolved Solid (TDS) mg/L	741	469	413	365	547	1000
Dissolved Oxygen (DO) mg/L	6.4	6.16	6.2	6.88	6.52	6
Salinity, ppt	0.68	0.41	0.35	0.3	0.49	-
pH	7.08	7.18	7.25	7.3	7.24	6.5 - 8.5
Turbidity (TURB),NTU	1.79	0.595	2.42	25.3	0.45	10

From **Table 2.4,** we can see that a little bit of salinity is present in all the water samples. Only GW 04 has a turbidity issue. But all the samples are good quality water.

Table 2.5: Sample water quality at Induria

Water Quality Parameter	Concentration Present		Bangladeshi Standard
	GW	SW	
	GW 04	SW 01	
Arsenic (AS) ppb	0		50
Iron (Fe) ppm	-		.3 -1.0
fluoride (F -) ppm	0.2578		1
Electrical Conductivity (EC) µS/cm	785	514	-
Total Dissolved Solid (TDS) mg/L	392	257	1000
Dissolved Oxygen (DO) mg/L	6.59	4.9	6
Salinity, ppt	0.33	0.18	-
pH	7.61	7.64	6.5 - 8.5
Turbidity (TURB),NTU	0.312	96.2	10

From the following **Table 2.5,** it has been assessed that the SW 01 is highly turbid. This means there are so many particles present in water. In addition, the DO level is slightly lower than the standard value. As a result, the environment is a little bit harsh for fish and other aerobic aquatic organisms.

Table 2.6: Sample water quality of Tipna

Water Quality Parameter	Concentration Present						
	GW					SW	
	DT	ST	DT (Primary School)	DT (Village Market)	DT (Tipna)	Pachura River	Singa River
Arsenic (AS) ppb	0	0	0	0	25		
Iron (Fe) ppm	-	0.434	-	-	-	-	-
fluoride (F -) ppm	0.1	0.1305	0.1623	-	-	-	-
Electrical Conductivity (EC) µS/cm	755	3030	708	713	3100	8230	7600
Total Dissolved Solid (TDS) mg/L	377	1520	354	356	1550	4120	3800
Dissolved OxyGen (DO) mg/L	-	-	0.29	-	-	1.8	5.95
Salinity, ppt	0.31	1.55	0.29	0.29	1.59	4.54	4
pH	7.52	7.24	7.59	7.71	7.26	7.2	7.67

From **Table 2.6,** we have found that the electrical conductivity of water samples ST, DT (Tipna), Pachura River, and Singa River is high. That means the sodium concentration is high. Almost all of the samples are saline. The water samples are saline. The DO value of DT (primary school) in Pachua River is insufficient. However, the DO level in the Sigra River is acceptable.

Table 2.7: Sample water quality of Shimulbank

Water Quality Parameter	Concentration Percent			
	GW			SW
	DT 01	DT 02	DT 03	SW 01
Arsenic (AS) ppb	200	200	200	-
Iron (Fe) ppm	0.3766	0.3609	0.6835	-
fluoride (F -) ppm	1.0933	1.6492	1.2267	-
Electrical Conductivity (EC) µS/cm	749	720	738	34.7
Total Dissolved Solid (TDS) mg/L	374	360	369	17.4
Dissolved Oxygen (DO) mg/L	0.45	0.45	3.71	4.6
Salinity, ppt	0.31	0.29	0.3	0
pH	7.5	7.6	7.54.463	7.7
Turbidity (TURB),NTU	3.07	1.57	1.41	10.8

From the following **Table 2.7,** it can be said that the presence of fluoride is high in all the groundwater samples. Dissolved oxygen is not at an acceptable level in the surface water. The value of the DO level in SW01 was discovered to be 4.6 mg/L. In this context, the survival of fish and other aerobic aquatic biota is not possible.

Table 2.8: Sample water quality of Datinakhali

Water Quality Parameter	Concentration Percent	
	GW	SW
	DT 01	SW 01
Arsenic (AS) ppb	0	-
Iron (Fe) ppm	-	-
fluoride (F -) ppm	0.3743	-
Flectrical Conductivity (EC) µS/cm	820	24.5
Total Dissolved Solid (TDS) mg/L	410	12.2
Dissolved OxyGen (DO) mg/L	6.74	6.91
Salinity, ppt	0.35	14.85
pH	6.86	6.67
Turbidity (TURB),NTU	7.15	102

From **Table 2.8**, it can be said that the SW 01 sample is highly saline water. Moreover, it is highly turbid water. There are too many particles present in the water sample SW 01, but there is no problem found in sample DT 01.

Table 2.9: sample water quality of Pathordubi

Water Quality Parameter	Concentration Percent				
	GW				SW
	GW 01	GW 02	GW 03	GW 04	SW 01
Arsenic (AS) ppb	0	0	0	0	-
Iron (Fe) ppm	-	-	-	0.2041	-
fluoride (F -) ppm	0.1393	0.7954	0.6891	0.5402	-
Flectrical Conductivity (EC) µS/cm	362	365	336	410	77.3
Total Dissolved Solid (TDS) mg/L	181	182	168	205	38.7
Dissolved OxyGen (DO) mg/L	6.16	6.13	6.28	6.2	6.58
Salinity, ppt	0.1	0.1	0.09	0.13	0
pH	7.49	7.13	7.24	7.29	7.6
Turbidity (TURB),NTU	1.54	2.51	0.904	18.1	31.8

From the **Table 2.9** we can see among the sample water GW 04 and SW 01 has the turbidity problem. That means a high percentage of particles present in water samples.

2.1.3 Sanitation Condition

For the assessment of sanitation conditions, some criteria have been set. The following criteria have been discussed below.

The sanitation condition of the Induria, Fulchari, Tipna, Pathordubi, and Datinakhali villages has been assessed qualitatively by the inventory survey through a questionnaire. For the assessment of the sanitation condition of the villages, some specific criteria were defined in the questionnaire. The surveyors noted down the appropriate answer after consultation with the local people during the survey.

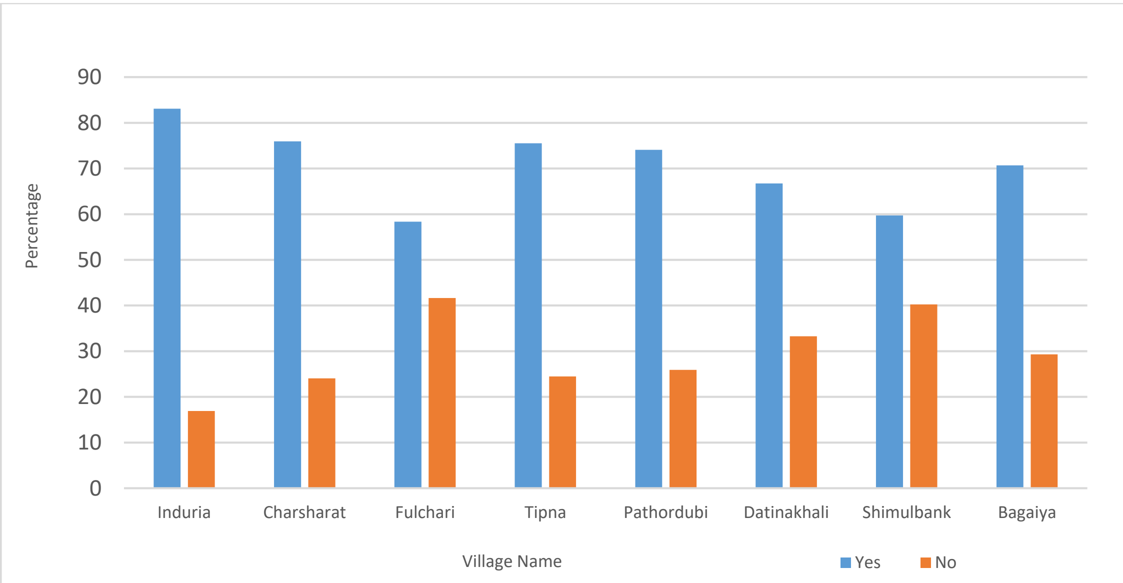


Figure 2.13: Toilet availability assessment

From **Figure 2.13**, we can see toilet availability isn't remarkable in these villages. Fulchari and Simulbank have the worst scenario in terms of toilet availability. In Fulchari, 41.64%, and in Shimulbank, 40.26% people do not own toilets. So overall, sanitation conditions are bad here. Besides that, a noticeable percentage of people in Charsarat (24.04%), Tipna (24.48%), Pathordubi (25.92%), Datinakhali (33.27%), and Bagaiya (29.32%) do not occupy toilets. But in Induria a remarkable percentage (83.1%) of people have their own toilet, though the percentage needs to be increased.

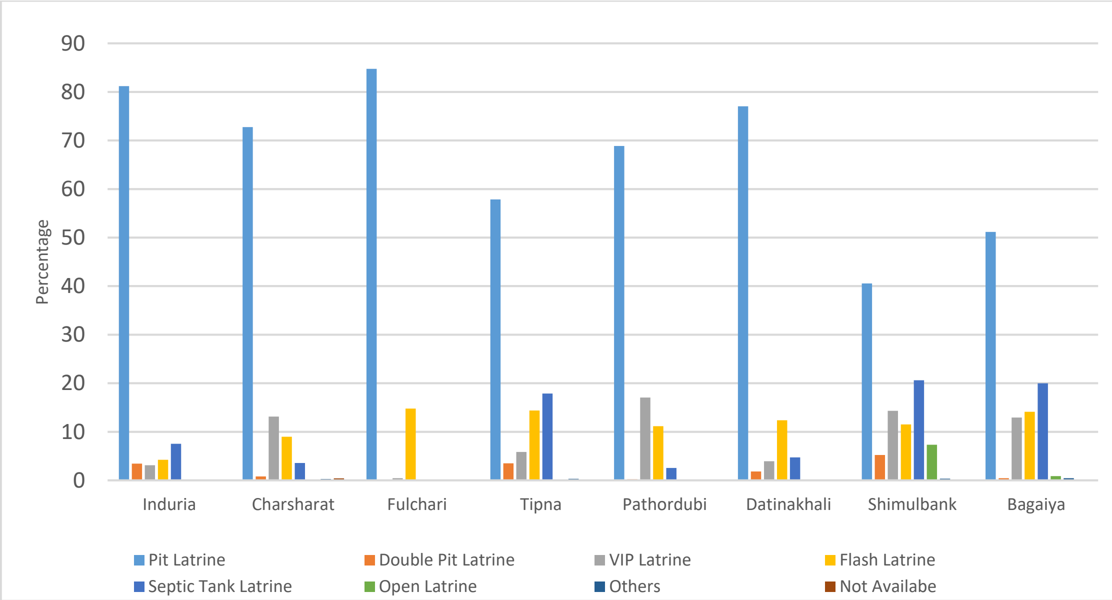


Figure 2.14: Toilet type assessment

Figure 2.14 shows that pit latrines are the most common type of toilet in all villages. The percentage has been found to be around 70 in Fulchari, Induria, Charsharat, Pathordubi, and Datinakhali. The rest are below 70%. The lowest percentage has been found at Shimulbank and the highest value has been found at Fulchari. Around 20% of people use septic tank latrines at Tipna, Bagaiya, and Shimulbank. Around 12% of people use flash latrines in all villages except induria and Charsharat. 13.14% of Charsharat, 17.07% of Pathordubi, 14.34% of Shimulbank, and 12.94% of Bagaiya have the vip latrine. The other villages do not have remarkable VIP latrines.

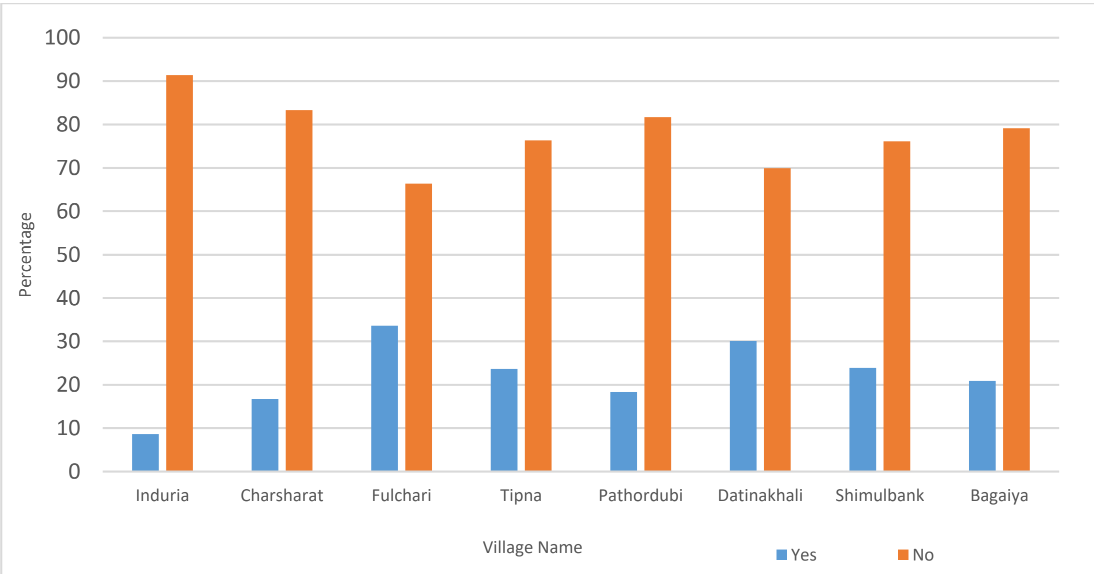


Figure 2.15: Percentage of using other household toilet assessment

Figure 2.15 demonstrates that the majority of individuals do not utilize the bathrooms of other families. At Fulchari (33.64%) and Datinakhali (30.08%), the use of alternative family toilets is very high. Tipna (23.67%), Charsharat (16.67%), Pathordubi (18.32%), Shimulbank (23.91%), and Bagaiya (20.89%) have also yielded notable quantities. In Induria, the lowest percentage was found (8.6%). The situation is fairly satisfactory in Induria.

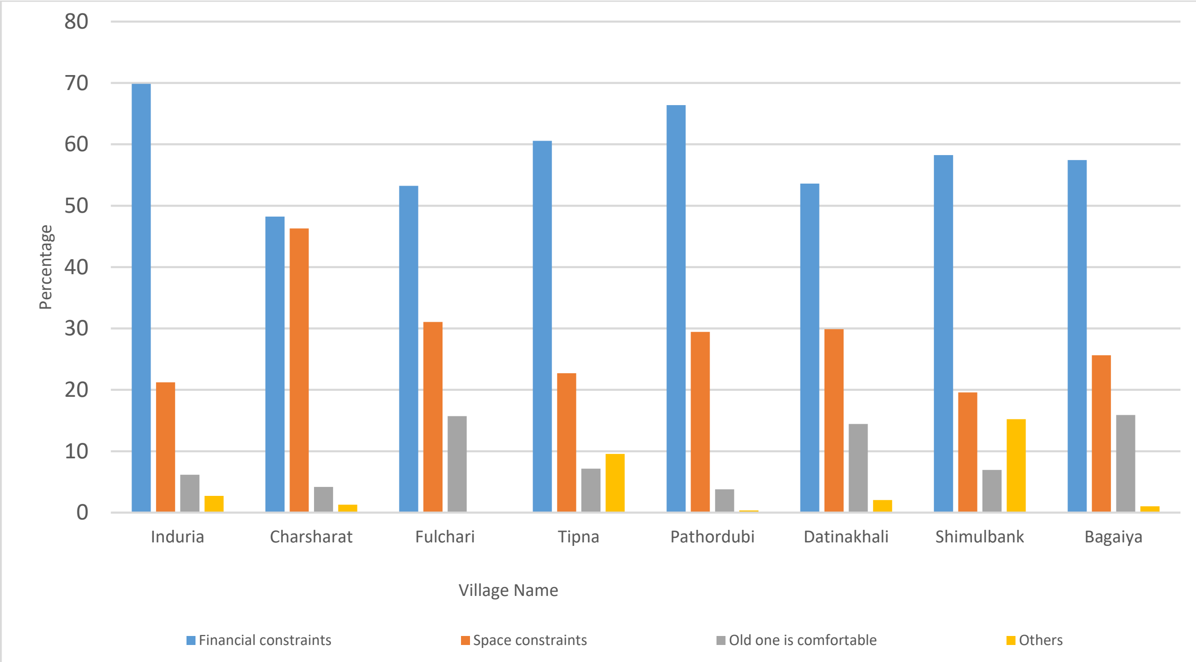


Figure 2.16: Requirement of toilet construction assessment

Figure 2.16 shows that The main reasons for not having a toilet have been identified as financial constraints, space constraints, and the current state of comfortability. Due to the financial crisis, 69.86% of people of Induria are unable to construct a toilet. 21.23% can't afford a toilet due to space constraints. 6.16% don't make a toilet due to the comfortability of the present condition. 2.74% can't make a toilet for some other reason. In Fulchari, 53.23 percent of people can't afford a toilet due to the financial crisis. There is a lack of space in 31.05% of the cases. 15.73% don't make a toilet due to the comfortability of the present condition. In Tipna, 60.56% of the people can't make a toilet due to the financial crisis. 22.71% can't afford a toilet due to lack of space. 7.17% don't make a toilet due to the comfortability of the present condition. 9.56% can't make a toilet for some other reason. In Pathordubi, 66.4% of the people can't make a toilet due to the financial crisis. 29.45% can't afford a toilet due to lack of space. 3.18% don't make a toilet due to the comfortability of the present condition. In Datinakhali, 53.61 percent of the people can't make a toilet due to the financial crisis. Due to a lack of space, 29.9% of people cannot afford a toilet. 14.43% don't make a toilet due to the comfortability of the present condition. 2.06% can't make a toilet for some other reason. The main causes of not having toilets are financial constraints at Charsharat, Shimulbank, and Bagaiya too. Around 58% of people at Shimulbank and Bagaiya and 48.23% at Charsharat can not afford to make a toilet. Besides, space constraints are also a major problem for not using toilet. At Charsarat (46.3%), the value has been found to be remarkable. Some of the people do not construct toilets because they are comfortable with the old ones. Financial constraints are the main reason in all the villages.

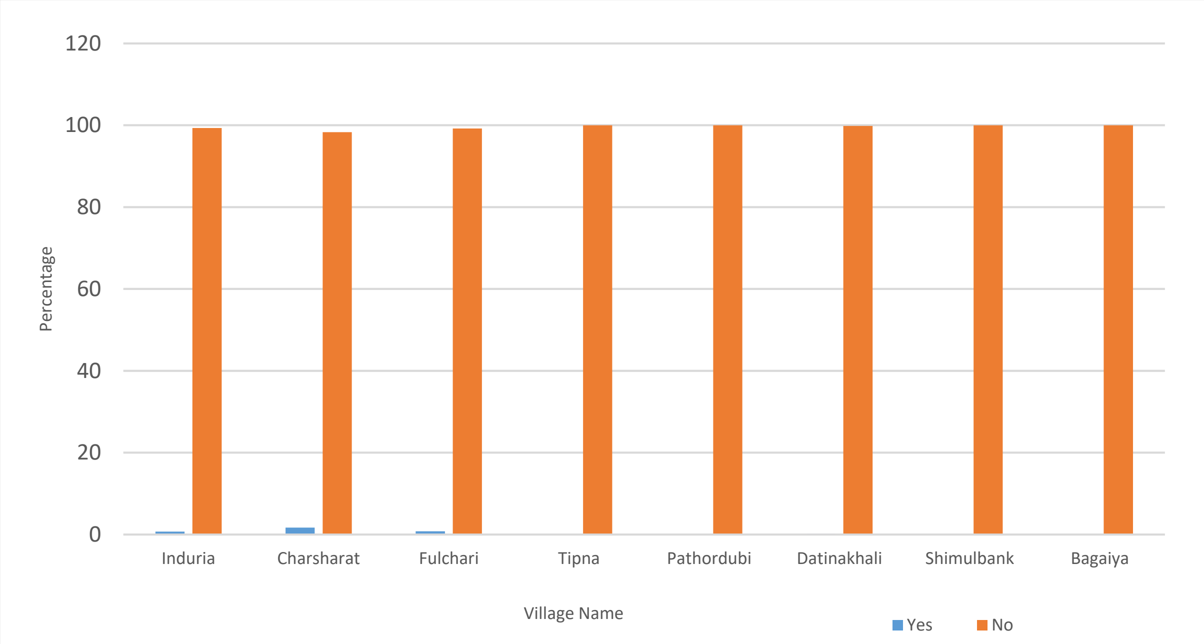


Figure 2.17: Community toilet quantity assessment

From **Figure 2.17,** it is observed that the community toilet percentage is almost zero in Induria, Fulchari, Charsharat, and Datinakhali. In Tipna, Shimulbak, Bagaiya, and Pathordubi, there is no community toilet at all.

Table 2.10: Sanitation Coverage for Disaster prone Areas

District	Village	HH	Population	Latrine Type	Non-Shared	Shared	Weight (Non-Shared)	Weight (Shared)	Equivalent Toilet	Total Equivalent Toilet	Total Requirement	Demand	% of Demand	Coverage
Barishal	Induria	728	3392	Double Pit Latrine	20	1	1	0.5	21	377	678.4	301	44.39	55.61
				Flash Latrine	22	4	0.8	0.4	19					
				Not Available	1	0	0	0	0					
				Open Latrine	1	0	0	0	0					
				Others	1	0	0	0	0					
				Pit Latrine	454	42	0.6	0.3	285					
				Septic Tank Latrine	42	4	0.9	0.45	40					
				VIP Latrine	18	1	0.7	0.35	13					
Chattogram	Charsharat	941	4573	Double Pit Latrine	6	0	1	0.5	6	426	914.6	489	53.44	46.56
				Flash Latrine	57	8	0.8	0.4	49					
				Not Available	2	1	0	0	0					
				Open Latrine	0	0	0	0	0					
				Others	0	2	0	0	0					
				Pit Latrine	442	84	0.6	0.3	290					
				Septic Tank Latrine	21	5	0.9	0.45	21					
				VIP Latrine	75	20	0.7	0.35	60					
Gaibandha	Fulchari	377	1583	Double Pit Latrine	0	0	1	0.5	0	117	316.6	199	62.90	37.10
				Flash Latrine	25	8	0.8	0.4	23					
				Not Available	0	0	0	0	0					
				Open Latrine	0	0	0	0	0					
				Others	0	0	0	0	0					
				Pit Latrine	124	65	0.6	0.3	94					

District	Village	HH	Population	Latrine Type	Non-Shared	Shared	Weight (Non-Shared)	Weight (Shared)	Equivalent Toilet	Total Equivalent Toilet	Total Requirement	Demand	% of Demand	Coverage
				Septic Tank Latrine	0	0	0.9	0.45	0					
				VIP Latrine	0	1	0.7	0.35	0					
Khulna	Tipna	772	3270	Double Pit Latrine	17	4	1	0.5	19	371	654	283	43.30	56.70
				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					
				VIP Latrine	28	7	0.7	0.35	22					
Kurigram	Pathordubi	2469	10038	Double Pit Latrine	4	0	1	0.5	4	1099	2007.6	909	45.28	54.72
				Flash Latrine	174	34	0.8	0.4	153					
				Not Available	1	0	0	0	0					
				Open Latrine	1	0	0	0	0					
				Others	0	0	0	0	0					
				Pit Latrine	1029	254	0.6	0.3	694					
				Septic Tank Latrine	39	9	0.9	0.45	39					
				VIP Latrine	279	39	0.7	0.35	209					
Satkhira	Datinakhali	568	2256	Double Pit Latrine	3	4	1	0.5	5	209	451.2	242	53.73	46.27
				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					

District	Village	HH	Population	Latrine Type	Non-Shared	Shared	Weight (Non-Shared)	Weight (Shared)	Equivalent Toilet	Total Equivalent Toilet	Total Requirement	Demand	% of Demand	Coverage
				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	67.48	32.52
				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					
Sylhet	Bagaiya	921	5399	Double Pit Latrine	3	0	1	0.5	3	426	1079.8	654	60.56	39.44
				Flash Latrine	87	9	0.8	0.4	73					
				Not Available	0	0	0	0	0					
				Open Latrine	6	0	0	0	0					
				Others	3	0	0	0	0					
				Pit Latrine	264	84	0.6	0.3	184					
				Septic Tank Latrine	111	25	0.9	0.45	111					
				VIP Latrine	69	19	0.7	0.35	55					

The sanitation demand and sanitation coverage have been analyzed based on the present condition of the disaster prone villages. From the following **Figure 2-18,** we can see that overall sanitation coverage is not good among the villages. The highest sanitation coverage has been assessed in Tipna, at 57%, and the lowest has been assessed in Shimulbank, at 33%.

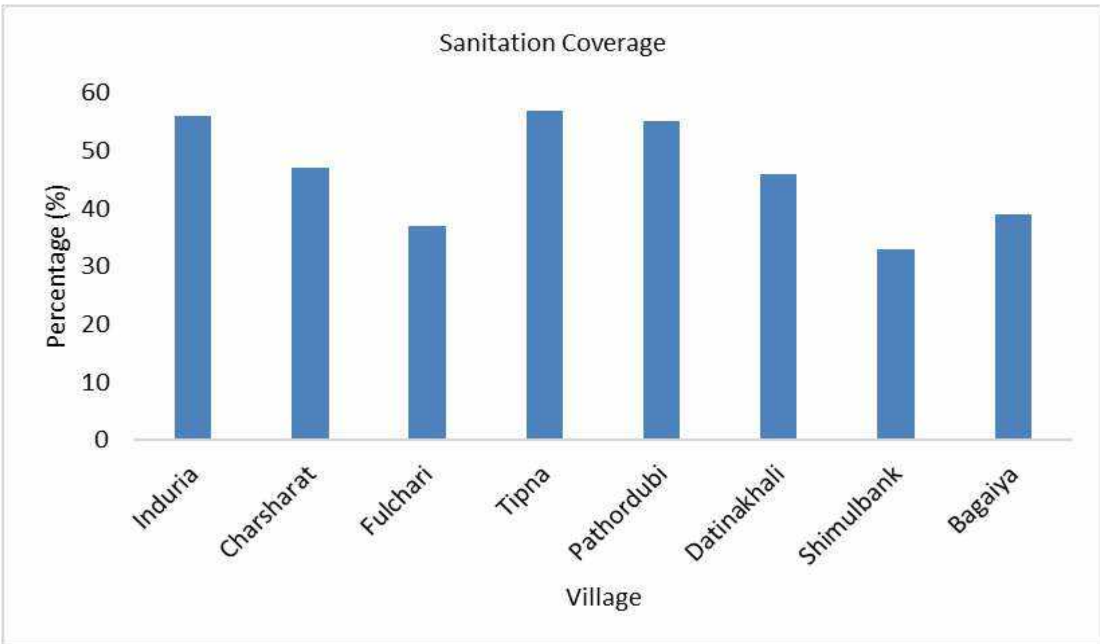


Figure 2.18: Sanitation coverage for disaster prone areas Hygiene Condition

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 conditions in the four villages subsequent to the survey.

For the assessment of hygiene conditions, some criteria have been set. The following criteria have been discussed below.

The sanitation condition of the Induria, Fulchari, Tipna, Pathordubi, Charsharat, Shimulbank, Bagaiya, and Datinakhali villages has been assessed qualitatively by the inventory survey through a questionnaire. For the assessment of the sanitation condition of the villages, some specific criteria were defined in the questionnaire. The surveyors noted down the appropriate answer after consultation with the local people during the survey.

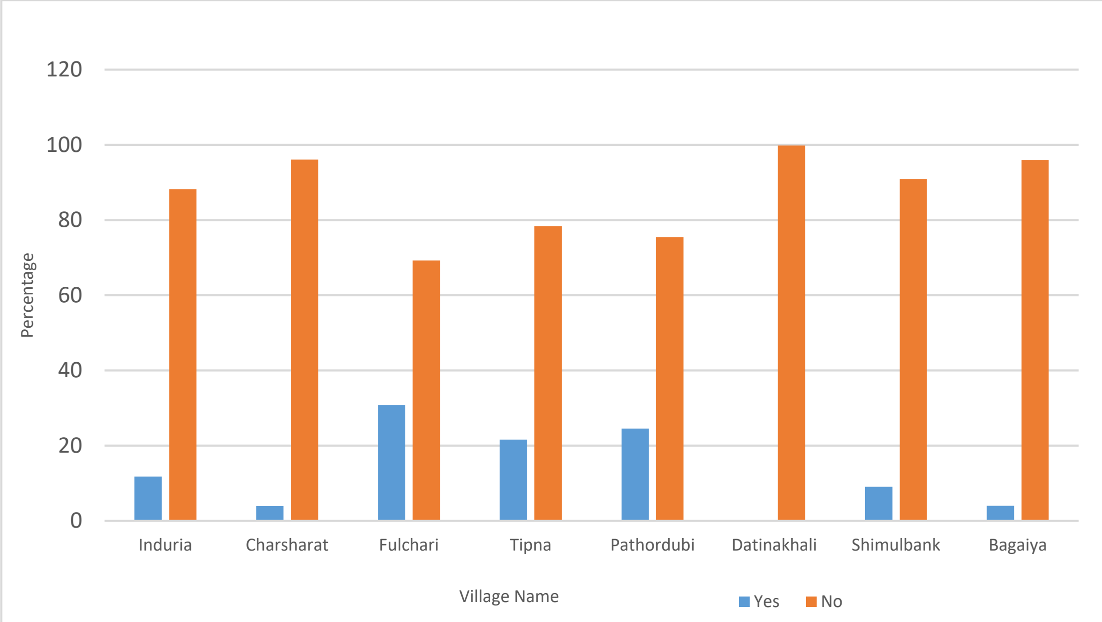


Figure 2.19: Toilet location assessment

Figure 2.19 shows that the majority of people use toilets located away from home**.** Fulchari, Pathordubi, and Tipna have the highest percentage of people using toilets near homes. In Fulchari (30.77%), Pathordubi (24.54%), and Tipna (21.63%) people use toilets near home. At Datinakhali almost 100% people use toilet that are away from home.

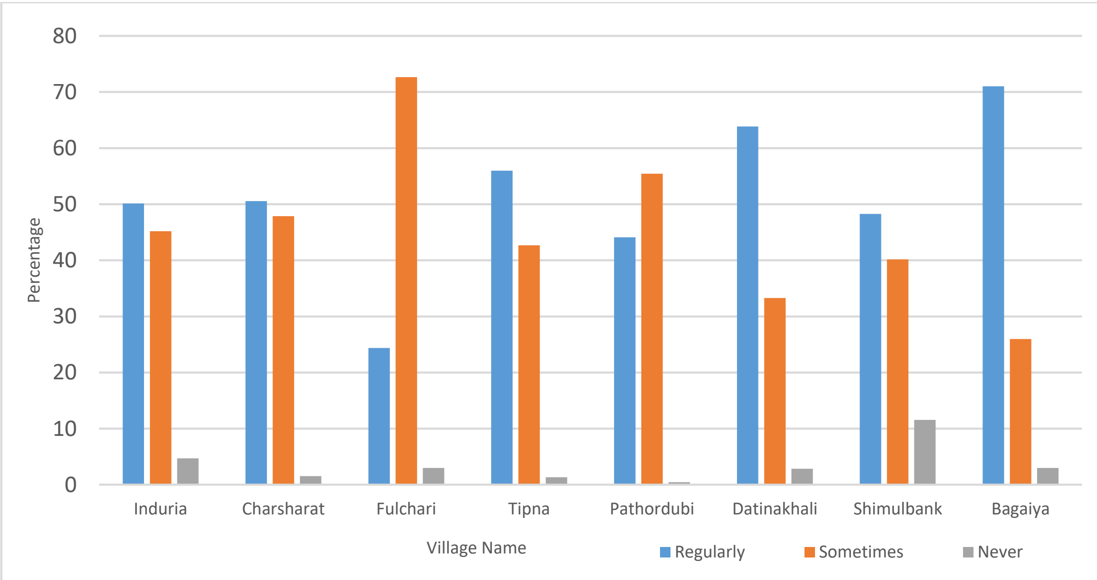


Figure 2.20: Wash hands Before Taking Food assessment

Figure 2.20 shows that around 50% of people in Induria, Charsharat, Tipna, and Shimulbank wash their hands before taking food. The majority of the rest wash their hands occasionally, and only a few never wash their hands. The maximum percentage has been found at Bagaiya (71.04%). The percentage is also remarkable in Datinakhali (63.87%). Around 26% of people in Bagaiya and 33.28% of people in Datinakhali wash their hands sometimes. The majority of people never wash their hands. Around 11.56% of people never wash their hands at Shimulbank, which is the highest value among the villages. The worst possible condition has been assessed in Fulchari. Only 24.38% of people wash their hands on a regular basis, while 72.64% wash their hands occasionally.

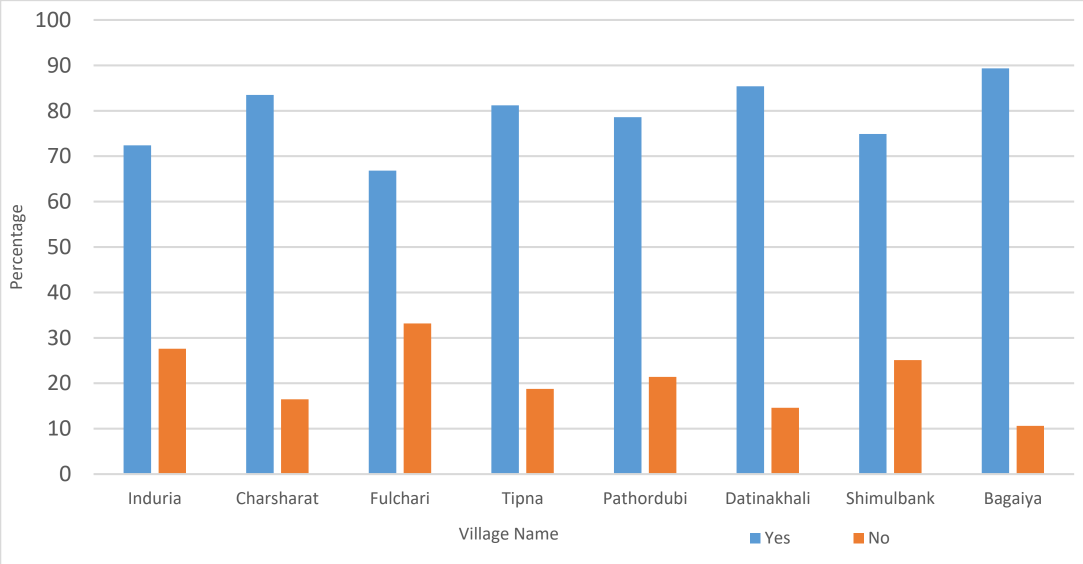


Figure 2.21: Cleaning hands with soap assessment

Figure 2.21 shows that most people in all villages wash their hands with soap. The percentage is highest at Bagaiya (89.36%). In Charsharat, Tipna, Datinakhali, and Bagaiya, the percentage is above 80%. The lowest percentage has been found at Fulchari (66.84%). The percentage of wash hands at Shimulbank is 74.89% and at Induria is 72.39%. Among these villages, the people of Fulchai are less aware of sanitation.

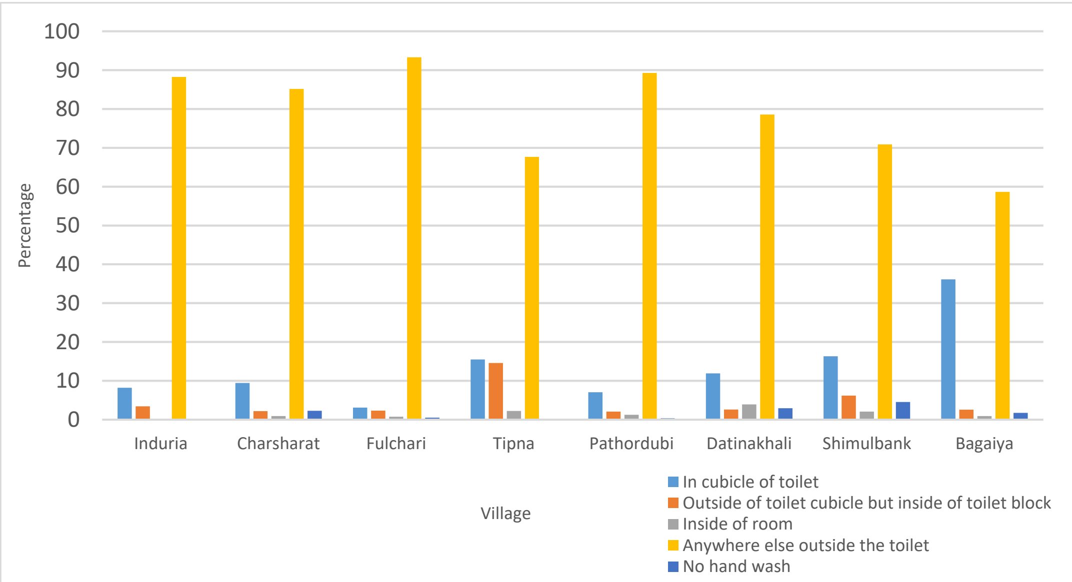


Figure 2.22: Washing hands after using toilet percentage

From **Figure 2.22**, it is observed that at Induria, 88.27% of people wash their hands anywhere else outside the toilet. 8.19% wash their hands inside the toilet cubicle. 3.41% wash hands outside of the toilet cubicle but inside the toilet block. Only 0.14% of people do not wash their hands. In Fulchari 93.32% people wash hands anywhere else outside the toilet. 3.08% wash their hands inside the toilet cubicle. 2.31% wash hands outside of the toilet cubicle but inside the toilet block. 0.77% wash hands inside the room. Only 0.51% of people do not wash their hands. In Tipna 67.69% people wash hands anywhere else outside the toilet. 15.51% wash hands inside the cubicle of the toilet, which is slightly better than Induria and Fulchari. 2.31% wash hands outside of the toilet cubicle but inside of toilet block. 2.23% wash their hands inside the room. In Tipna everybody wash hands after using toilet. At Pathordubi, 88.27% of people wash their hands anywhere else outside the toilet. 7.06% wash hands inside the cubicle of the toilet. 2.06% wash hands outside of the toilet cubicle but inside the toilet block, and 1.23% wash hands inside the room. Only 0.36% of people do not wash their hands. In Datinakhali, 78.59% of people wash their hands anywhere else outside the toilet. 11.93% wash their hands inside the toilet cubicle. 2.61% wash hands outside of the toilet cubicle but inside the toilet block. 3.92% wash their hands inside the room. Only 2.94% of people do not wash their hands. Charsharat (85%), Shimulbank (71%), and Bagaiya (59%), all wash their hands after using the toilet. However, a significant number of people have been observed washing their hands in toilet cubicles. After using the toilet, the majority of people in all villages wash their hands. Only a few people do not wash their hands after using the restroom.

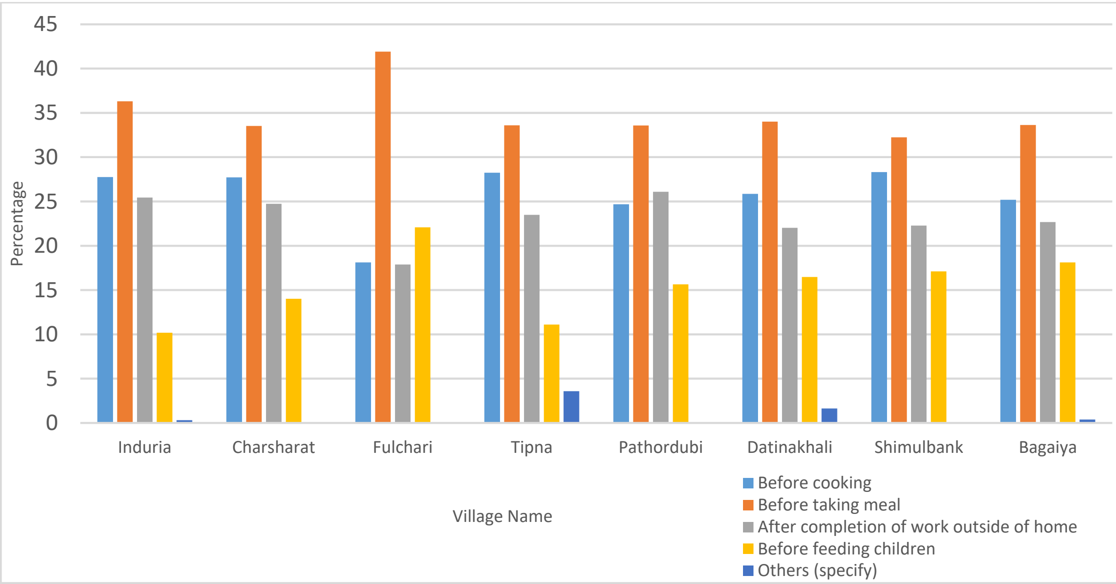


Figure 2.23: Wash hands at other times

From **Figure 2.23**, it is observed that in Induria, 27.76% of people wash their hands before cooking. 36.3% wash their hands before eating. Furthermore, 25.45% of people wash their hands after finishing work outside. 10.18% wash hands before feeding children, and 0.31% wash hands after completing other work, such as after feeding or bathing animals. In Fulchari, 18.12% of people wash their hands before cooking. 41.9% wash their hands before eating. Also, 17.89% of people wash their hands after completing work outside. 22.08% wash hands before feeding children. Before cooking, 28.24% of Tipna residents wash their hands. 33.59% wash their hands before taking a meal. Furthermore, 23.48% of people wash their hands after finishing work outside. 11.11% wash hands before feeding children. 3.58% wash hands after completing other work. In Pathordubi, 24.68% of people wash their hands before cooking. 33.58% wash hands before taking a meal. Furthermore, 26.1% of people wash their hands after finishing work outside. 15.64% wash hands before feeding children. 25.86% of people in Datinakhali wash their hands before cooking. 34.01% wash hands before taking a meal. In addition, 22.02% of people wash their hands after finishing work outside. 16.48% wash hands before feeding children. 1.63% wash hands after completing other work. At Charsharat (27.71%), Shimulbank (28.31%), and Bagaiya (25.19%), people wash their hands before cooking. After that, 33.53% of people of Charsharat, 32.24% in Shimulbank, and 33.63% in Bagaiya wash their hands before taking meals. After finishing work outside the home, 24.74% of Charsharat residents, 22.28% of Shimulbank residents, and 22.67% of Bagaiya residents wash their hands. Again, 14% of Charsharat, 17% of Shimulbank, and 18% of Bagaiya wash their hands before feeding children.

2.1.5 Assessment of DPHE Intervention

Since its establishment in 1926, DPHE has worked to ensure that all citizens of Bangladesh have access to clean water and proper sanitation. The term "Water Point Mapping" (WPM) refers to an activity in which the locations of all public water points in a given area are recorded alongside relevant demographic, technical, and administrative data. **Table 2.11** shows the details of DPHE's current water supply interventions in the villages:

Table 2.11: DPHE existing intervention for water supply in Disaster Prone Upazilas

Tech	STW-6		DTW-6		DTW-Tdev		PSF		RWH		SST/VSST		STW-TDev		RW-6		RW-Tdev	
Upazila	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional
Hijla,Barishal			214	205														
Fulchari, Gaibanda	126	117							1	1			135	122	8	8		
Dumuria, Khulna.			648	636														
Bhurungamari, Kurigram	143	139											5	5	18	12		
Shyamnagar, Satkhira.	55	35	598	518			200	143	144	112	404	265						
Mirsharai, Chattagram	33	32	201	189											5	5		
Dakshin sunamganj, Sunamganj			184	178	18	18												
Gowainghat, Sylhet	96	80	47	44													61	51

2.2 Socio-Economic Context and Community Perception

Bangladesh lies in the northeastern part of South Asia with an area of 147,570 sq. km and a population of around 168.10 million, having a population density of 1,116 people/sq. Km. 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 SDGs era of the SDGs 98.5 of population has access to water from improved water sources. However, only 42.6 % 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 police access to safe & 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 & urban populations by increasing service delivery standards; Phase-3: 2026-2030 continue to work for sustaining universal coverage in rural & urban.

2.2.1 Socio Economic setting

The feasibility study was conducted in 15 villages. Out of them, 8 villages are selected as disaster-prone villages. This chapter deals with the social structure and poverty conditions of eight selected disaster-prone villages.

Demographic Profile

The demographic profile of the study villages has been taken from the primary survey of the villages. From the survey, it is observed that the Pathordubi village of Kurigram district has the highest population (10,038) comprising 2469 households (HH). The average household size in Pathordubi is 4.07, which is close to the national average. The following **Table 2.12** represents the demographic data of the pilot villages. Among these five villages, Fulchari has the lowest population (1583), comprising 377 households (HH).

Table 2.12: Demographic Profile of the Study Villages

Village	Total HH	Total Population	Total Male	Total Female	Sex Ratio	Avg. HH
Induria	728	3392	1771	1621	109.3	4.66
Fulchari	377	1583	803	780	102.9	4.2
Tipna	772	3270	1672	1598	104.6	4.24
Pathordubi	2469	10038	5086	4952	102.7	4.07
Datinakhali	568	2256	1146	1110	103.2	3.97
Shimulbank	462	2629	1360	1269	107.2	5.69
Bagaiya	921	5399	2732	2667	102.4	5.86
Charsharat	941	4573	2425	2148	112.9	4.86

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 both in the pilot and sample villages. On average, in the pilot villages, about 32% of both males and females are adults, whereas in the sample villages, the number of female adults (about 34%) is higher than the number of male adults (32%). Because of lower infant and under-five mortality rates (U5MR), the percentage of children is also noticeable in the studied villages. The following **Table 2.13** presents the age structure of the studied villages.

Table 2.13: Age structure of population in the Study villages

Village	Adult (> 18 yrs)		Children Under 5 years		Children (5-18 years)	
	Female (%)	Male (%)	Boy (%)	Girl (%)	Boy (%)	Girl (%)
Induria	29.9	31.7	5.7	5.8	14.9	12.1
Fulchari	31.5	29.4	7	5.9	14.4	11.8
Tipna	33.9	34.5	4.8	4.9	11.8	10.2
Pathordubi	35.4	33.9	5	4.5	11.8	9.5
Datinakhali	35.3	33.6	5	4.3	12.2	9.6
Shimulbank	27	28.8	5.2	5.9	17.7	15.3
Bagaiya	27.7	27.7	6.2	6.5	16.7	15.3
Charsharat	29.7	34.3	5.2	4.9	13.6	12.4

Source: CEGIS Field Survey, 2022

Gender and Marital Status of the HH Head

In the surveyed villages, the majority of the HH heads are male. The following **Table 2.14** shows that more than 90% of HH heads are male in every village except Fulchori. Fulchori has approximately 14.06% female-headed HHs.Most importantly, in two villages, i.e., Induria and Pathordubi, a few third gender headed HHs have been found.

Table 2.14: Sex of the HH Heads in the Villages

District	Village	Male	Female	Third Gender
Barishal	Induria	92.86	7.01	0.14
Gaibandha	Fulchari	85.94	14.06	
Khulna	Tipna	94.17	5.83	
Kurigram	Pathordubi	92.3	7.65	0.04
Satkhira	Datirnakhali	90.49	9.51	
Sunamganj	Shimulbank	91.77	8.23	
Sylhet	Bagaiya	91.75	8.25	
Chattogram	Charsharat	95.96	3.94	0.11

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 2.15**.

Table 2.15: Marital Status of the HH Heads

Village	Married (one wife)	Married (more than one wife)	Widow	Unmarried	Widower	Separated	Divorcee
Induria	91.9	1	5.2	0.7	0.4	0.8	
Fulchari	83	2.9	10.3	0.8	0.3	0.8	1.9
Tipna	90.4	1.8	3.6	1.3	1	1.6	0.3
Pathordubi	89.3	2.6	6.3	0.3	0.5	0.6	0.6
Datinakhali	89.6	0.5	5.1	1.2	0.5	1.6	1.4

Village	Married (one wife)	Married (more than one wife)	Widow	Unmarried	Widower	Separated	Divorcee
Shimulbank	84.4	4.8	6.5	4.1	0.2		
Bagaiya	91.3	1.2	5.4	1.3	0.4	0.2	0.1
Charsharat	91.3	2.7	2.0	3.1	0.5	0.3	0.1

Source: CEGIS Field Survey, 2022

Occupation of the HH Head

In the pilot villages, the majority (more than 90%) of the HH heads are employed. They are involved in different occupations to earn their livelihoods. Agriculture is the main occupation for the majority of them in most of the villages, followed by day labor and private jobs. In Datinakhali of Shatkhira, Shimulbank of Shunamganj, and Bagaiya of Sylhet, the majority of the HH heads' occupation is daily labor. Moreover, a remarkable number of HH heads rely on business as their main means of livelihood. The following **Table 2.16** present the occupations of HH heads in the pilot villages.

Table 2.16: Main Occupation of the HH Head

Village	Government Job	Private Job	Business	Agricultural	Day Laborer	Housewife	Transport Driving	Expatriates	Fisherman	Male Servant	Self-employed	Village Doctor	Others
Induria	0.7	13.1	12	35.4	23.6	2.8	4.7	0.3	2.3		2.1		0.8
Fulchari	1.1	1.3	5.6	47.5	30.2	2.7	2.9						6.4
Tipna	1.7	5.6	16.6	31	20.6	1.3	14.6		0.1	0.9			5.7
Pathordubi	1.3	4.4	12.2	36.2	32.2	3.5	3.7	0.4	0.1	0.4	2	0.3	1
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	32.9	3.7	0.7	12.6	2.6	2.4	3.5	0.4	0.4
Bagaiya	0.7	2.3	18.1	15.3	37.2	5.5	3.7	1.1	0.4	0.5	4.5	0.8	0.4
Charsharat		0.5	17.2	34.3	37.9	1.0	4.6						

Income and Expenditure

The average monthly income of the HHs in the 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 2,768 ranges from BDT246 to BDT4686). 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 much higher than that of other occupational groups. The following **Table 2.17** represents the average monthly income and expenditure in the pilot villages.

Table 2.17: Average Monthly Income and Expenditure in the Pilot Villages

Village	Average Monthly Income	Average Monthly Expenditure
Induria	13,467	13,221
Fulchari	11,920	7,791
Tipna	17,398	12,712
Pathordubi	11,593	9,912
Datinakhali	11,035	8,367
Shimulbank	18,020	13,674
Bagaiya	14,667	13,044
Charsharat	17,374	14,140

Housing Condition and Housing Tenancy

The average housing condition of the pilot villages shows that the majority of the houses are kutcha. In Fulchori, about 95.5% of the houses are Kutcha. On the other hand, in Tipna, more than 30% of houses are semi-pucca. The following **Figure 2.24** shows the housing condition of the pilot villages.

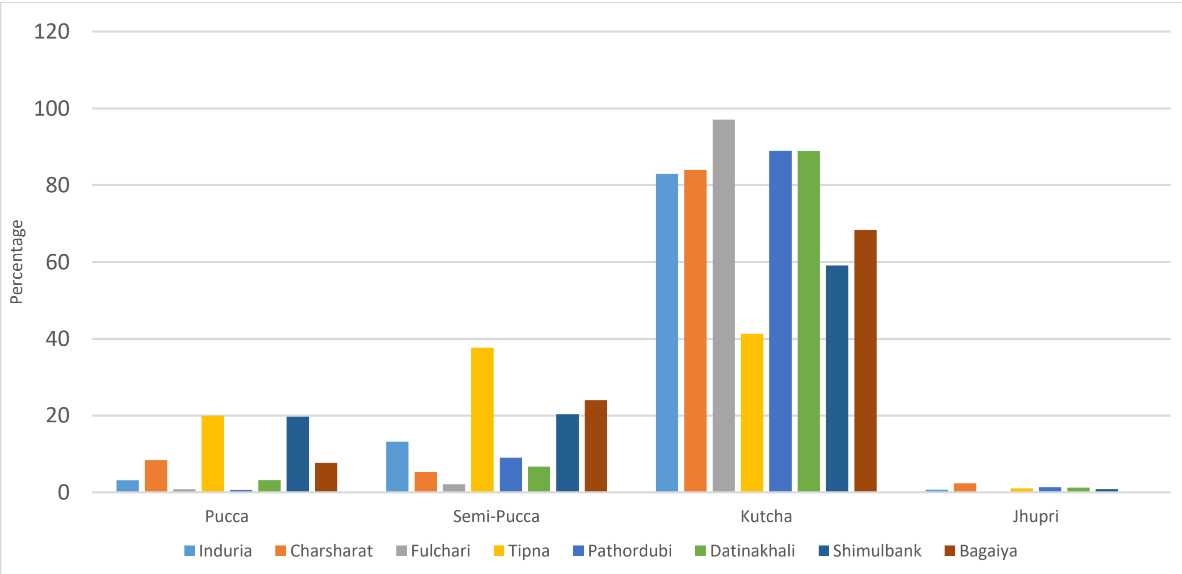


Figure 2.24: Housing Condition in the Pilot Villages

However, most of the houses are owned by the HHs. A very few houses are rented, and some are government settlements. The following **Figure 2.25** represents the housing tenure in the pilot villages.

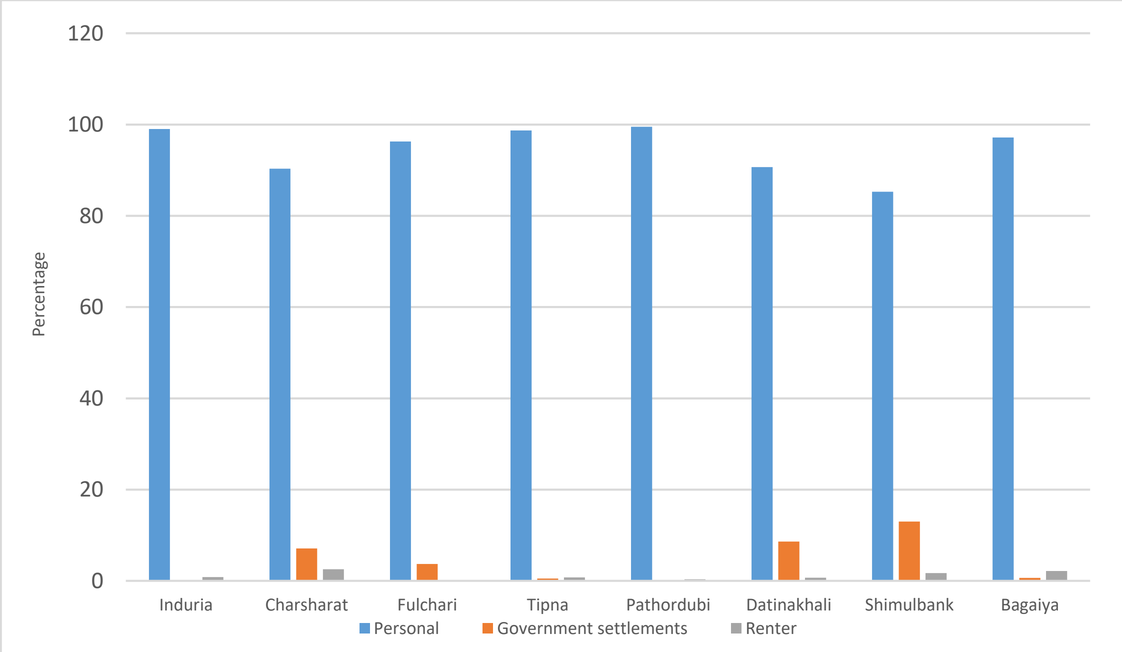


Figure 2.25: Housing Tenancy in Pilot Villages

Status of School-Going Children

In this study, the status of school-going children aged >5 years is analyzed. From the survey results, it is observed that near about 50% of boys and girls are attending school. It is also observed that the ratio of school-going boys is a little bit higher than that of school-going girls in every pilot village. However, the percentage of children not attending school is comparatively lower. In this respect, the percentages of children not attending school are relatively higher in Shimulbank, Datinakhali, and Fulchari villages than other pilot villages.

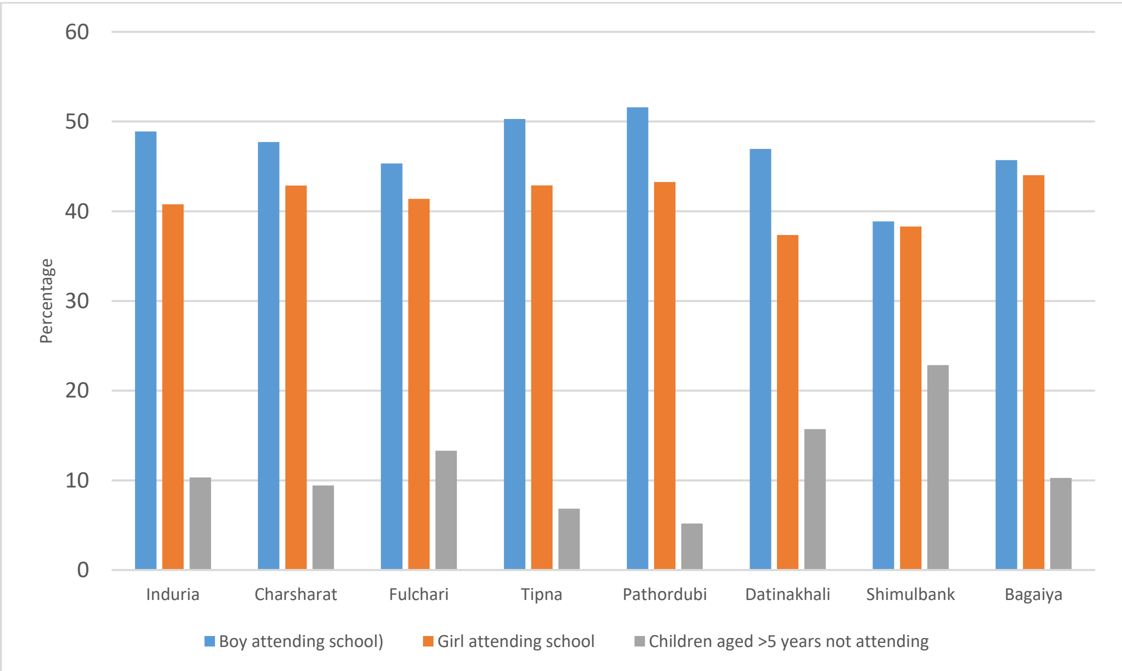


Figure 2.26: School going children status

Disability

Figure 2.27 shows that 3.5% to 11.3% of the HHs have disabled people in the pilot villages. The highest number of HHs with disabled members are seen in Shimulbank (10.8%) villages. On average, however, more than 90% of the HHs have no members with disabilities in the pilot villages.

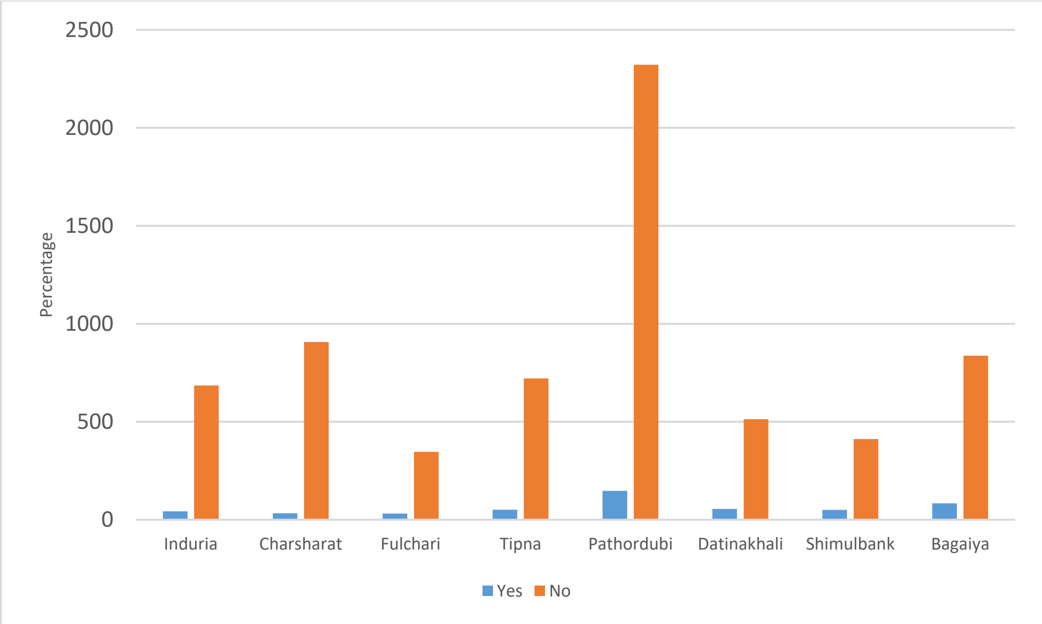


Figure 2.27: Status of Disable people in the Pilot Villages

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 2.18** represents the disability types found in the pilot villages.

Table 2.18: Types 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
Induria	2.3	34.9	4.7	7.0	23.3	11.6				2.3	14.0	
Charsharat	3.0	24.2	21.2	9.1	12.1	9.1	6.1		3.0	3.0	9.1	
Fulchari	3.2	61.3	6.5	9.7	9.7	3.2			3.2		3.2	
Tipna	2.0	43.1	7.8	7.8	7.8	11.8	7.8				5.9	5.9
Pathordubi	2.7	48.3	16.3	8.8	9.5	4.1	5.4	2.0		1.4	1.4	
Datinakhali	7.3	49.1	5.5	14.6	10.9	5.5	7.3					
Shimulbank	12.0	40.0	12.0	14.0	8.0	4.0	4.0			2.0	4.0	
Bagaiya	2.4	34.5	11.9	23.8	8.3	8.3	3.6	1.2			6.0	

2.2.2 Beneficiary Community Description

Cyclone Prone

Tipna, Datinakhali, and Induria are cyclone-prone villages among the 15 villages selected for the "My Village- My Town" project. The total household number is 728, 722, and 568 in Induria, Tipna, and Datinakhali villages, respectively. From the survey, it has been seen that the adult female percentage is higher than others in Datinakhali village.

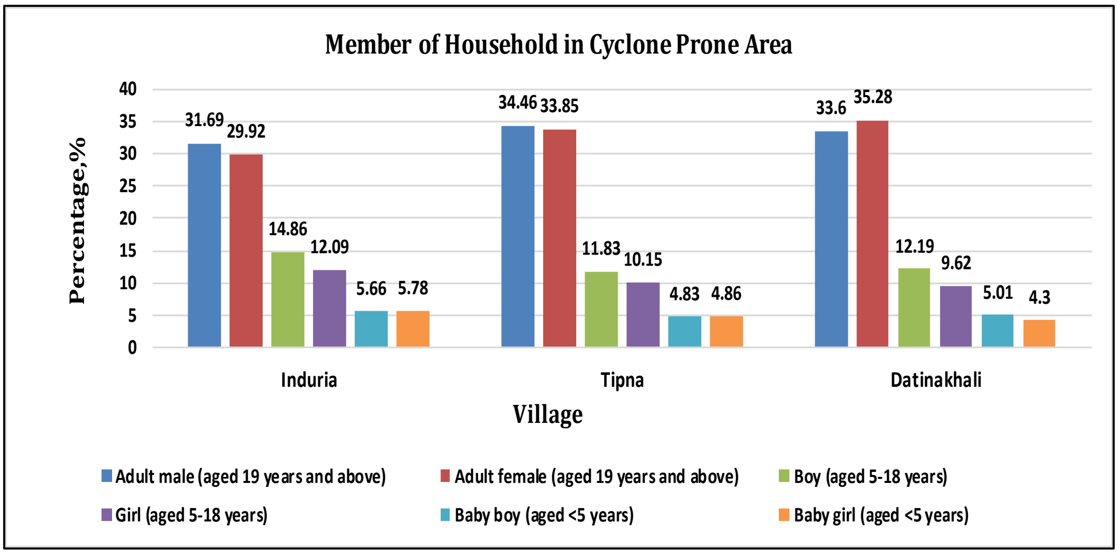


Figure 2.28: Member of Household in cyclone Prone Area

The total population is 3392, 3270, and 2256 in Induria, Tipna, and Datinakhali villages, respectively. The total male population is higher than the female population among the villages here.

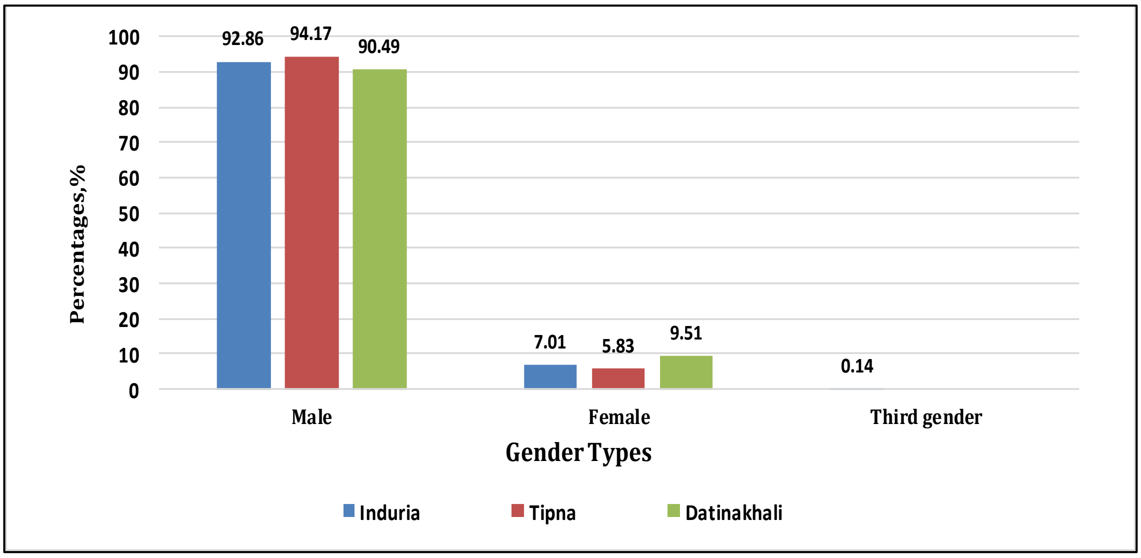


Figure 2.29: Gender Distribution (HH Head) of Cyclone Prone Area

Most of the household in these three villages of this area is of personal type.

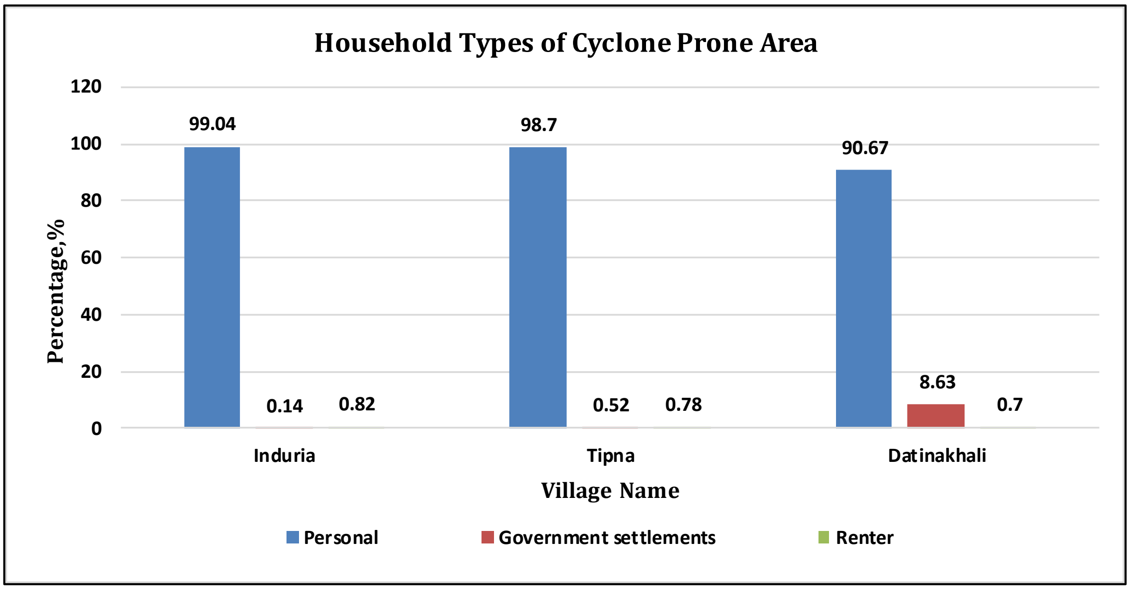


Figure 2.30: Household Type of Cyclone Prone Area

Flood Prone

Fulchari and Pathordubi are located in flood-prone areas; Fulchari is in Beel area but Pathordubi in plain land. The selected villages are among the 15 villages selected for the "My Village- My Town" project. The total household numbers are 377 and 2469 in Fulchari and Pathordubi villages, respectively. From the survey, it has been seen that the adult male percentage is higher than the adult female percentage in these villages.

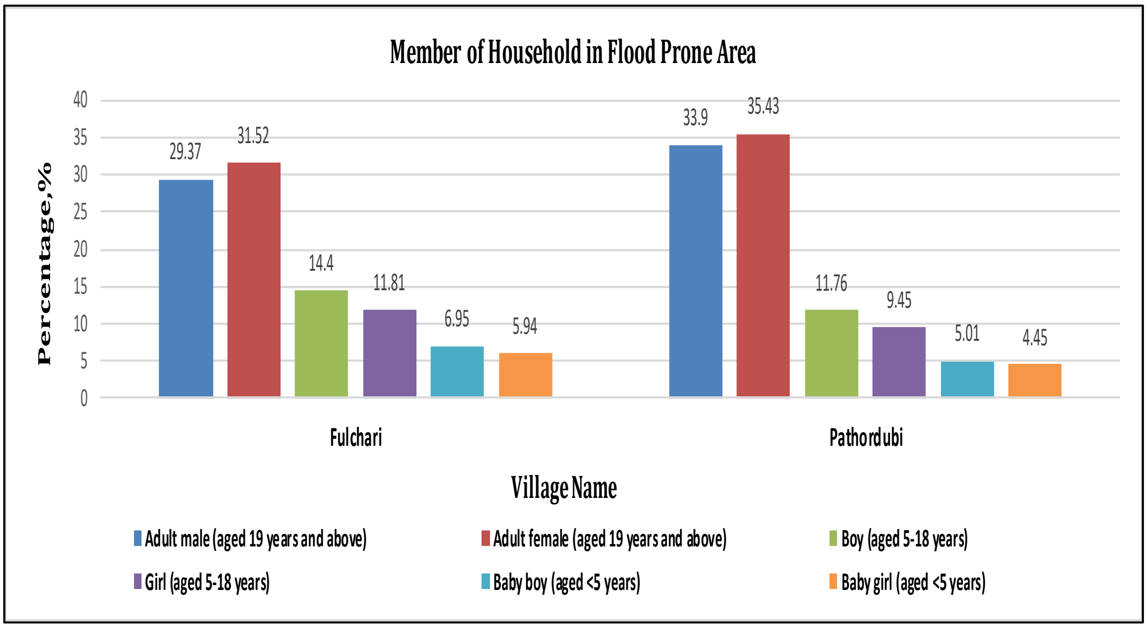


Figure 2.31: Member of Household in Flood Prone Area

The total population is 1583 and 10038 in Fulchari and Pathordubi villages, respectively. The total male population is much higher than the female population in these villages.

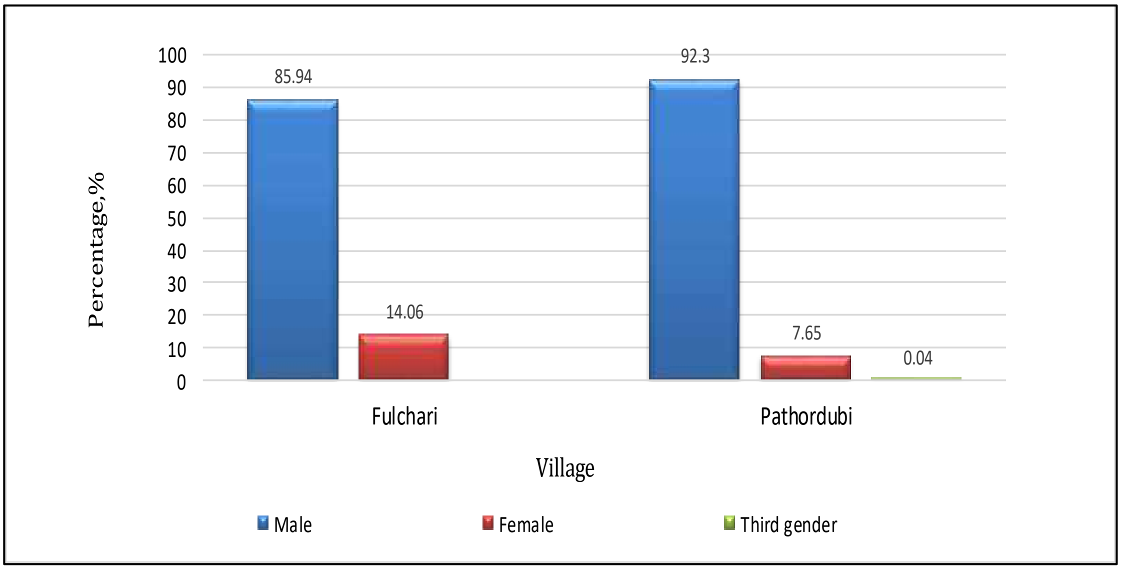


Figure 2.32: Gender Distribution (HH Head) of Flood prone Area

Most of the household in these three villages of this area is of personal type.

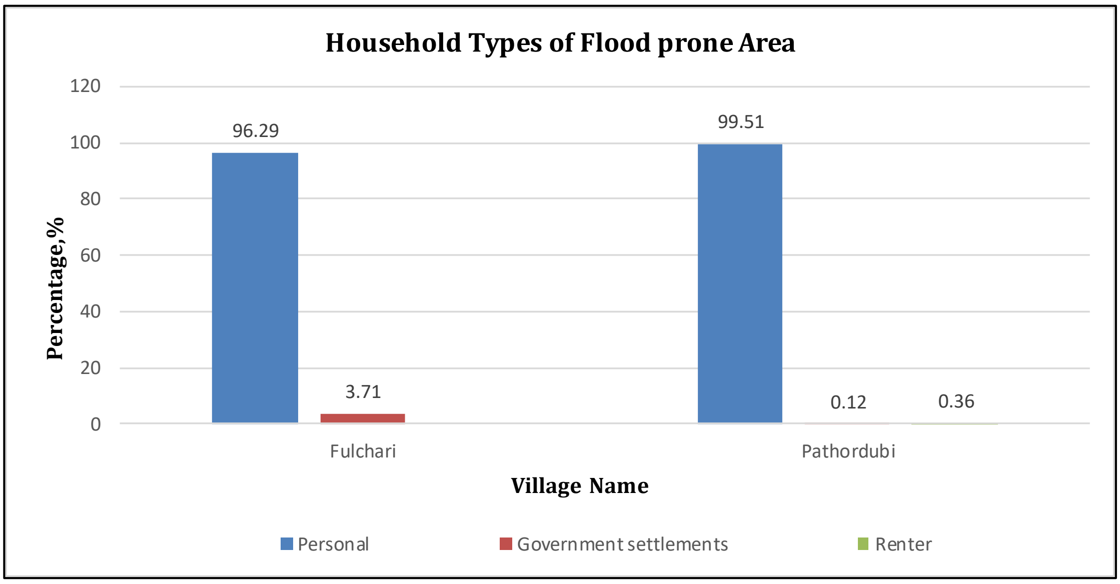


Figure 2.33: Household Types of Flood Prone Area

2.2.3 Economic Activities

The feasibility study was conducted in 15 villages. Out of them, 8 villages are selected as disaster prone villages. This chapter deals with the economic activities of eight selected disaster-prone villages.

Occupation of the HH Head

In the pilot villages, the majority (more than 90%) of the HH heads are employed. They are involved in different occupations to earn their livelihoods. Agriculture is the main occupation for the majority of them in most of the villages, followed by day labor and private jobs. In Datinakhali of Shatkhira, Shimulbank of Shunamganj, and Bagaiya of Sylhet, the majority of the HH heads' occupation is daily labor. Moreover, a remarkable number of HH heads rely on business as their main means of livelihood. The following **Table 2.19** present the occupations of HH heads in the pilot villages.

Table 2.19: Main Occupation of the HH Head

Village	Government Job	Private Job	Business	Agricultural	Day Laborer	Housewife	Transport Driving	Expatriates	Fisherman	Male Servant	Self-employed	Village Doctor	Others
Induria	0.7	13.1	12	35.4	23.6	2.8	4.7	0.3	2.3		2.1		0.8
Fulchari	1.1	1.3	5.6	47.5	30.2	2.7	2.9						6.4
Tipna	1.7	5.6	16.6	31	20.6	1.3	14.6		0.1	0.9			5.7
Pathordubi	1.3	4.4	12.2	36.2	32.2	3.5	3.7	0.4	0.1	0.4	2	0.3	1
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	32.9	3.7	0.7	12.6	2.6	2.4	3.5	0.4	0.4
Bagaiya	0.7	2.3	18.1	15.3	37.2	5.5	3.7	1.1	0.4	0.5	4.5	0.8	0.4
Charsharat		0.5	17.2	34.3	37.9	1	4.6						

Source: CEGIS Field Survey, 2022

Income and Expenditure

The average monthly income of the HHs in the 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 2,768 ranges from BDT246 to BDT4686). It is 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 much higher than that of other occupational groups. The following **Table 2.20** represents the average monthly income and expenditure in the pilot villages.

Table 2.20: Average Monthly Income and Expenditure in the Pilot Villages

Village	Average Monthly Income	Average Monthly Expenditure
Induria	13,467	13,221
Fulchari	11,920	7,791
Tipna	17,398	12,712
Pathordubi	11,593	9,912
Datinakhali	11,035	8,367
Shimulbank	18,020	13,674
Bagaiya	14,667	13,044
Charsharat	17,374	14,140

Source: CEGIS Field Survey, 2022

3. Water Resources Assessment in the Villages

3.1 Water Availability Analysis

Water availability analysis is capable of portraying the behavior 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 8 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 8 villages for the feasibility study.

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.

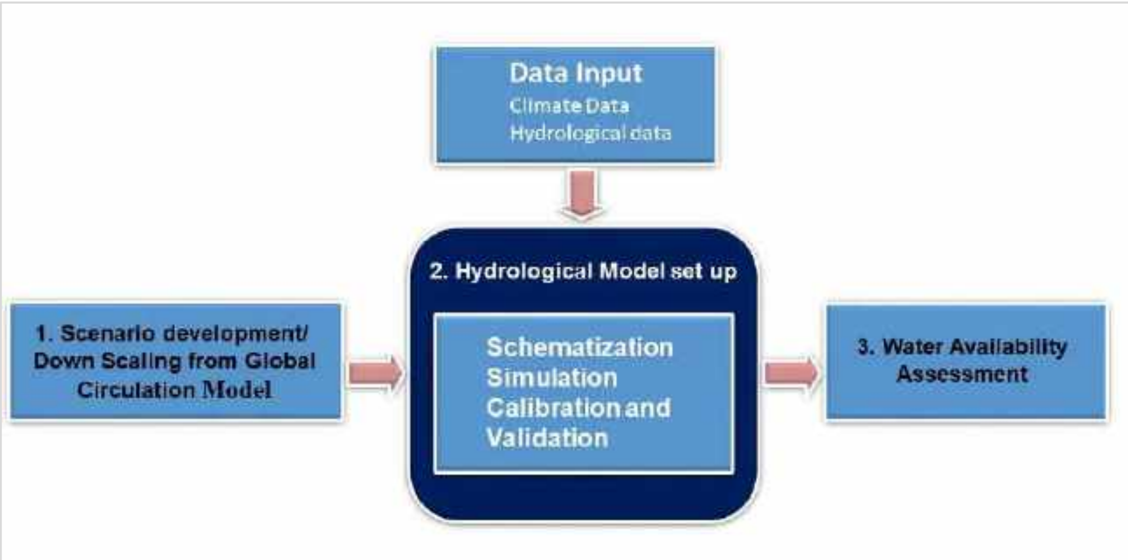


Figure 3.1: Overall Study Approach

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. The SWAT model is very flexible, can assess surface water availability, is easy to modify, and takes less simulation time than 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, land use to estimate loss and storage, and water source 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

The 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 the sink, and defining flow direction and accumulation, have been done automatically through the SWAT user interface. Additional outlets have been incorporated manually. The overlay of land use, soil layer, and slope class defines the Hydrological Response Units (HRU)s. HRU is the smallest hydrological simulation unit with a unique soil, land use, and slope combination. The discretization of the basin into HRUs allows a detailed simulation of the hydrological processes.

Simulation

The study used different model calculation units, i.e., 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/). The calculations were based on hydrological characteristics and data availability and defined accordingly. 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 or the Muskingum River routing method. In this simulation, the Muskingum method has been used. The SCS curve number (CN) method has been used for estimating runoff, and the variable CN: Moisture condition II curve number has been specified. The Hargreaves method has been used for calculating Potential Evapotranspiration (PET) 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

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

Step 3: Water Availability Assessment

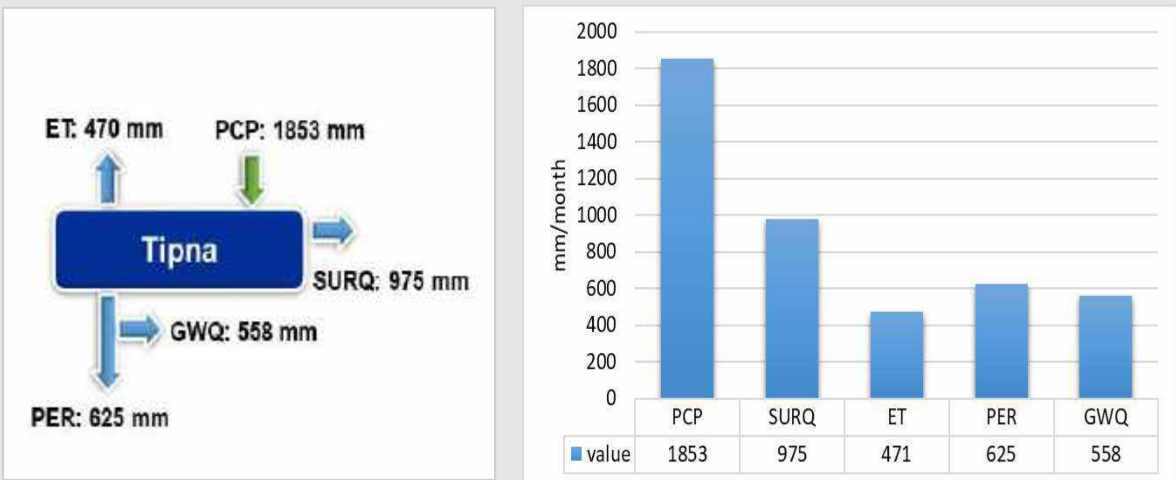
In this step, a SWAT model was set up for baseline conditions to simulate water's temporal and spatial distribution in the study area

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. The average annual rainfall of the village is 1853 while the national yearly 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. The monthly variation of water availability as illustrated in **Figure: 3.3**

Rainfall is the input to water balance. However, water loses through evapotranspiration and percolation and contributes to stream flow through surface runoff. The yearly evapotranspiration loss is 470 mm, 26% of annual rainfall; whereas yearly percolation was 625 mm.

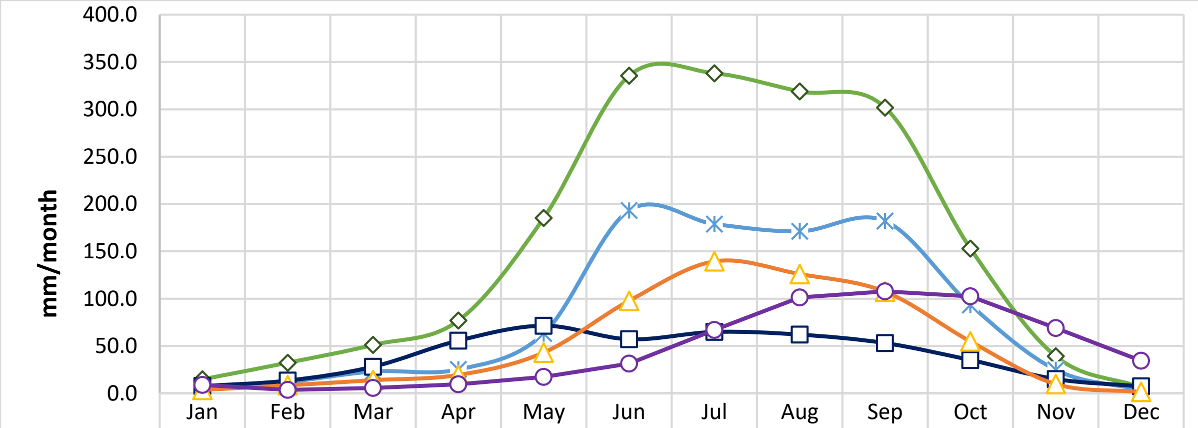
The water loses through evapotranspiration and percolation. The remaining water contributes to stream flow as overland and lateral (subsurface) flow. The water from shallow aquifers also contributes to stream flow as base flow. Baseflow exceeds precipitation in November. The average surface runoff for Tipna is 975 mm; whereas the base 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

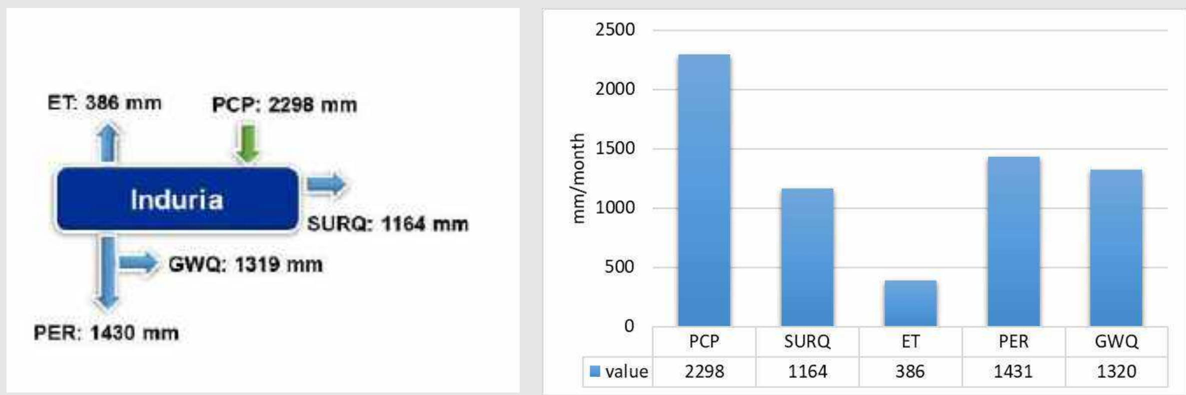
Figure 3.3: Average Monthly water balance

Water Balance for the Village Induria

The simulation results of the annual water for Induria village which is located in the south-west areas of Bangladesh are shown in **Figure 3.4** for the simulation period of 1981 to 2022. The average annual rainfall of the village is 2298 while the national yearly average is about 2100. The monsoon starts in May and reaches its peak at about 464.5 mm in June. The monthly variation of water availability is illustrated in **Figure: 3.5**

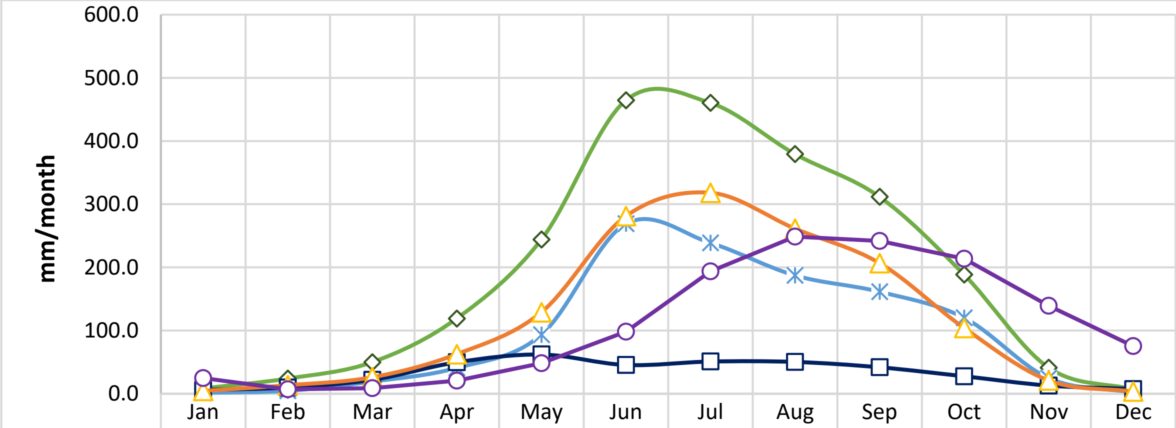
Rainfall is the input to the water balance. However, water loses through evapotranspiration and percolation and contributes to stream flow through surface runoff. The yearly evapotranspiration loss is 386 mm, 17% of annual rainfall; whereas yearly percolation was 1430 mm.

The water loses through evapotranspiration and percolation. The remaining water contributes to stream flow as overland and lateral (subsurface) flow. The water from shallow aquifer also contributes to stream flow as base flow. The annual average surface runoff for Induria is 1164 mm; whereas the base flow is 1319 mm. Baseflow exceeds precipitation in October.



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	8.3	23.9	49.9	119.1	244.0	464.5	460.3	379.4	311.7	188.6	41.2	6.7
SURQ	1.5	4.8	19.2	40.9	93.4	269.1	238.8	187.3	161.5	120.3	24.8	2.1
ET	5.9	9.7	22.0	49.8	62.1	45.5	51.0	50.4	41.9	27.6	12.8	7.3
PER	4.4	13.4	26.0	62.6	128.9	281.0	318.0	261.2	206.7	104.1	21.0	3.4
GWQ	24.6	7.0	8.9	20.6	48.2	98.1	193.8	248.7	241.9	213.7	139.2	75.3

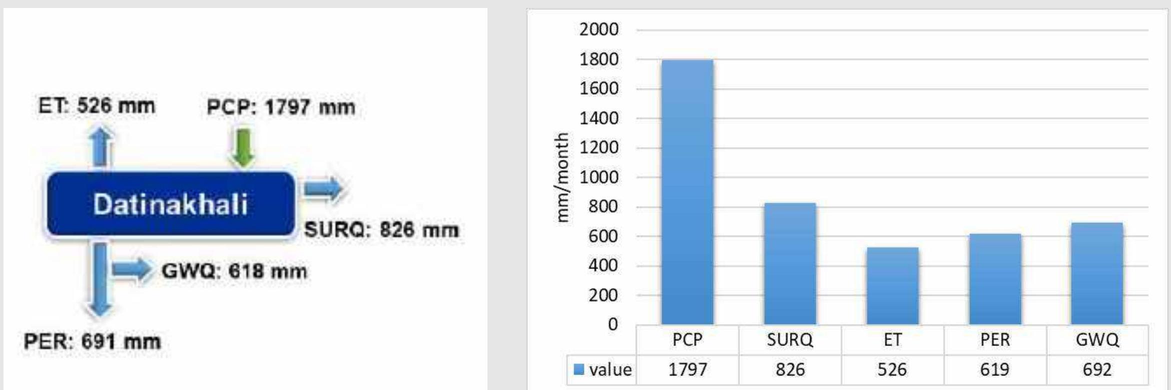
Figure 3.5: Average Monthly water balance

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 3.6** for the simulation period of 1981 to 2022. The average annual rainfall of the village is 1797 while the national yearly average is about 2100. The monsoon starts in May and reaches its peak at about 352.6 mm in July. The monthly variation of water availability as illustrated in **Figure 3.7**

Rainfall is the input to the water balance. However, water loses through evapotranspiration and percolation and contributes to stream flow through surface runoff. The yearly evapotranspiration loss is 526 mm, 29% of annual rainfall; whereas yearly percolation was 691 mm.

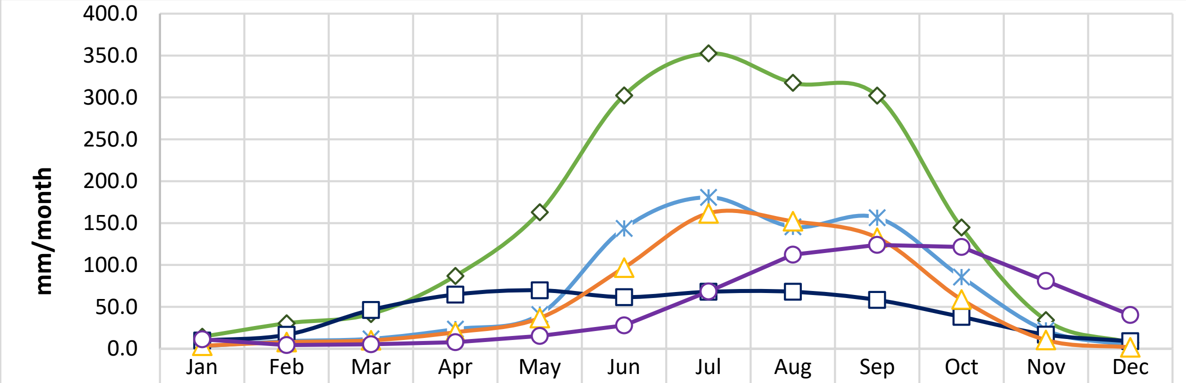
The water loses through evapotranspiration and percolation. The remaining water contributes to stream flow as overland and lateral (subsurface) flow. The water from shallow aquifers also contributes to stream flow as base flow. The average surface runoff for Datinakhali is 826 mm; whereas base flow was 618 mm. Baseflow exceeds precipitation in October.



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	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

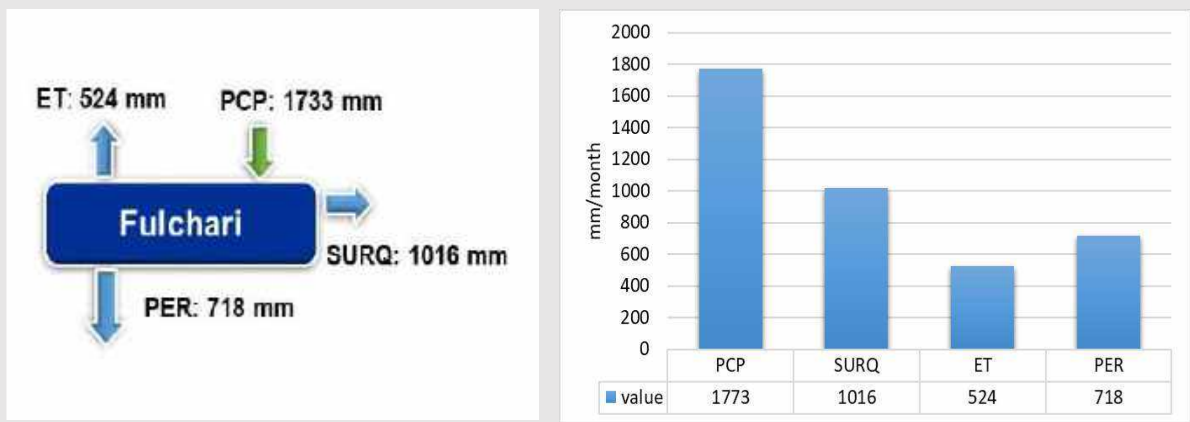
Figure 3.7: Average Monthly water balance

Water Balance for the Village Fulchari

The simulation results of the annual water for Fulchari village which is located in the northwest areas of Bangladesh are shown in **Figure 3.8** for the simulation period of 1981 to 2022. The average annual rainfall of the village is 1753 while the national yearly average in the driest part of the country is about 1500. The monsoon starts in May and reaches its peak at about 355.9 mm in July. Monthly variation of water availability is illustrated in **Figure: 3.9**

Rainfall is the input to the water balance. However, water loses through evapotranspiration and percolation and contributes to stream flow through surface runoff. The yearly evapotranspiration loss is 524 mm, 30% of annual rainfall; whereas yearly percolation ws 718 mm.

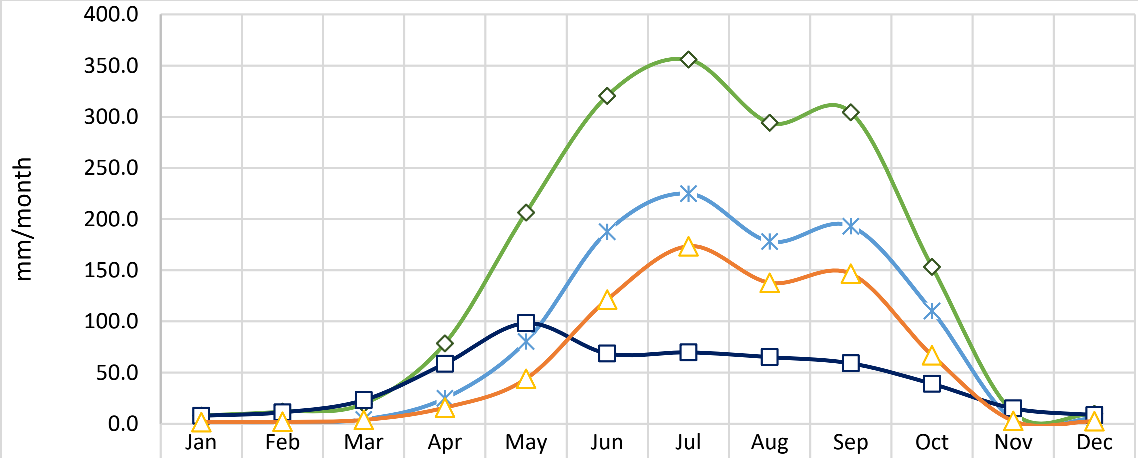
The water loses through evapotranspiration and percolation. The remaining water contributes to stream flow as overland and lateral (subsurface) flow. The water from shallow aquifers also contributes to stream flow as base flow. The annual average surface runoff for Shimulbak is 1016 mm.



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

GWQ: Groundwater contribution to stream flow

Figure 3.8: Average annual water balance



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PCP	8.0	11.8	19.5	78.5	206.4	320.4	355.9	294.1	304.3	153.5	11.1	9.7
SURQ	1.7	1.6	4.3	24.8	80.4	187.7	224.9	178.0	193.0	110.3	4.0	5.3
ET	7.8	11.2	23.1	58.7	98.3	68.7	69.8	65.1	59.1	39.1	15.0	8.4
PER	1.6	2.0	3.8	15.8	44.0	121.4	173.5	137.8	146.6	66.9	2.8	2.4

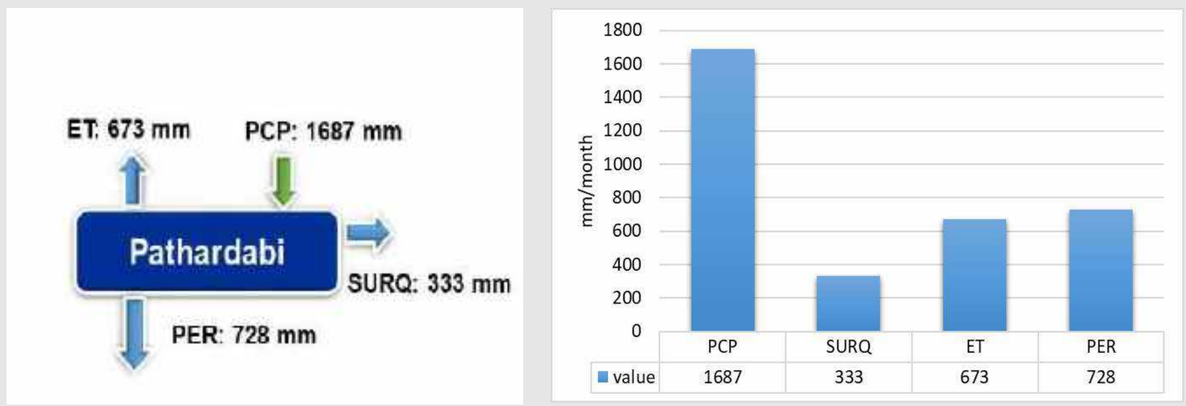
Figure 3.9: Average Monthly water balance

Water Balance for the Village Pathardabi

The simulation results of the annual water for Pathardabi village which is located in the northwest areas of Bangladesh are shown in **Figure 3.10** for the simulation period of 1981 to 2022. The average annual rainfall of the village is 1687 while the national yearly average in the driest part of the country is about 1500. The monsoon starts in May and reaches its peak at about 411.1 mm in July. Monthly variation of water availability is illustrated in **Figure: 3.11**

Rainfall is the input to the water balance. However, water loses through evapotranspiration and percolation and contributes to stream flow through surface runoff. The yearly actual evapotranspiration loss is 673 mm, 32% of annual rainfall; whereas yearly percolation was 728 mm.

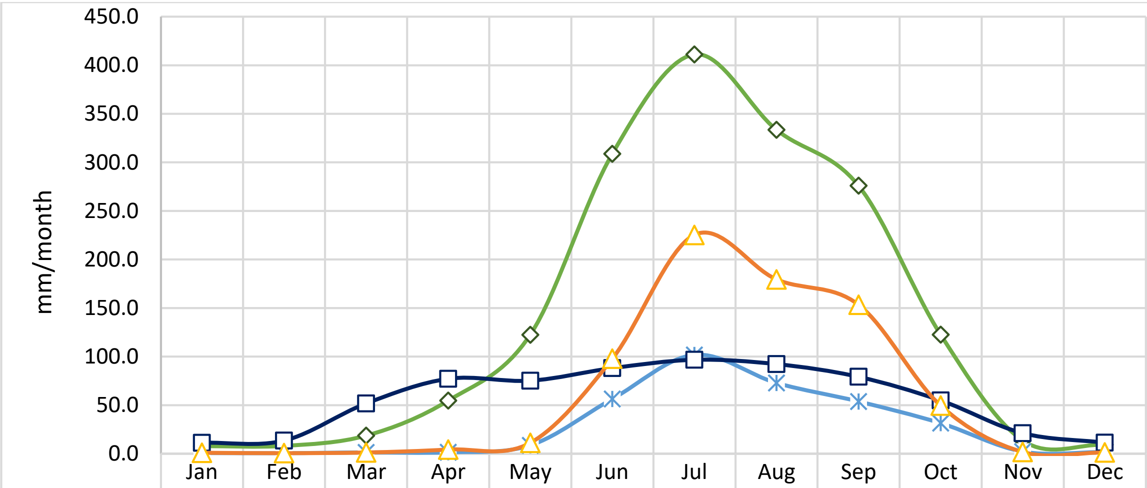
The water loses through evapotranspiration and percolation. The remaining water contributes to stream flow as overland and lateral (subsurface) flow. The water from shallow aquifers also contributes to stream flow as base flow. The annual average surface runoff for Pathardabi is 333 mm.



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

GWQ: Groundwater contribution to stream flow

Figure 3.10: Average annual water balance



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PCP	7.9	8.1	18.7	54.7	122.5	308.8	411.1	333.5	275.9	122.6	13.7	9.2
SURQ	0.7	0.6	1.4	1.5	8.7	56.4	101.8	72.9	53.8	31.5	2.2	1.8
ET	11.3	13.5	51.8	77.2	75.2	88.2	96.8	92.4	79.2	54.9	21.2	11.4
PER	1.0	0.6	1.3	4.4	11.2	97.8	225.4	179.5	153.4	49.6	1.9	1.4

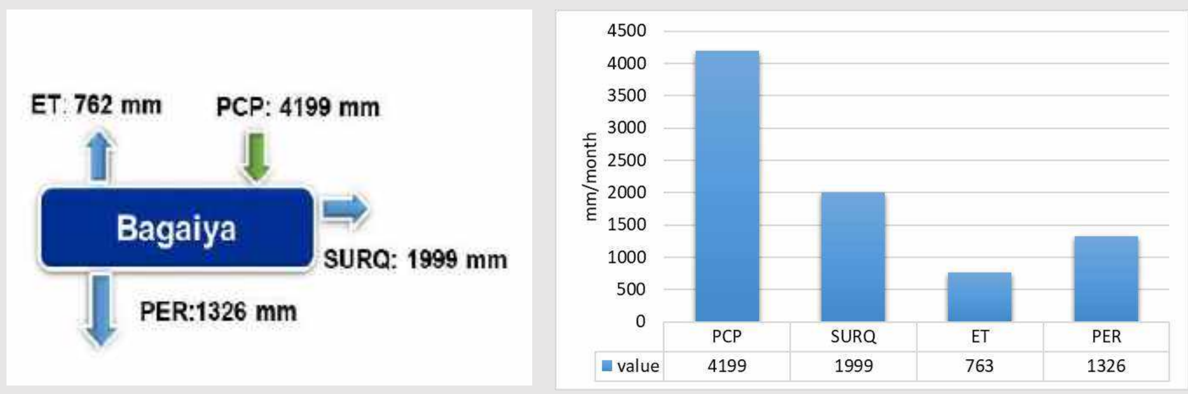
Figure 3.11: Average Monthly water balance

Water Balance for the Village Bagaiya

The simulation results of the annual water for Bagaiya village which is located in the northeast areas of Bangladesh are shown in **Figure 3.12** for the simulation period of 1981 to 2022. The average annual rainfall of the village is 4199 while the national yearly average is about 2100. The monsoon starts in May and reaches its peak at about 426.7 mm in July. Monthly variation of water availability is illustrated in **Figure: 3.13**

Rainfall is the input to the water balance. However, water loses through evapotranspiration and percolation and contributes to stream flow through surface runoff. The yearly evapotranspiration loss is 762 mm, 18% of annual rainfall; whereas yearly percolation was 1326 mm.

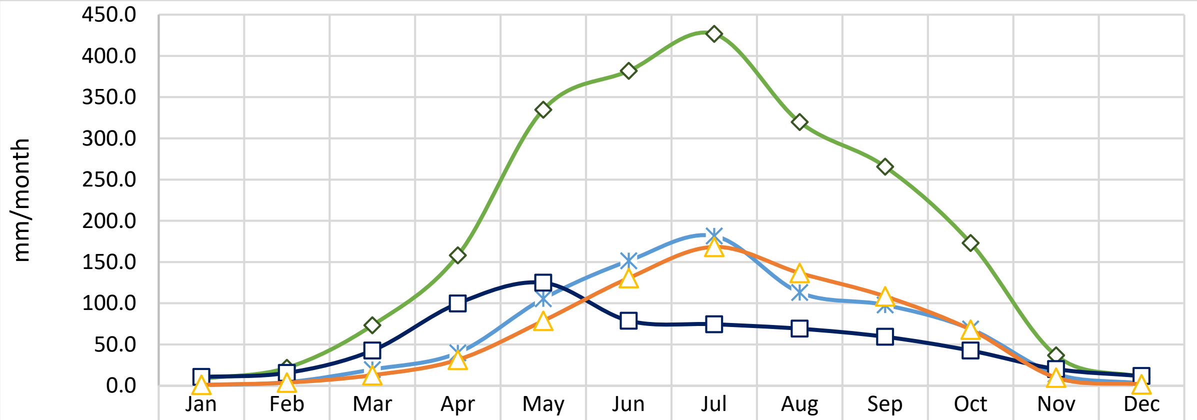
The water loses through evapotranspiration and percolation. The remaining water contributes to stream flow as overland and lateral (subsurface) flow. The water from shallow aquifers also contributes to stream flow as base flow. The annual average surface runoff for Bagaiya is 1999 mm.



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

GWQ: Groundwater contribution to stream flow

Figure 3.12: Average annual water balance



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PCP	8.3	21.7	73.3	158.0	334.8	381.9	426.7	319.8	265.6	173.1	36.8	10.3
SURQ	0.7	4.2	19.6	39.9	105.6	151.5	181.6	113.0	97.9	68.8	14.2	2.8
ET	10.5	15.5	42.6	99.7	124.9	78.8	74.5	69.1	59.3	42.6	20.2	11.7
PER	1.0	3.7	12.7	31.5	78.7	130.6	168.4	136.7	108.4	68.0	9.8	1.6

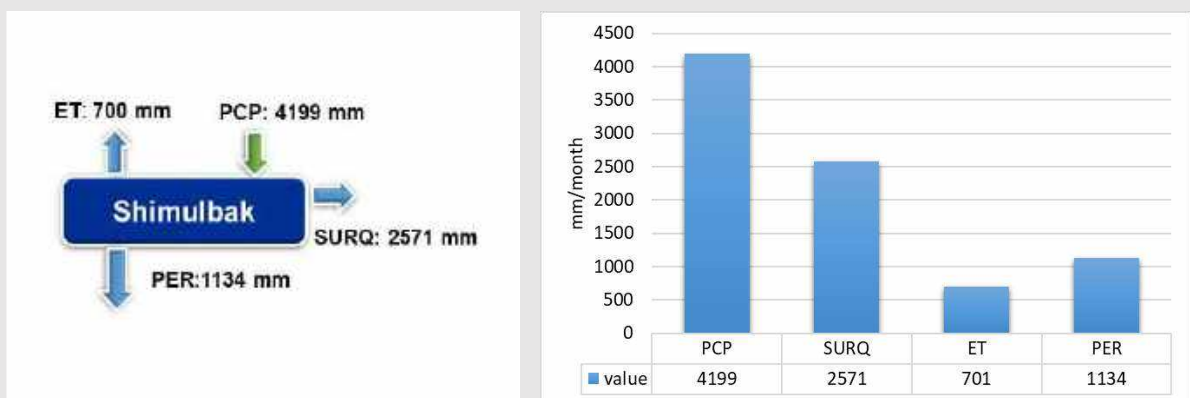
Figure 3.13: Average Monthly water balance

Water Balance for the Village Shimulbak

The simulation results of the annual water for Shimulbak village which is located in the northeast areas of Bangladesh are shown in **Figure 3.14** for the simulation period of 1981 to 2022. The average annual rainfall of the village is 4199 while the national yearly 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: 3.15**

Rainfall is the input to the water balance. However, water loses through evapotranspiration and percolation and contributes to stream flow through surface runoff. The yearly evapotranspiration loss is 700 mm, 18% of annual rainfall; whereas yearly percolation was 1134 mm.

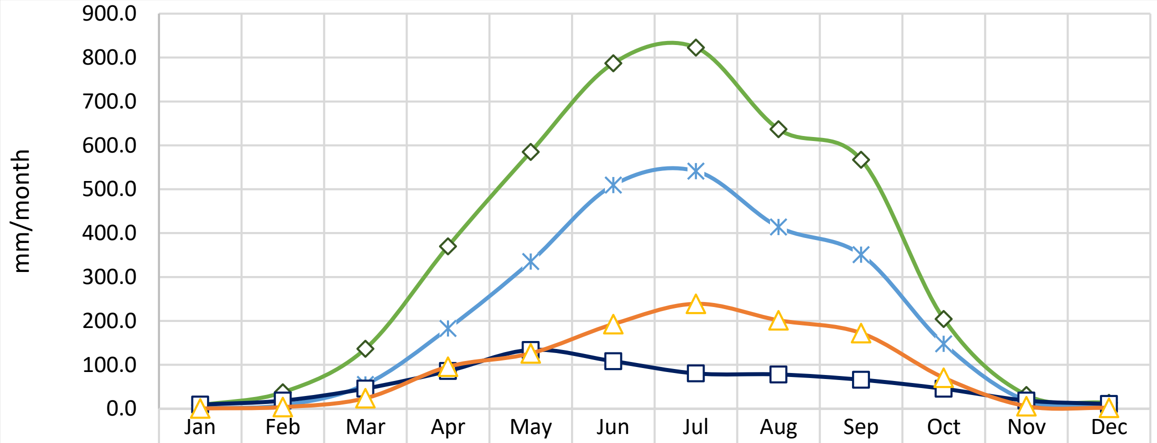
The water loses through evapotranspiration and percolation. The remaining water contributes to stream flow as overland and lateral (subsurface) flow. The water from shallow aquifers also contributes to stream flow as base flow. The annual average surface runoff for Shimulbak is 2551 mm.



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

GWQ: Groundwater contribution to stream flow

Figure 3.14: 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 3.15: Average Monthly water balance

Ground Water

Annual groundwater data for the eight villages have been collected from BWDB through National Water Resources Database website for the years 1984 to 2013. The nearest station data has been considered for some villages with data unavailability. Then the trend analysis was 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

1. Induria, Barishal

Annual groundwater data for a thirty (30) years period for Induria village have been analyzed and graphically represented in the **Figure 3.16**. The figure depicts a little growing tendency in groundwater over time. It is found that the water level is not changed much during this time span.

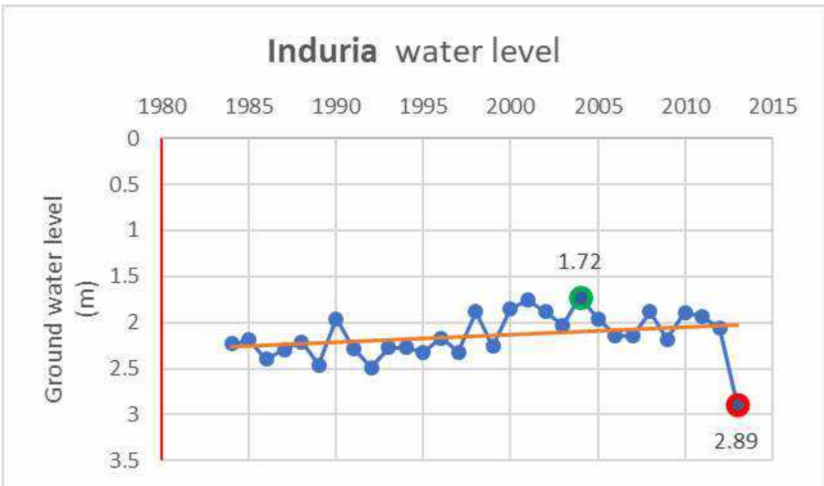


Figure 3.16: Annual groundwater trend (1984-2013) in Induria village

2. Charsharat, Chattogram

Annual groundwater data for a thirty (30) years period for Induria village have been analyzed and graphically represented in the **Figure 3.17.** The graph demonstrates the groundwater level's declining tendency over time. In 1993 the groundwater level was observed at 1.08 m, whereas in 2010 the value was 2.67 m. So, during this period the groundwater level has been lowered by 1.59m.

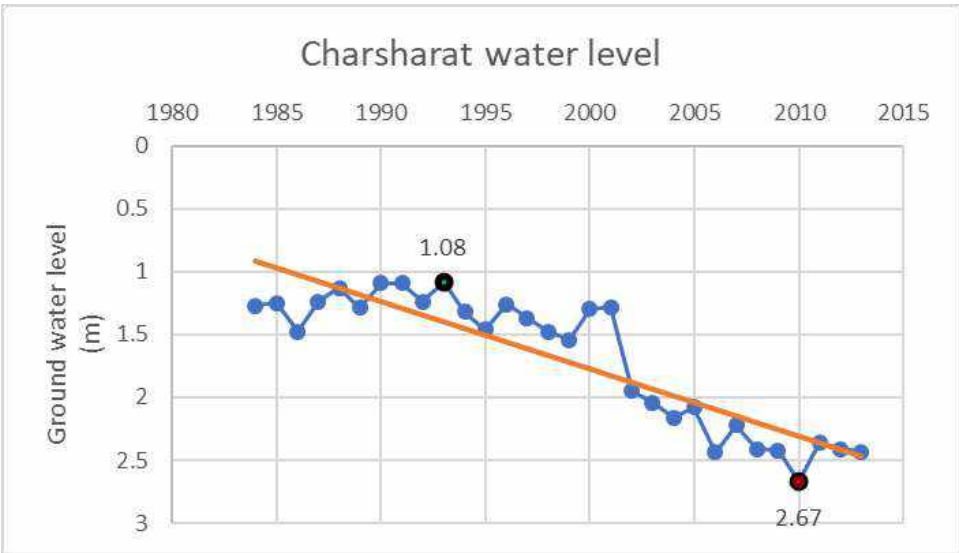


Figure 3.17: Annual groundwater trend (1984-2013) in Charsharat village

3. Pathordubi, Kurigram

Annual groundwater data for a twenty-seven (27) years period for Pathordubi village have been analyzed and graphically represented in figure14. The figure shows a slightly downward movement of the water level. In 1984 the water level was found at 2.37m and in 2011 the level was moved to 4.22m. There is a sharp movement in water level from 2010 to 2011. This may be due to the lack of rainfall occur in 2010.

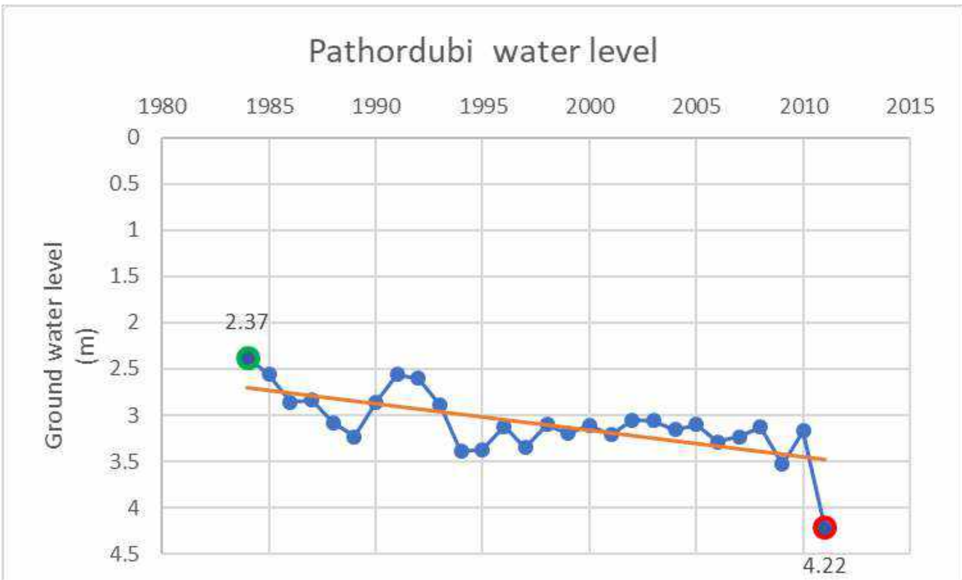


Figure 3.18: Annual groundwater trend (1984-2013) in Pathordubi village

4. Datinakhali, Satkhira

For Datinakhali village, annual groundwater data for a thirty (30) year period have been studied and visually shown in the **Figure 3.19**. 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.

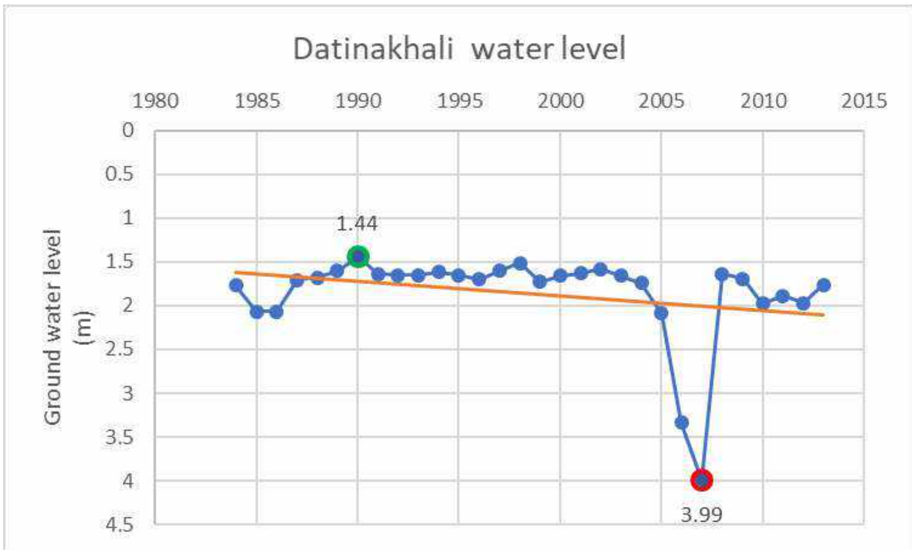


Figure 3.19: Annual groundwater trend (1984-2013) in Datinakhali village

5. Shimulbank, Sunamganj

Annual groundwater data for a twenty-two (22) years period for Shimulbank village have been analyzed and graphically represented in **Figure 3.20**. 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.

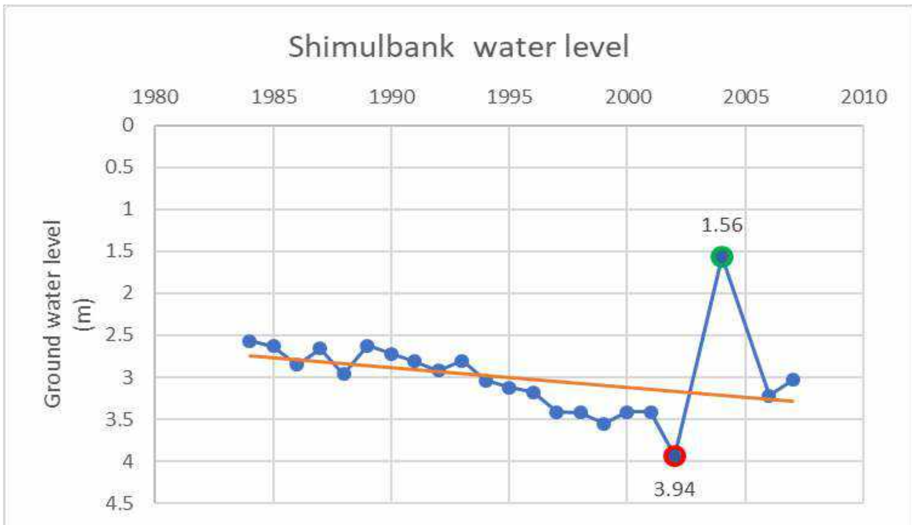


Figure 3.20: Annual groundwater trend (1984-2013) in Shimulbank village

6. Bagaiya, Sylhet

Annual groundwater data for a thirty (30) years period for Bagaiya village have been analyzed and graphically represented in **Figure 3.21**. The time series data demonstrate that groundwater occurs in this region at relatively shallow depths. The figure shows a slightly lowering trend in water level. The water table changed significantly from 4.68 meters in 2010 to 7.64 meters in 2011, and then again a sharp shift to the value of 2.92m.

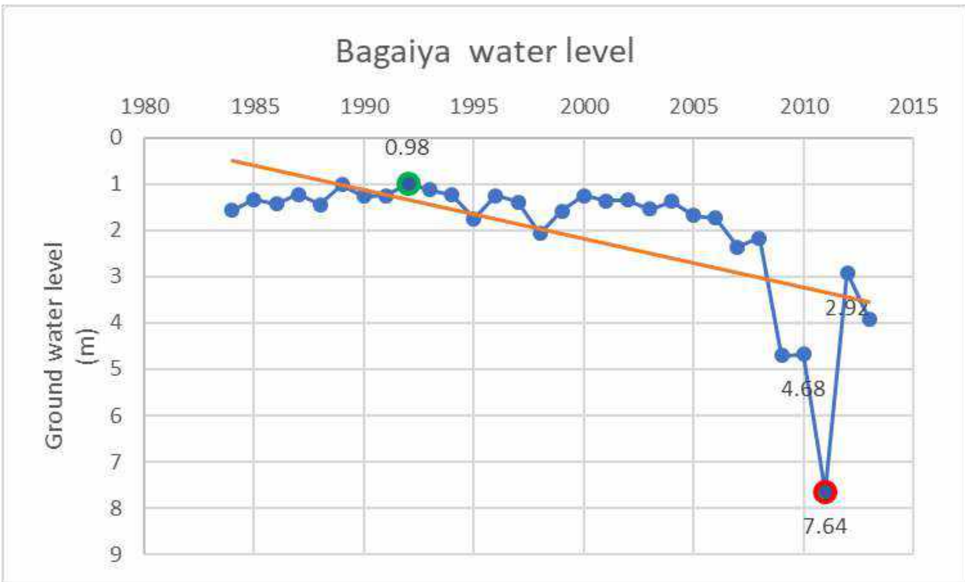
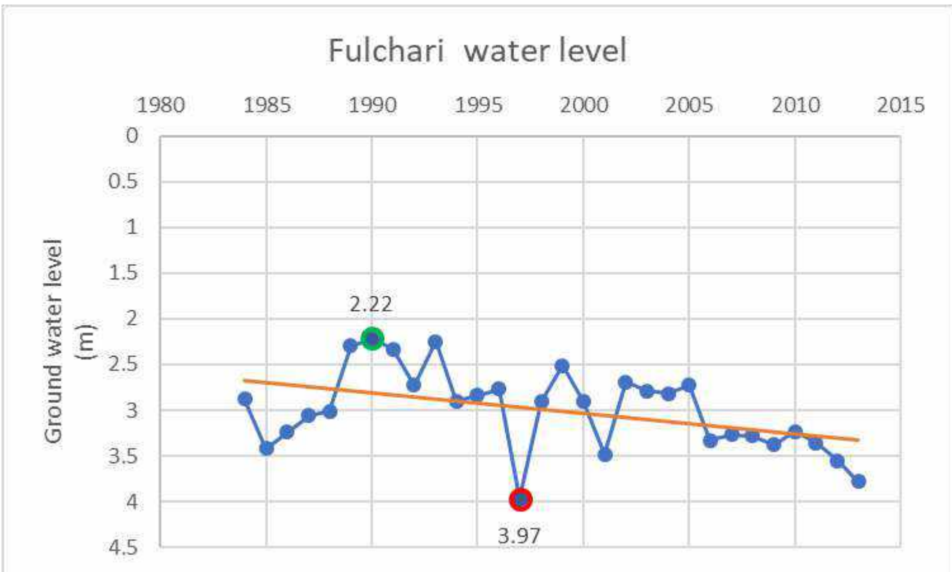


Figure 3.21: Annual groundwater trend (1984-2013) in Bagaiya village

7. Fulchari, Gaibandha

Figure 3.22 shows the trend analysis of the annual groundwater level for the Fulchari village over a thirty (30) year period. The groundwater level is trending slightly lower, as seen by the graph. The groundwater levels were discovered in 1990 at a depth of 2.22 m and 3.97 m in 1997.



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8. Tipna, Khulna

Annual groundwater data for a thirty (30) years period for Tipna village have been analyzed and graphically represented in the **Figure 3.23**. 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.

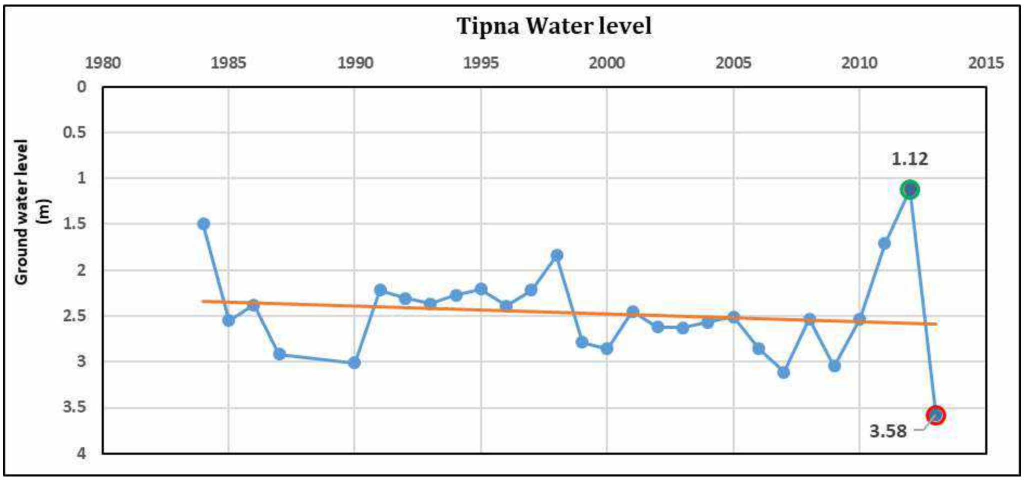


Figure 3.22: Annual groundwater trend (1984-2013) in Tipna village

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 (DPHE). In the cases of Bagaiya, Simulbank, and Chotta Harina villages, 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 3.1-3.6** shows the suitable aquifer for a safe piped water supply and water quality of the aquifer.

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/I, chloride (CI^-) concentration is 30 mg/I and arsenic (As) concentration is 0.008 mg/I. From the water quality result, it is seen that iron, arsenic and chloride concentration is with in allowable limit of drinking water standards (ECR 1997).

Table 3.1: Water point depth and water quality of the test wells in Tipna Village of Dumuria Upazila under Khulna district

SL	Latitude	Longitude	Water Point Depth	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**

District: Kurigram, Upazila: Bhurungamari, Union: Pathordubi, Village: Pathordubi

For Pathordubi village in kurigram district, suitable aquifer has been found in suitable aquifer has been found in shallow depth (60m). Water quality test result from test well shows iron (Fe) concentration is 0.20-0.90 mg/I, chloride (CI-) concentration is 25-26 mg/I and arsenic (As) concentration is 0.001-0.003 mg/I. From the water quality result, it is seen that Iron, arsenic and chloride concentration is with in allowable limit of ECR 1997.

Table 3.2: Water point depth and water quality of the test wells in Pathordubi Village of Bhurungamari Upazila under Kurigram district

SL	Latitude	Longitude	Water Point Depth	Water Quality Parameters		
				Fe (mg/l)	As (mg/l)	CI^- (mg/l)
1.	26.156975	89.624091	60.97	0.5	0.001	25
2.	26.146665	89.604215	60.97	0.4	0.001	26
3.	26.141769	89.625344	61	0.9	0.003	26
Drinking Water Standards (ECR, 1997)				**0.3-1.0**	**0.05**	**150-600**

District: Barisal; Upazila: Hijla; Union: Memania; Village: Induria

In Induria village of Hijla Upazila under Barisal district suitable aquifer has been found in Deep depth (268m). Water quality test result from test well shows iron (Fe) concentration is 0.184-0.196 mg/I, chloride (CI-) concentration is 35 mg/I and arsenic (As) concentration is 0.0001 mg/I. From the water quality result, it is seen that Iron, arsenic and chloride concentration is with in allowable limit of ECR 1997.

Table 3.3: Water point depth and water quality of the test wells in Induria Village of Hijla Upazila under Barisal district

SL	Latitude	Longitude	Water Point Depth	Water Quality		
				Fe (mg/l)	As (mg/l)	CI^- (mg/l)
	22.96664	90.51837	268	0.196	0.0001	35
	22.96766	90.52307	267	0.184	0.0001	35
	22.96748	90.52313	268	0.196	0.0001	35
Drinking Water Standards (ECR, 1997)				**0.3-1.0**	**0.05**	**150-600**

District: Sylhet; Upazila: Gowainghat; Union: Rustimpur; Village: Bagaiya

In Bagaiya village of Gwainghat Upazila under Sylhet district suitable aquifer has been found in Shallow depth (54.50 m). Water quality test result from test well shows iron (Fe) concentration is 4.5 mg/I, chloride (CI-) concentration is 19 mg/I and arsenic (As) concentration is 0.015 mg/I. From the water quality result, it is seen that Iron, arsenic and chloride concentration is with in allowable limit of ECR 1997.

Table 3.4: Water point depth and water quality of the test wells in Bagaiya Village of Gowainghat Upazila under Sylhet district

SL	Latitude	Longitude	Water Point Depth	Water Quality		
				Fe (mg/l)	As (mg/l)	CI^- (mg/l)
	25.15209	91.88243	54.50	4.5	0.015	19
Drinking Water Standards (ECR, 1997)				**0.3-1.0**	**0.05**	**150-600**

District: Gaibandha, Upazila: Fulchari, Union: Fulchari, Village: Baje Fulchari

In Baje Fulchari village of Fulchari Upazila under Gaibandha district suitable aquifer has been found in Shallow depth (38 m). Water quality test result from test well shows iron (Fe) concentration is 0.5 – 0.8 mg/I, chloride (CI-) concentration is 24-28 mg/I and arsenic (As) concentration is 0.001 – 0.002 mg/I. From the water quality result, it is seen that Iron, arsenic and chloride concentration is with in allowable limit of ECR 1997.

Table 3.5: Water point depth and water quality of the test wells in Baje Fulchari Village of Fulchari Upazila under Gaibandha district

SL	Latitude	Longitude	Water Point Depth	Water Quality		
				Fe (mg/l)	**As (mg/l)**	**CI$^-$ (mg/l)**
	25.18664	89.64109	38.10	0.5	0.001	24
	25.20597	89.63057	36.58	0.8	0.002	28
Drinking Water Standards (ECR, 1997)				**0.3-1.0**	**0.05**	**150-600**

District: Chattogram, Upazila; Mirsarai, Union: Ichakhali, Village; Charsharat.

In Charsharat village of Mirsarai Upazila under Chattogram district suitable aquifer has been found in Deep depth (160 m). Water quality test result from test well shows iron (Fe) concentration is 0.09-0.12 mg/I, chloride (CI-) concentration is 30-180 mg/I and arsenic (As) concentration is 0.001-0.005 mg/I. From the water quality result, it is seen that Iron, arsenic and chloride concentration is with in allowable limit of ECR 1997.

Table 3.6: Water point depth and water quality of the test wells in Charsharat Village of Mirsarai Upazila under Chattogram district

SL	Latitude	Longitude	Water Point Depth	Water Quality		
				Fe (mg/l)	**As (mg/l)**	**CI$^-$ (mg/l)**
	22.44225	91.29549	167.98	0.12	0.004	180
	22.44372	91.29392	155.48	0.15	0.005	165
	22.45361	91.30234	161.58	0.09	0.001	30
Drinking Water Standards (ECR, 1997)				**0.3-1.0**	**0.05**	**150-600**

3.2 Hydrogeological Assessment

Bangladesh was hydrogeologically classed as a younger alluvium, complex geology, older alluvium, and coastal area based on its physiography, geology, and groundwater development potential (BGS, 1979). Folded Tertiary formations make the hydrogeology difficult. The groundwater survey identified 15 development zones (UNDP, 1982). Each zone's development potential is compared to the others.

At the moment, the principal water delivery systems that are being utilized at Datinakhali are the PSF, RWHS, SST/VSST, and STW, No. 6 systems. In most cases, the water contained in the underlying aquifer is not of very good quality. Both the existence of high arsenic levels in shallow groundwater and the presence of excessive salinity in groundwater pose a threat to the area, and both of these hazards pose a risk to the region. The bad quality of the water, which is caused by the intrusion of brackish and salty water, is a significant barrier to development, and the conditions of the groundwater are highly unpredictable, which further worsens the problem.

In Tipna, the most effective water supply technologies at the moment are the DTW (Deep Tubewell), No. 6/T. Dev, and STW (Shallow Tubewell). Water of good quality can typically be found 700 feet below the surface of the ground. The region is at risk for both the occurrence of high arsenic levels in shallow groundwater and the presence of high salinity in groundwater. Development is severely hampered by the low quality of water caused by the incursion of brackish and saline water, and groundwater conditions are extremely changeable. The main and composite aquifers can only be developed in solitary freshwater regions. The level of groundwater is not particularly deep, and the trend in the level is nearly constant right now. A deep tubewell between 250 and 300 meters can be built to provide the villagers with water.

The STW (Shallow Tubewell) and No. 6 are the primary water supply techniques now used in Pathordubi. Water of good quality can usually be found 75 feet below the surface of the ground. The majority of the area is made up of the Teesta River's coarse sediments, which have the highest transmissivities in the nation. Some sections of the water have a high iron content, but overall the water quality is good. The depth of the groundwater is not great, and the trend in the level is nearly constant right now. To provide water to the villagers, a deep tubewell up to 100 meters deep can be built.

In Induria Deep Tubewell, No. 6/T. Dev. (DTW) is a prime example of current water supply technology. In most cases, good water can be found 900 feet below the surface of the earth. The region is at risk for both the occurrence of high arsenic levels in shallow groundwater and the presence of high salinity in groundwater. Development is severely hampered by the low quality of water caused by the incursion of brackish and saline water, and groundwater conditions are extremely changeable. Water abstraction for the village's residents can be accomplished by building a deep tubewell, up to roughly 300 meters deep. The level of groundwater is not particularly deep, and the trend in the level is nearly constant right now.

The STW (Shallow Tubewell) and No. 6 are the primary water delivery techniques now used in Fulchari. 50 feet below the surface of the ground is the typical depth at which good quality water is found. According to hydrogeology, the region seems to have the greatest potential for groundwater development. The majority of the area is made up of the Teesta River's coarse sediments, which have the highest transmissivities in the nation. Some sections of the water have a high iron content, but overall the water quality is good. The depth of the groundwater is not great, and the trend in the level is nearly constant right now. Although there is a slight chance of finding arsenic in shallow groundwater, the area is practically devoid of the possibility of highly salinized groundwater.

In Shimulbak, DTW (Deep Tubewell) and No 6/ T. Dev. are acting as prime water supply technologies. Good quality water is typically found at a depth of 650 feet below ground. The area is hydro-geologically complex, with a series of folded tertiary formations. The region is deemed unsuitable for extensive groundwater development. Because the aquifers have low transmissivities, intensive development would result in significant drawdown. Deep tubewell of about 300 meters can be built to extract water. The area is nearly free of the risk of high salinity in groundwater, but there is a reasonable risk of arsenic in shallow groundwater.

At Bagaiya, DTW (Deep Tubewell, No. 6) and STW (Shallow Tubewell, No. 6) are examples of current prime water supply technology. Good quality water is typically found at a depth of 450 feet below ground. 133. The area is hydro-geologically complex, with a set of folded Tertiary formations. The region is deemed unsuitable for extensive groundwater development. Because the aquifers have low transmissivities, intensive development would result in significant drawdown. Deep tubewell of about 200 meters can be built to extract water. The area is nearly free of the risk of high salinity in groundwater, but there is a moderate risk of arsenic in shallow groundwater.

At Charsarat, DTW (Deep Tubewell), No. 6/T. Dev, STW (Shallow Tubewell) and No. 6 are examples of current prime water supply technology. Good quality water is typically found at a depth of 600 feet below ground. The area is at risk of high salinity in groundwater, as well as a moderate risk of high arsenic in shallow groundwater. Groundwater situations are highly variable, and development is hampered by the low quality of water caused by brackish and saline water intrusion. The depth of the groundwater level is not very great, and the current trend of the groundwater level is nearly constant.

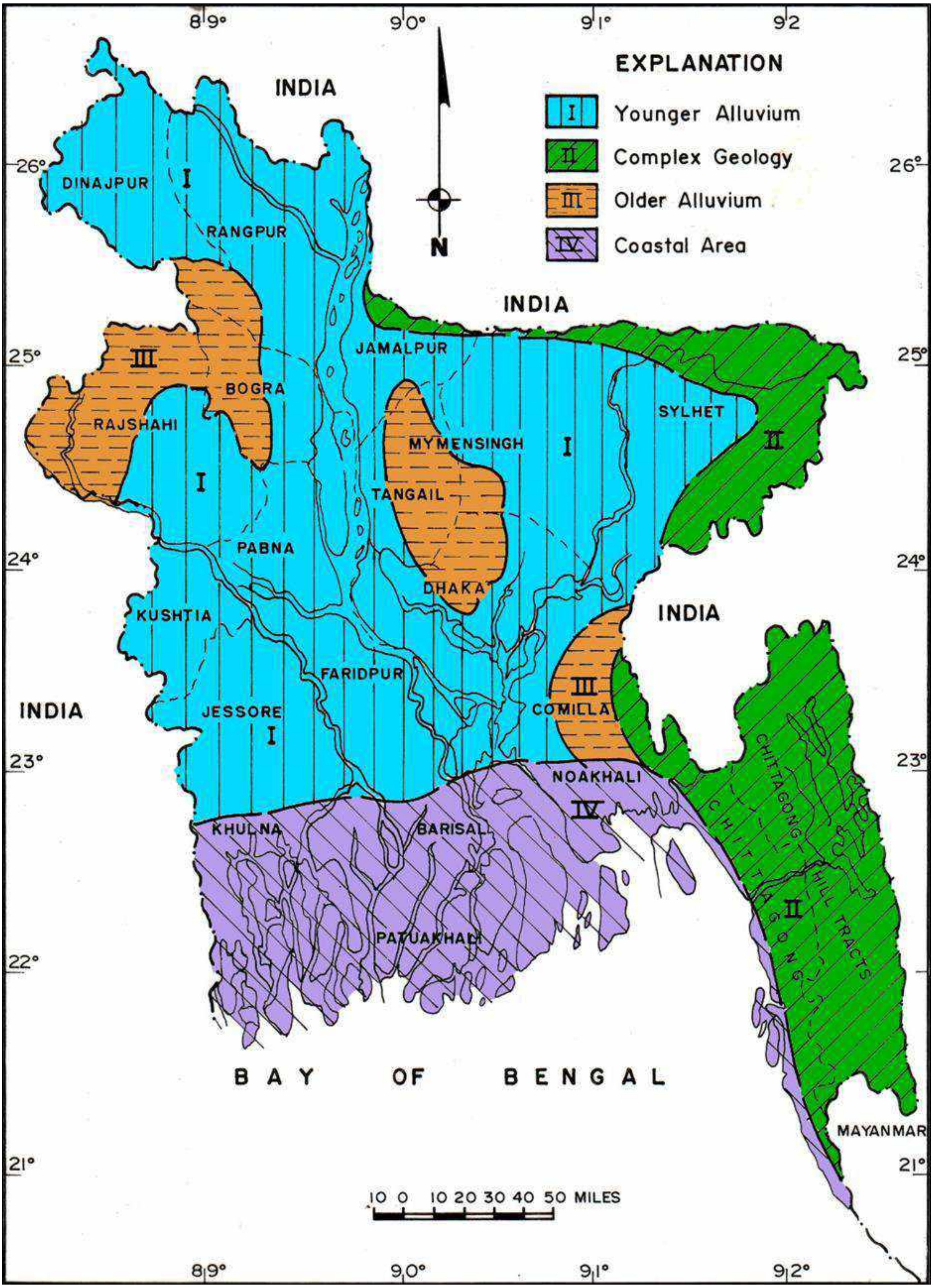


Figure 3.23: Hydrogeological Classification of Bangladesh (bgs 1979)

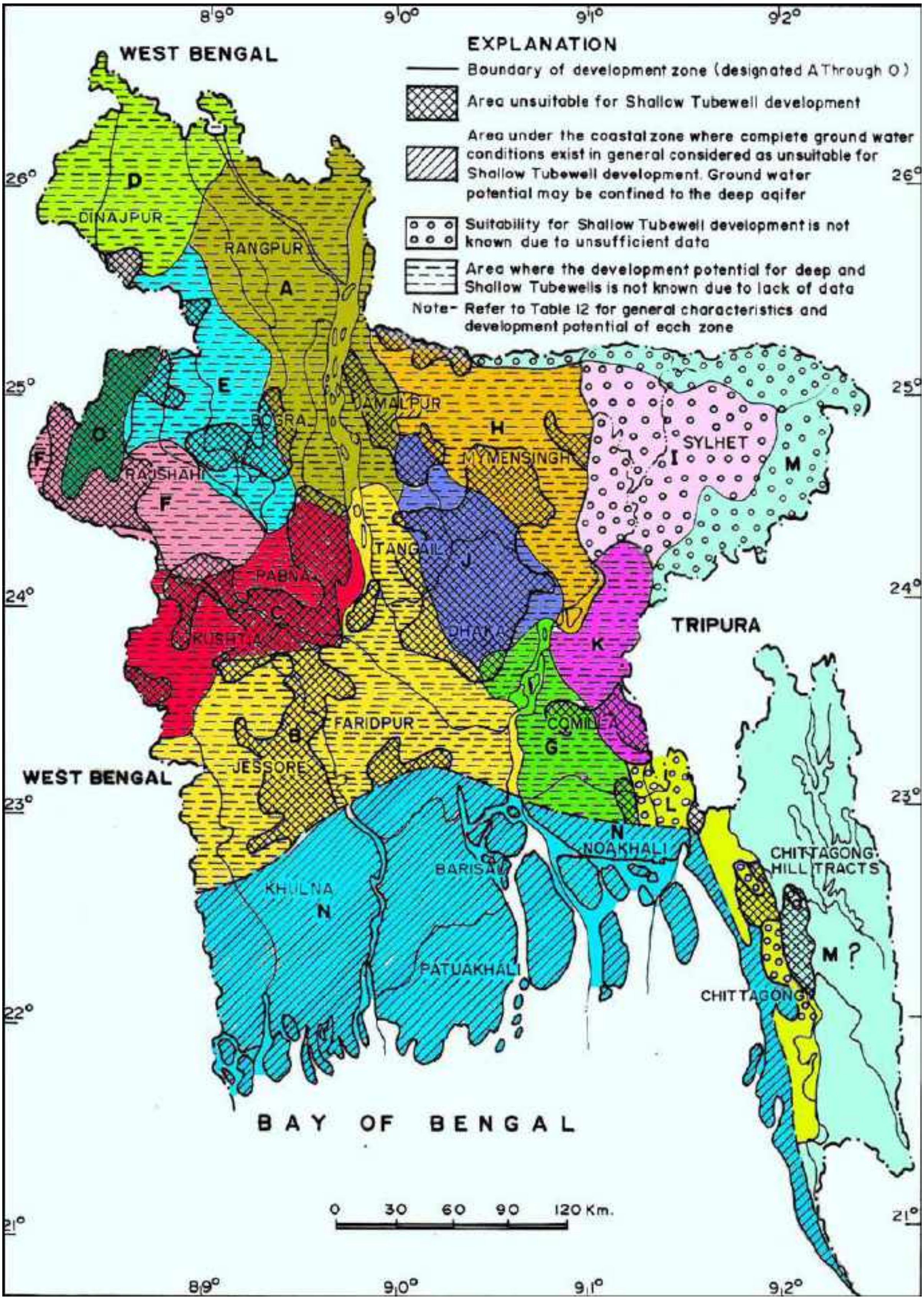


Figure 3.24: Major Groundwater Development Zone of (UNDP 1982)

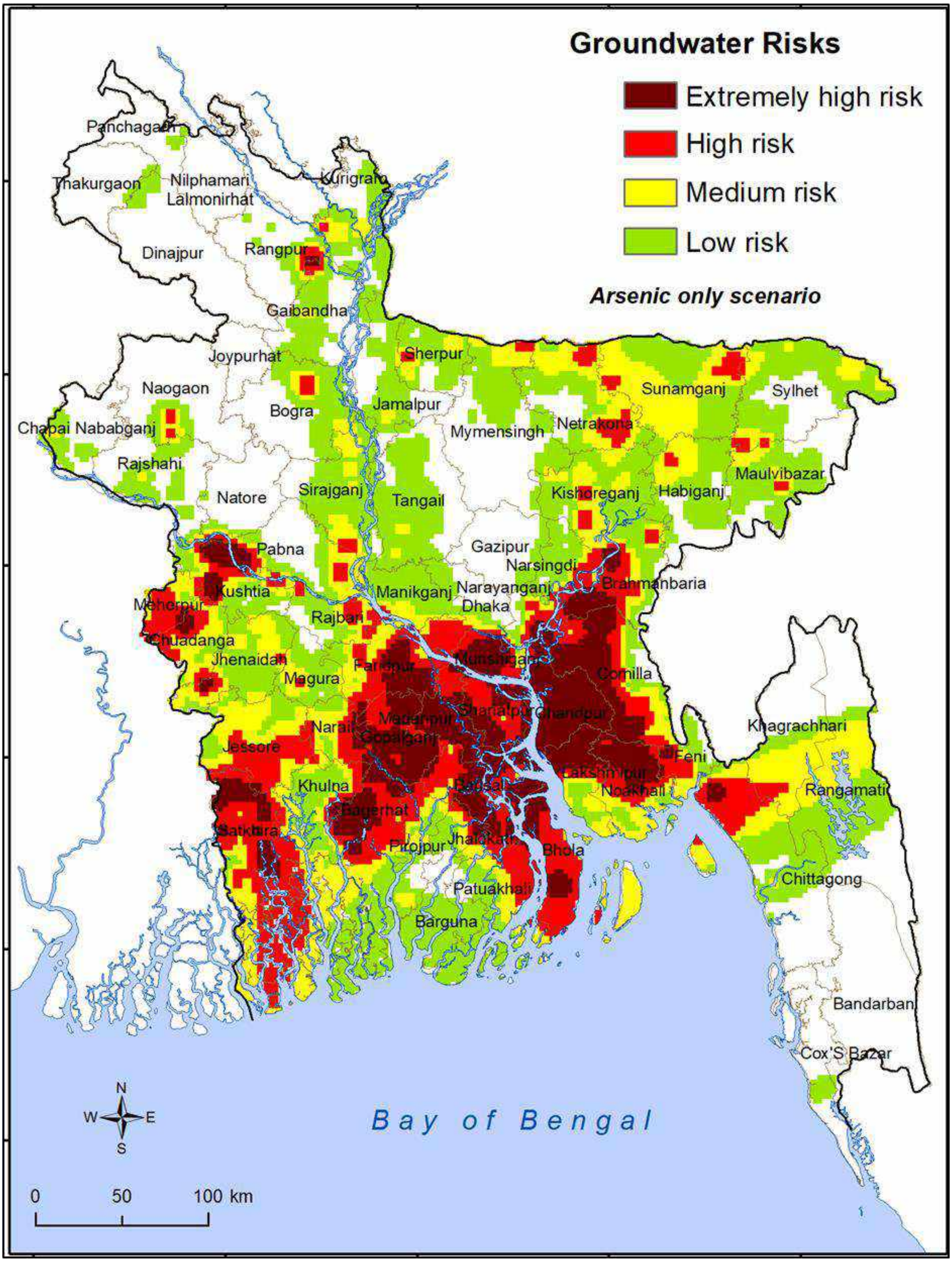


Figure 3.25: Groundwater risk maps at the national scale in Bangladesh featuring risks imposed by groundwater arsenic alone

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).

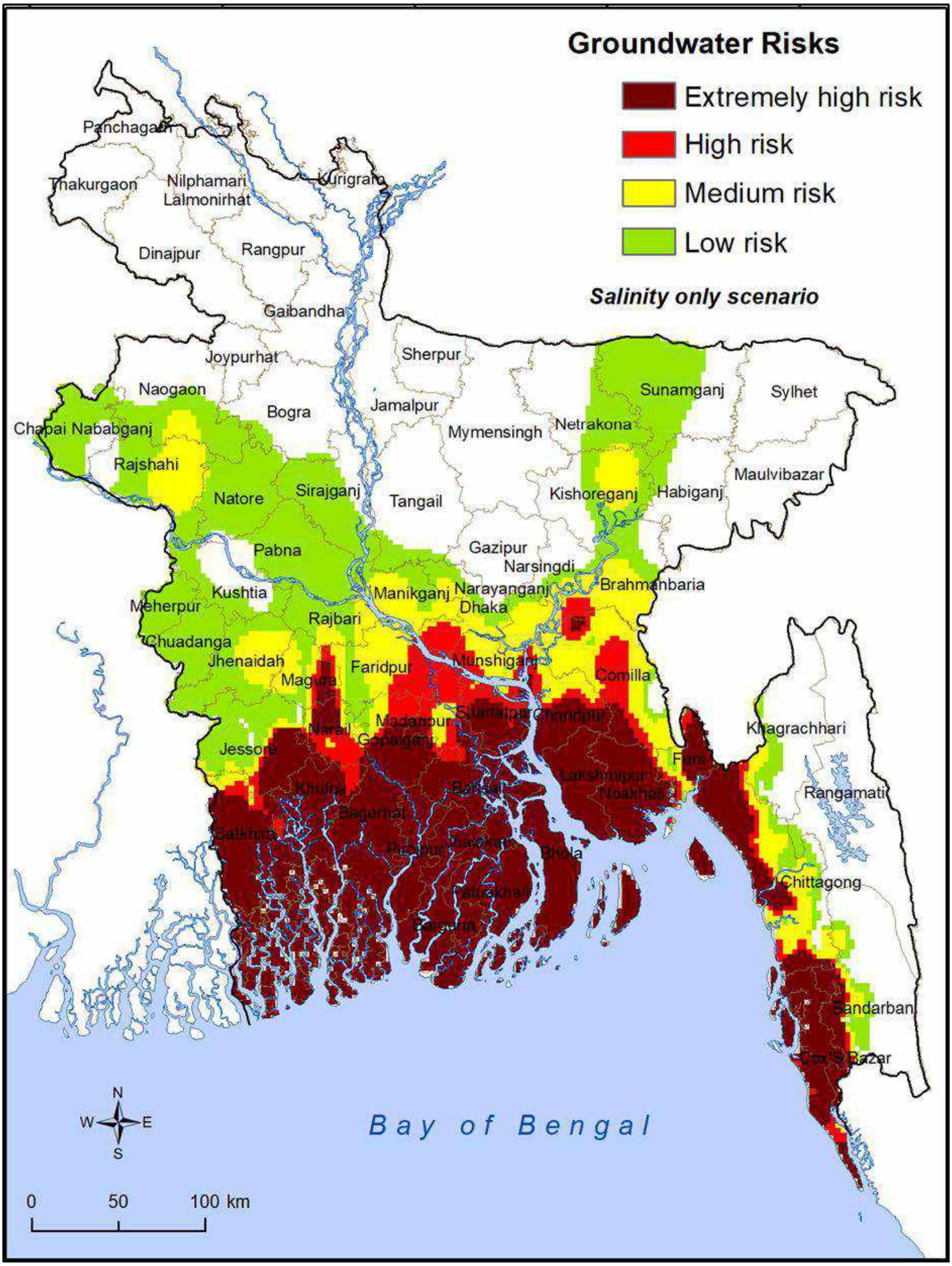


Figure 3.26: Groundwater risk maps at the national scale in Bangladesh featuring risks imposed by groundwater salinity (EC: electrical conductivity) alone

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).

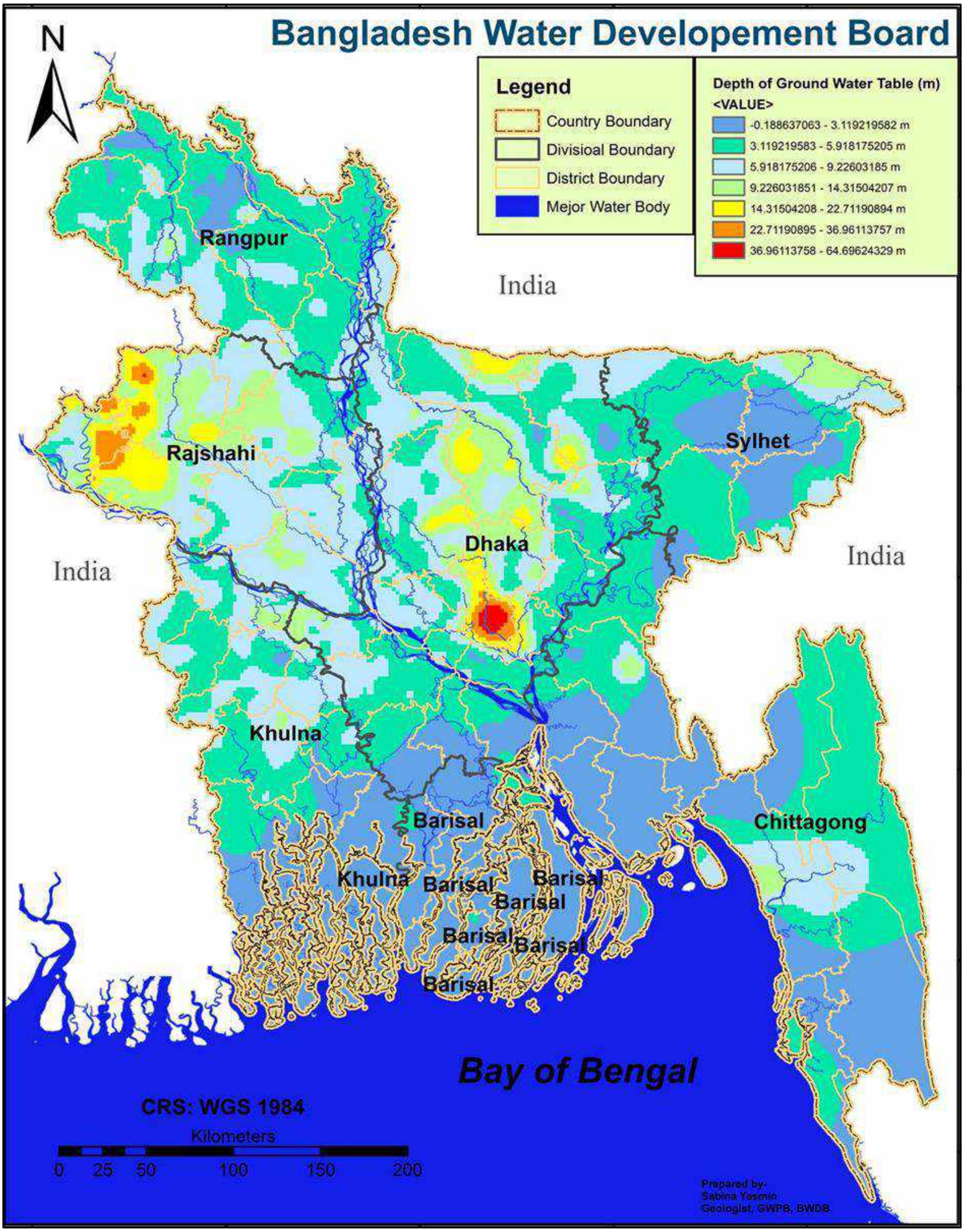


Figure 3.27: Depth to Groundwater Table in dry season 2016

Table 3.7: Overall Hydrogeological Information

Village	Hydrogeological Classification	Major Groundwater Development Zone	Average Groundwater Depth(ft)	Groundwater Risk Based on Arsenic Concentrations	Groundwater Risk Based on Salinity
Induria	Coastal Area	Zone-N	6-9	Extreamly high risk	Extreamly high risk
Fulchari	Younger Alluvium	Zone A	3-6	Low risk	No risk
Tipna	Coastal Area	Zone-N	6-9	Low risk	Extreamly high risk
Pathordubi	Younger Alluvium	Zone A	3-6	No risk	No risk
Datinakhali	Coastal Area	Zone-N	6-9	Extreamly high risk	Extreamly high risk
Shimulbank	Younger Alluvium	Zone I	3-6	High risk	Low risk
Bagaiya	Younger Alluvium	Zone I	0-3	Low risk	No risk
Charsarat	Complex Geology	Zone N	3-6	High risk	Extreamly high risk

Zone A refers to the excellent groundwater development potentiality. Zone N refers to the domestic supply.

3.3 Climate Change Risk Assessment

Assessment of future climate change is of great importance for the sustainable planning of the water resources of Bangladesh. Global climate change impacts Bangladesh's temperature, rainfall, the overall hydrologic cycle, and the Ganges basin. Therefore, assessing future climate change in the availability of water resources and demand is essential for long-term future planning.

Global Circulation Models (GCM) simulate plausible future climate conditions based on different scenarios. IPCC assesses future climate change through the Coupled Model Inter-comparison Project (CMIP). 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.The narratives 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 the 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 have been used for future climate change assessment as these scenarios represent the 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 to 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 experience performing climate change analysis for future scenario development through dynamic and statistical downscaling. CEGIS has proven and strong expertise in processing and analysing the GCM and downscaled data and performing statistical and dynamic downscaling for Bangladesh.

The GCM and dynamically downscaled RCM outputs contain significant system biases for 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 before using RCMs in climate change impact assessment at the local scale.

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

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

The downscaling exercises and future climate change anomalies assessment through bias correction have been performed on Maximum Temperature, Minimum Temperature, and Rainfall (precipitation) for three different SSPs of the CMIP6 dataset in different time slices up to 2100. The time slices considered were the 2050s (2036-2065) under two SSP scenarios, i.e., SSP126, SSP370, and SSP585. Following IPCC practice, the base period for the climate change analysis has been considered from 1981 to 2022.

The precipitation and temperature are assumed to change in the future under various climate change scenarios. The following tables summarize the change in rainfall and temperature for three climate change scenarios SSP126, SSP370, and SSP585. It would help to understand the climate change in the selected villages.

Table 3.8: 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 3.9: Change in Temperature for Datinakhali Village by 2050s Different Climate Change Scenerio

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 3.10: Change in Rainfall for Tipna Village by 2050s Different Climate Change Scenerio

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 3.11: Change in Temperature for Tipna Village by 2050s Different Climate Change Scenerio

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

Table 3.12: Change in Rainfall for Pathardubi Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Rainfall (%)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
SSP126	3.42	2.86	5.21	10.39	-4.30	-3.91	-3.53	6.12	4.75	8.35	11.70	-0.47
SSP370	3.59	4.14	-7.30	9.89	-0.39	-1.83	-2.16	8.79	7.81	6.44	-0.64	-3.49
SSP585	4.79	3.14	6.63	16.05	4.52	-1.16	-1.52	8.91	4.12	13.31	11.91	2.56

Table 3.13: Change in Temperature for Pathardubi Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Temperature (0C)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
SSP126	1.48	1.72	1.62	1.32	1.54	1.70	1.30	1.20	1.42	1.50	1.52	1.66
SSP370	1.86	1.92	1.58	1.16	1.22	1.62	1.62	1.60	1.88	2.10	1.98	1.82
SSP585	2.28	2.12	2.06	1.76	1.84	1.88	1.92	1.92	2.26	2.40	2.38	2.28

Table 3.14: Change in Rainfall for Induria Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	-4.03	-2.67	3.36	6.01	-3.21	-4.90	1.73	6.30	9.08	12.87	6.83	-5.75
SSP370	-3.53	-4.92	-9.57	7.31	-4.56	-9.16	0.78	6.61	7.66	4.51	-1.57	-8.00
SSP585	-3.87	5.58	-1.15	7.10	3.77	-4.83	3.39	10.64	10.29	4.86	3.60	-0.25

Table 3.15: Change in Temperature for Induria Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.32	1.62	1.34	1.22	1.26	1.30	1.12	1.00	1.20	1.32	1.38	1.40
SSP370	1.80	1.94	1.64	1.30	1.32	1.52	1.46	1.44	1.66	1.90	1.90	1.62
SSP585	2.02	2.00	1.86	1.60	1.60	1.76	1.66	1.62	1.88	2.08	2.14	1.94

Table 3.16: Change in Rainfall for Fulchari Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	3.42	2.86	5.21	10.39	-4.30	-3.91	-3.53	6.12	4.75	8.35	11.70	-0.47
SSP370	3.59	4.14	-7.30	9.89	-0.39	-1.83	-2.16	8.79	7.81	6.44	-0.64	-3.49
SSP585	4.79	3.14	6.63	16.05	4.52	-1.16	-1.52	8.91	4.12	13.31	11.91	2.56

Table 3.17: Change in Temperature for Fulchari Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.48	1.72	1.62	1.32	1.54	1.70	1.30	1.20	1.42	1.50	1.52	1.66
SSP370	1.86	1.92	1.58	1.16	1.22	1.62	1.62	1.60	1.88	2.10	1.98	1.82
SSP585	2.28	2.12	2.06	1.76	1.84	1.88	1.92	1.92	2.26	2.40	2.38	2.28

Table 3.18: Change in Temperature for Bagaiya Village by 2050s Different Climate Change Scenerio

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 3.19: Change in Temperature for Bagaiya Village by 2050s Different Climate Change Scenerio

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 3.20: Change in Temperature for Shimulbak Village by 2050s Different Climate Change Scenerio

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 3.21: Change in Temperature for Shimulbak Village by 2050s Different Climate Change Scenerio

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 3.22: Change in Temperature for Charsarat Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	-2.97	-6.39	3.81	-0.07	-5.77	0.24	6.47	7.77	12.62	10.62	4.27	-2.11
SSP370	-3.24	-7.48	-7.46	-0.65	-7.28	-4.30	4.70	9.70	13.60	4.57	0.21	-8.25
SSP585	-2.97	3.78	0.57	1.89	-0.62	2.08	6.66	10.09	14.98	7.89	1.83	0.18

Table 3.23: Change in Temperature for Charsarat Village by 2050s Different Climate Change Scenerio

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.28	1.56	1.30	1.20	1.28	1.30	1.04	0.94	1.12	1.26	1.30	1.40
SSP370	1.80	1.98	1.66	1.36	1.38	1.56	1.38	1.38	1.60	1.86	1.88	1.70
SSP585	2.22	2.08	1.90	1.70	1.68	1.78	1.64	1.66	1.88	2.08	2.24	2.14

3.4 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 **Figure 3.28-3.35.**

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 228. The minimum number of pond is observed within the class of '0-100m^3 and '>5000' 'which is 4% of the total surveyed pond. The total number of pond under all class is around 761.

Table 3.24: Water Volume Class of Disaster Prone Villages

District	Upazila	Union	Village	Total Pond	Dry season water volume class (m3)						
					C1	C2	C3	C4	C5	C6	C7
					(No of Pond)						
Barishal	Hijla	Memania	Induria	75	1	12	25	23	13	1	0
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
Chattagram	Mirsarai	Ichakhali	Charsharat	170	4	2	2	30	109	16	7
Kurigram	Bhurungamari	Pathordubi	Pathordubi	86	1	14	22	26	17	4	2
Sylhet	Gowainghat	Rustimpur	Bagaiya	39	0	0	0	3	14	6	16
Gaibandha	Fulchari	Fulchari	Fulchari	17	0	0	4	3	7	1	2
Total (%)				**100%**	**4%**	**19%**	**19%**	**20%**	**30%**	**5%**	**4%**

Table 3.25: Class Ranges

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

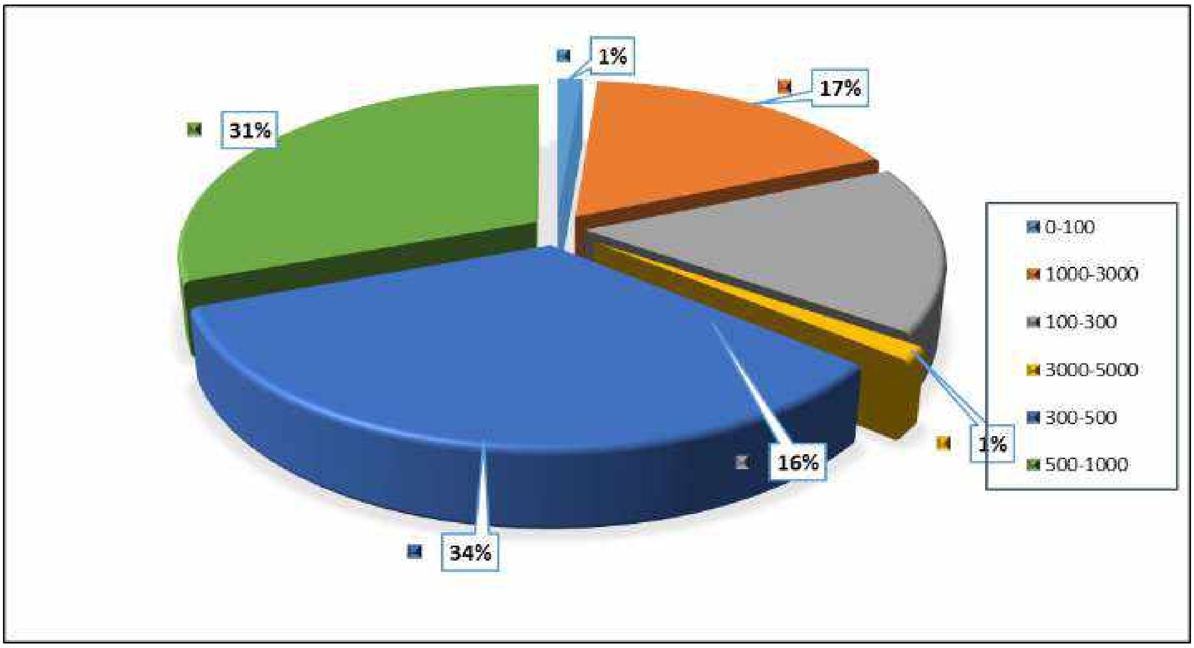


Figure 3.28: Dry season water volume of ponds for Induria village

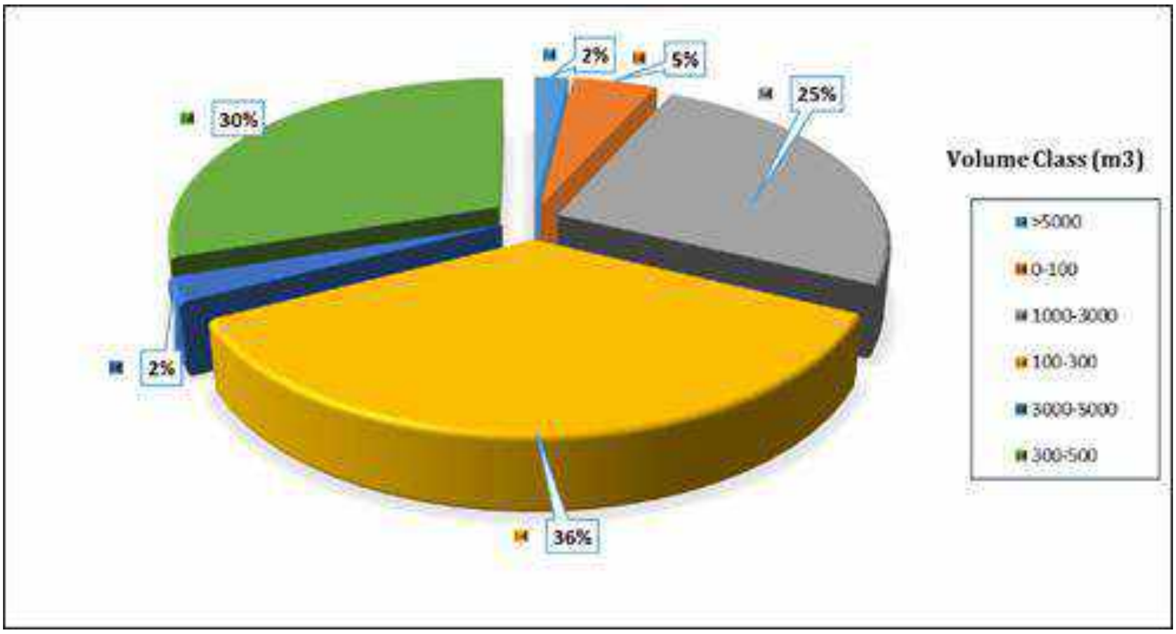


Figure 3.29: Dry season water volume of ponds for Tipna village

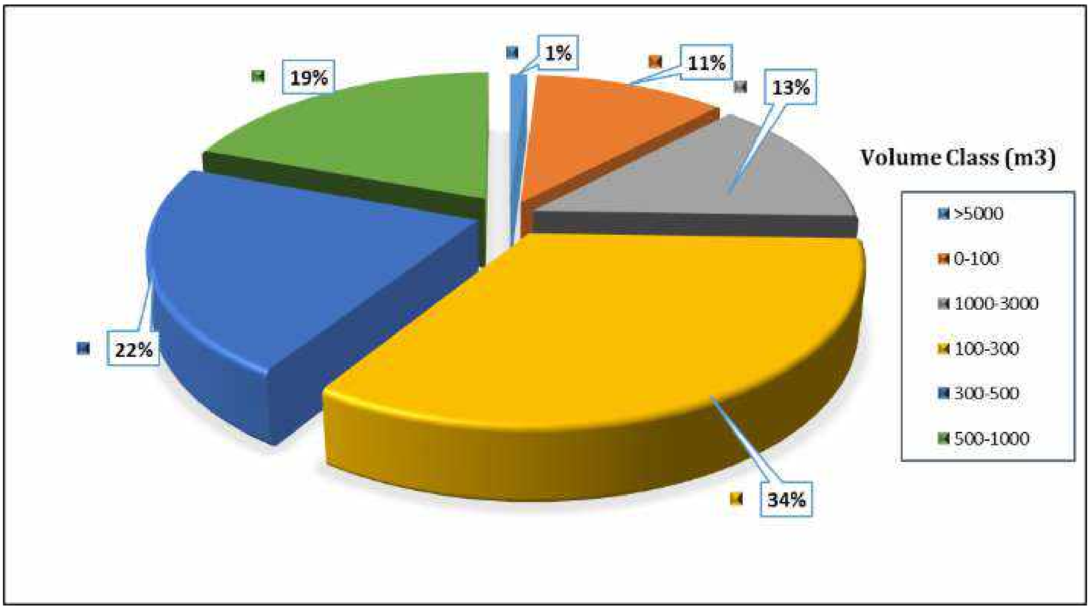


Figure 3.30: Dry season water volume of ponds for Datinakhali village

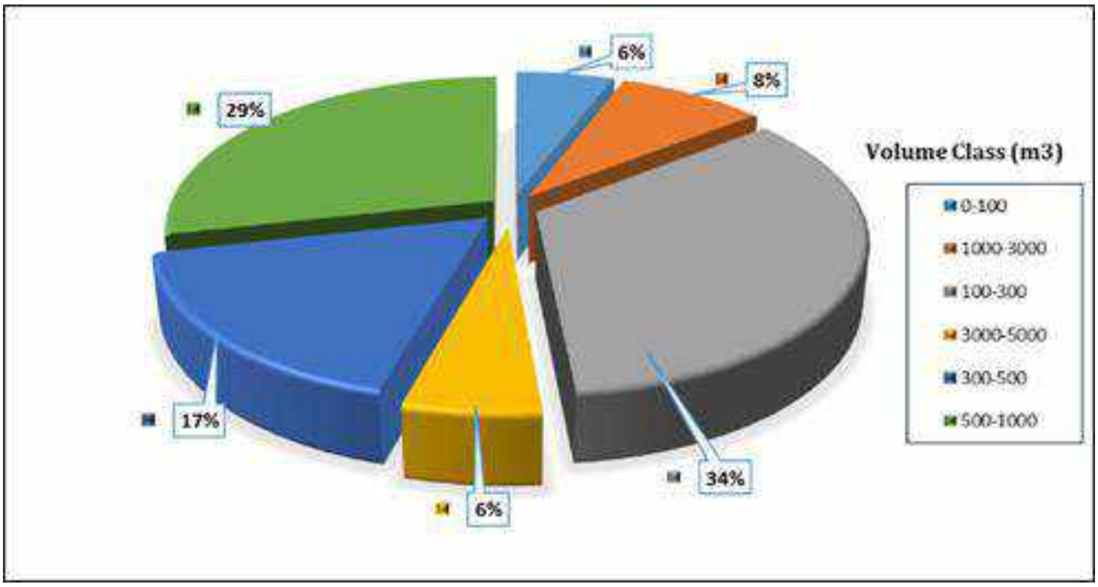


Figure 3.31: Dry season water volume of ponds for Shimulbank village

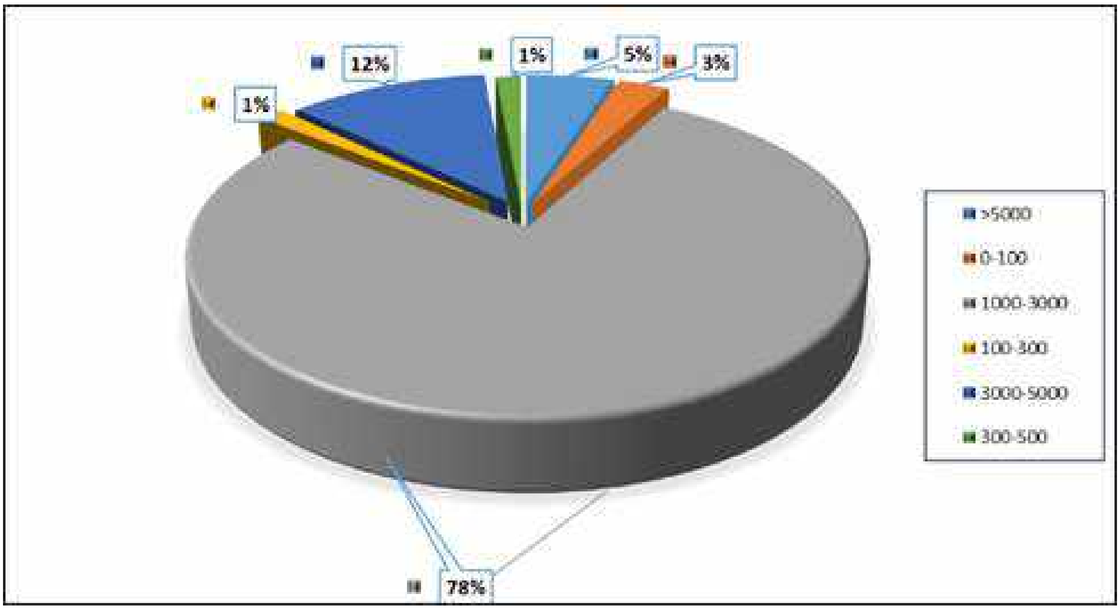


Figure 3.32: Dry season water volume of ponds for Charsharat village

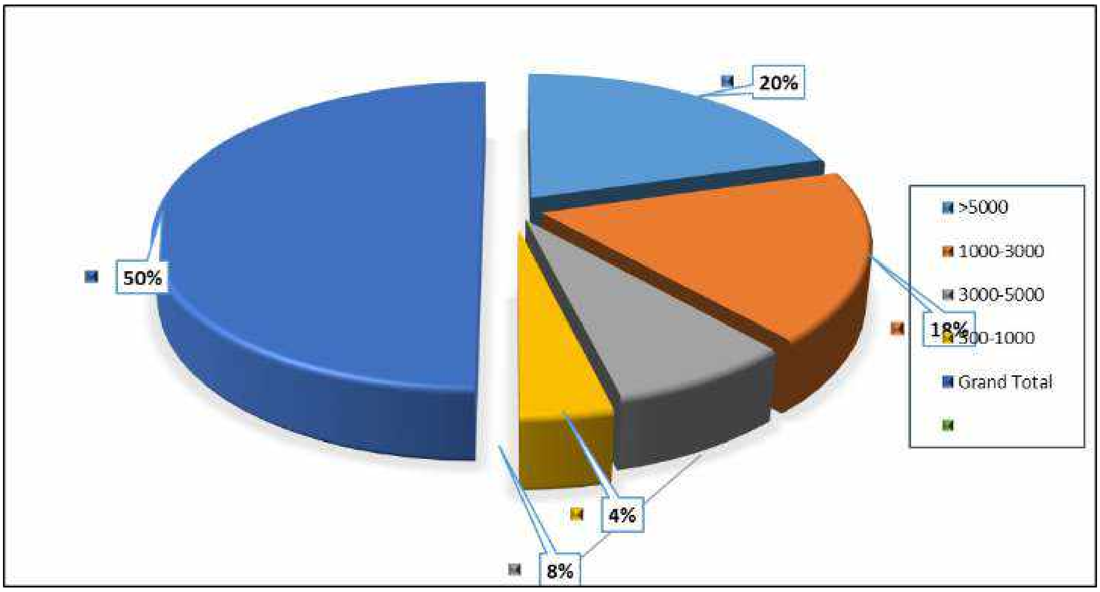


Figure 3.33: Dry season water volume of ponds for Bagaiya village

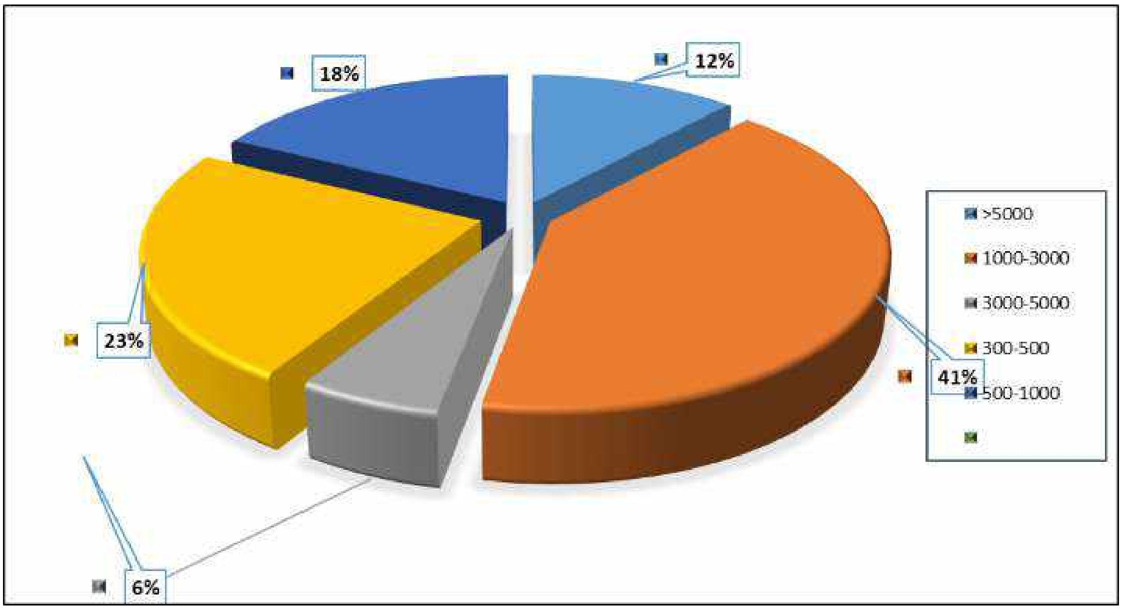


Figure 3.34: Dry season water volume of ponds for Fulchari village

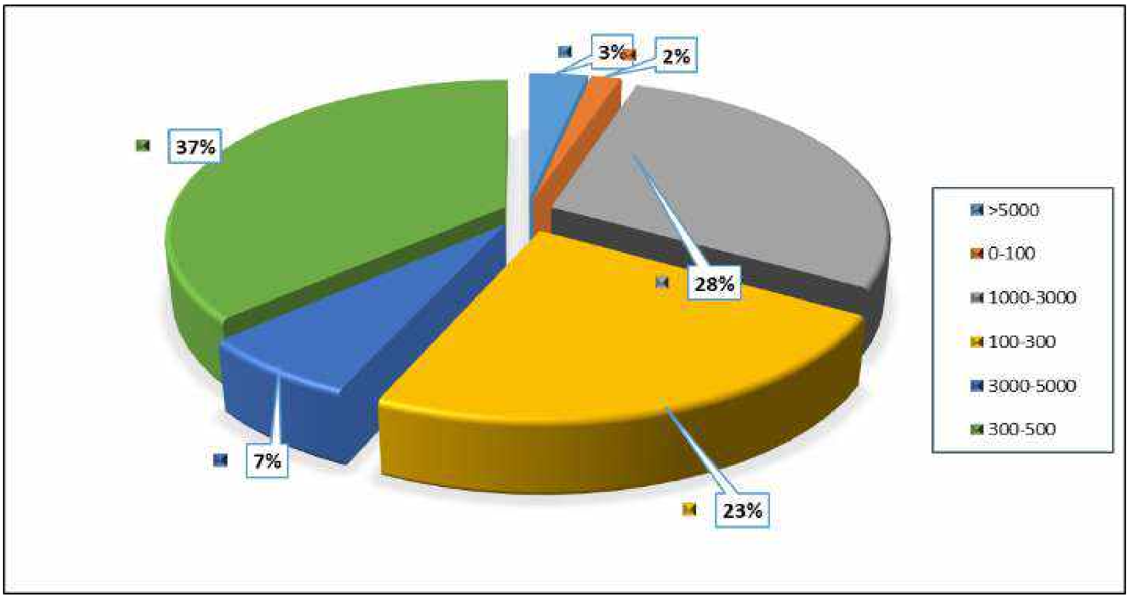


Figure 3.35: Dry season water volume of ponds for Pathordubi village

Usages of the ponds

Data on usage of the pond has been analyzed from the field data and presented in **Table 3-26**. 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 3-26** it has been observed that around 42 % of total ponds have been used for fish + bath/wash. And it has been observed that around 37% 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 3.26: Summary result of uses of the pond

District	Upazila	Union	Village	Surveyed Pond	X1	X2	X3	X4	X5	X6
Barishal	Hijla	Memania	Induria	75	7	0	12	45	9	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
Chattagram	Mirsarai	Ichakhali	Charsharat	170	2	0	12	148	7	1
Kurigram	Bhurungamari	Pathordubi	Pathordubi	86	5	0	42	33	5	1
Sylhet	Gowainghat	Rustimpur	Bagaiya	39	4	0	3	26	5	1
Gaibandha	Fulchari	Fulchari	Fulchari	17	2	0	3	9	2	1
Total (%)				**100%**	**6%**	**0%**	**12%**	**37%**	**42%**	**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 **Figure 3-36 - 3-3.43** and **Table 3-27**. It is found that 79% of the total surveyed pond falls under (< 25) % vegetation coverage, 13% under (25 –40) % vegetation coverage and 6% under (40 –60) % vegetation coverage. From **Table 3-27** it is observed that 601 ponds out of 761 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.

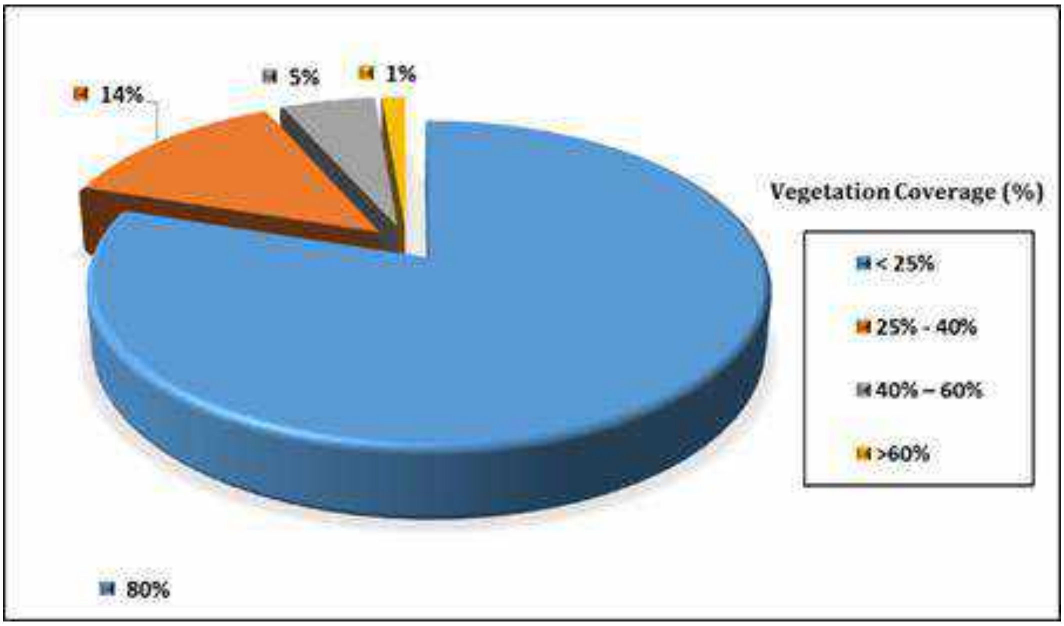


Figure 3.36: Percentage of total surveyed pond under different vegetation category in Induria village

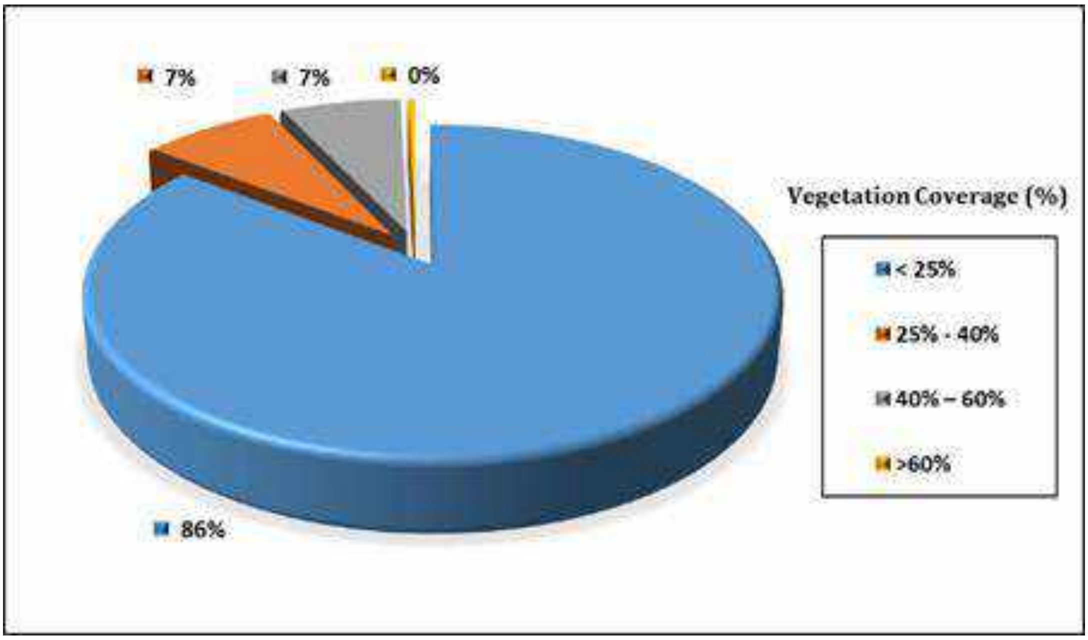


Figure 3.37: Percentage of total surveyed pond under different vegetation category in Induria village

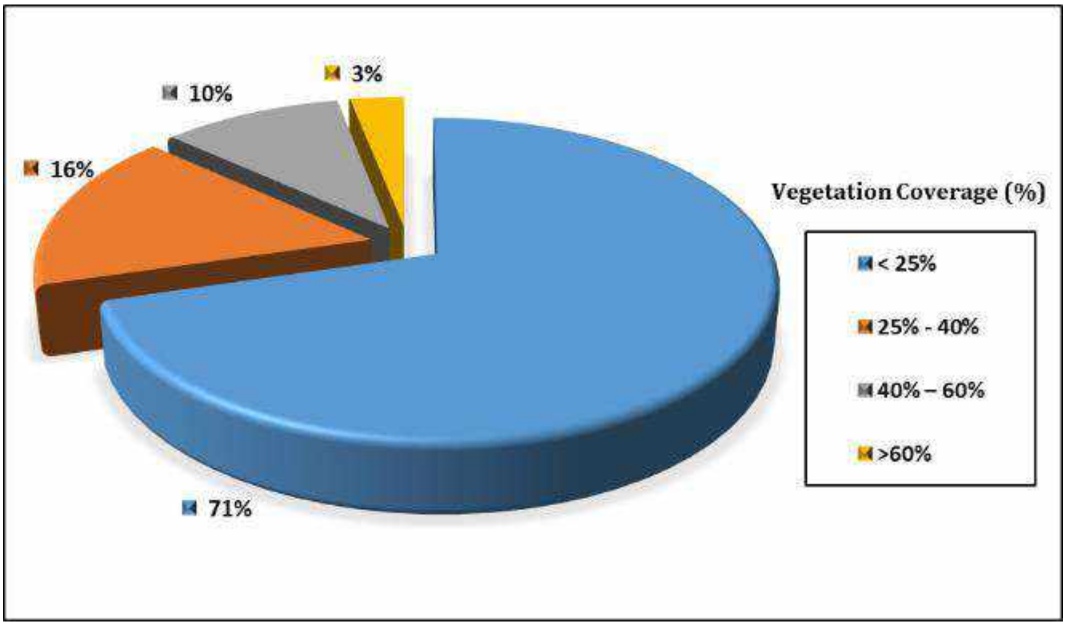


Figure 3.38: Percentage of total surveyed pond under different vegetation category in Datinakhali village

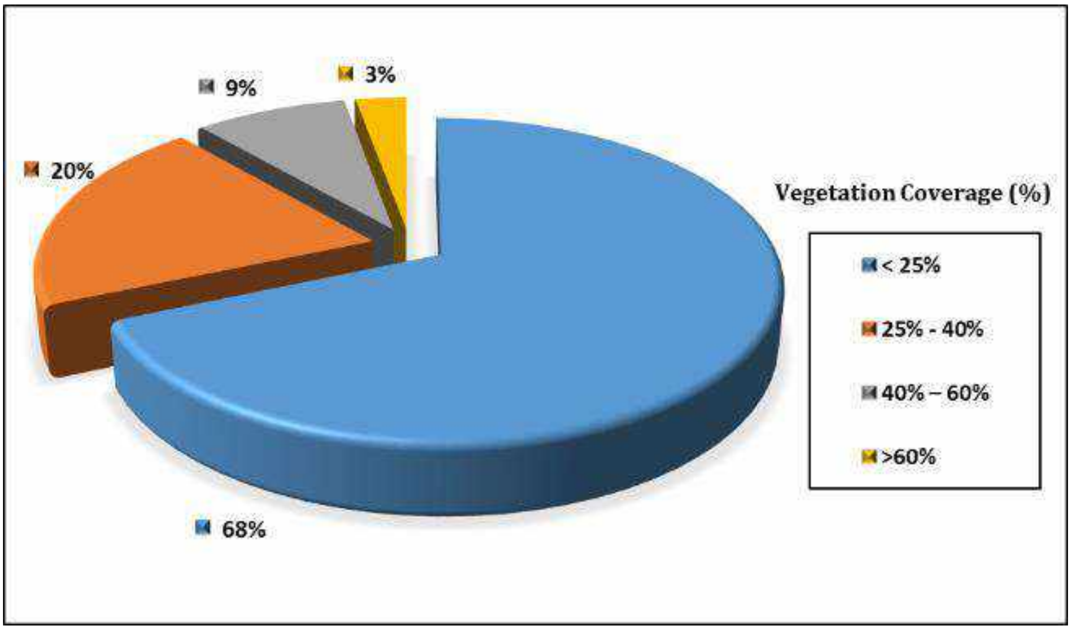


Figure 3.39: Percentage of total surveyed pond under different vegetation category in Shimulbank village

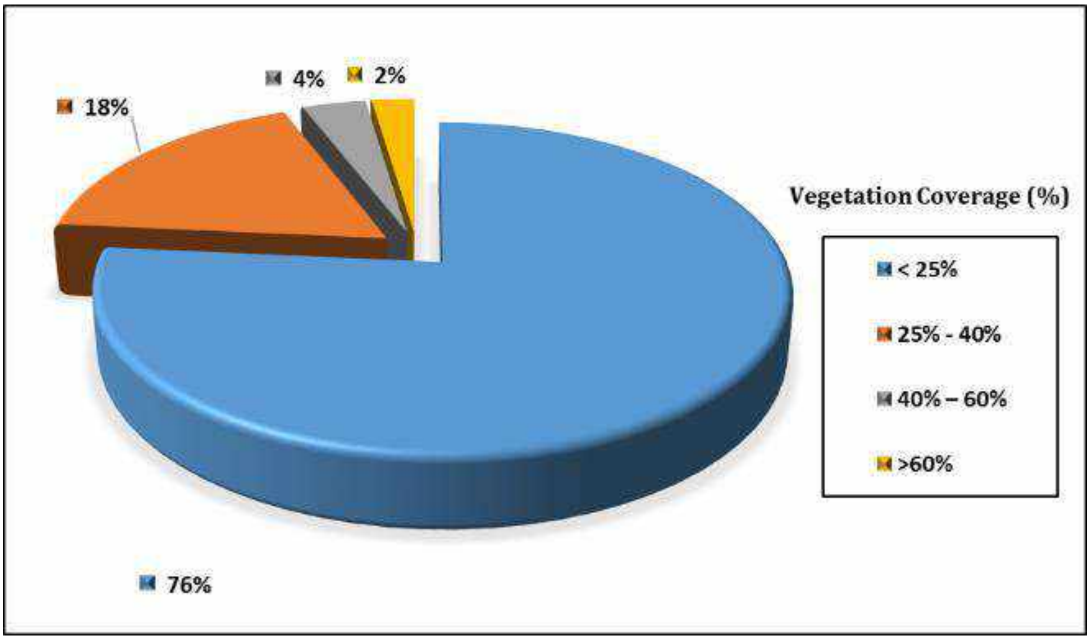


Figure 3.40: Percentage of total surveyed pond under different vegetation category in Charsharat village

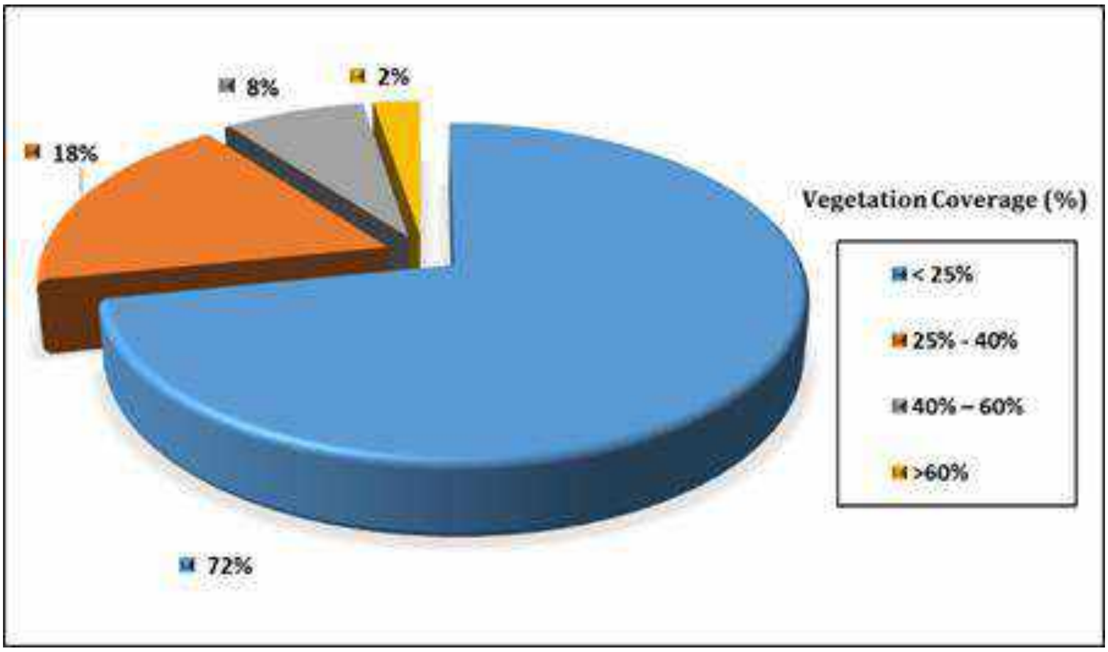


Figure 3.41: Percentage of total surveyed pond under different vegetation category in Bagaiya village

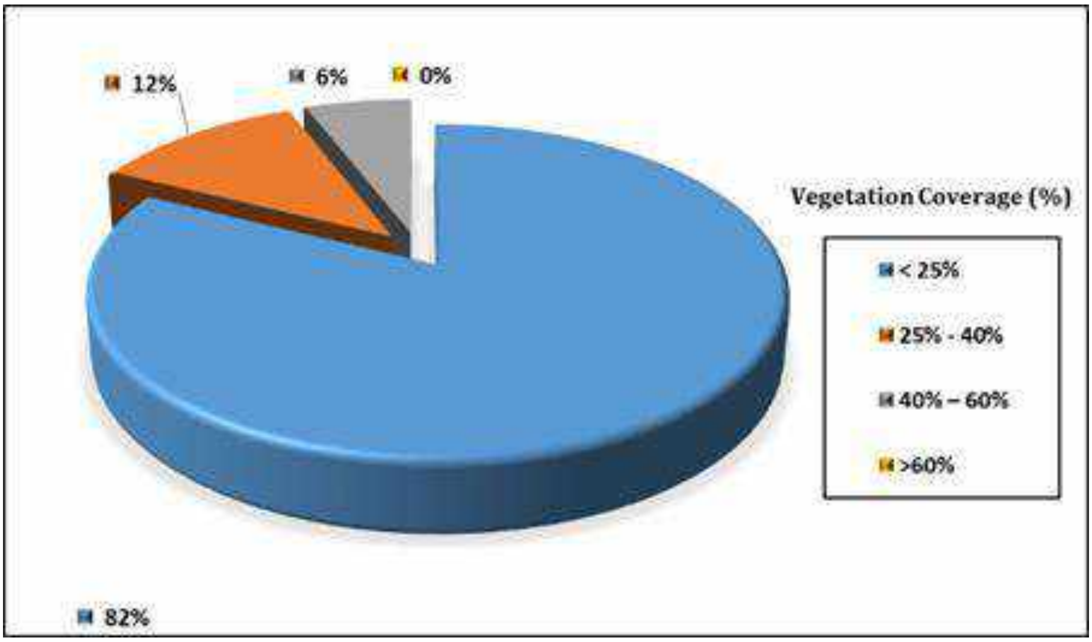


Figure 3.42: Percentage of total surveyed pond under different vegetation category in Pathordubi village

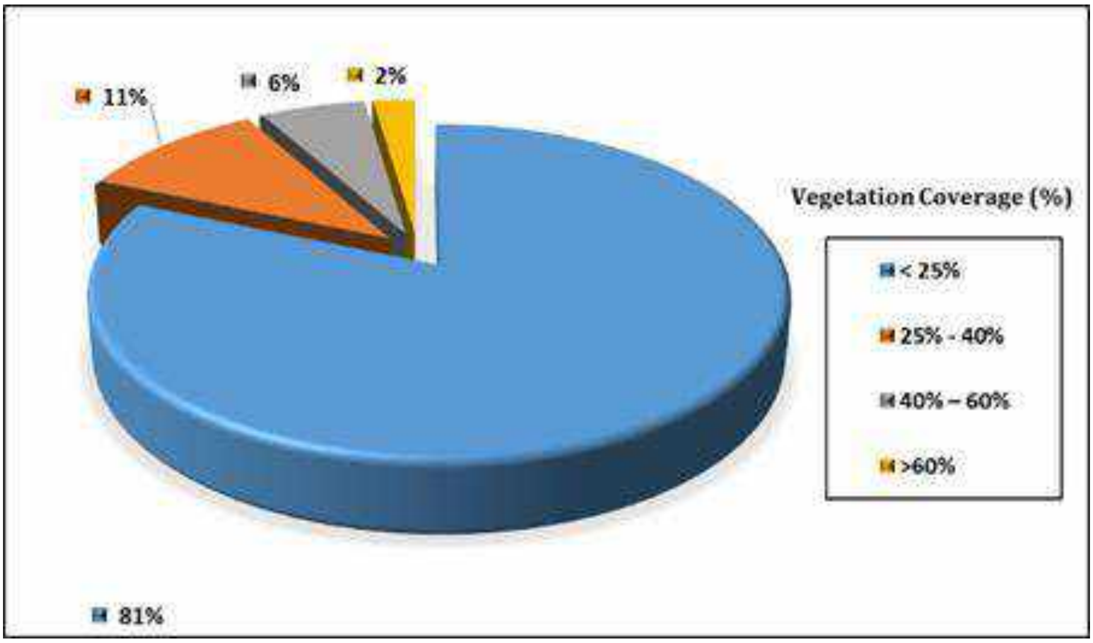


Figure 3.43: Percentage of total surveyed pond under different vegetation category in Pathordubi villag

Table 3.27: Percentage % of vegetation coverage of pond

District	Upazila	Union	Village	Total Pond	< 25%	25% - 40%	40% – 60%	>60%
Barishal	Hijla	Memania	Induria	75	60	10	4	1
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
Chattagram	Mirsarai	Ichakhali	Charsharat	170	130	30	6	4
Kurigram	Bhurungamari	Pathordubi	Pathordubi	86	70	9	5	2
Sylhet	Gowainghat	Rustimpur	Bagaiya	39	28	7	3	1
Gaibandha	Fulchari	Fulchari	Fulchari	17	14	2	1	0
Total (%)				**100%**	**79%**	**13%**	**6%**	**2%**

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 3-28**. 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 3.28: Village wise pond water color information

District	Upazila	Union	Village	Total Pond	Water Color		
					Good	Normal	Bad
Barishal	Hijla	Memania	Induria	75	30	43	2
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
Chattagram	Mirsarai	Ichakhali	Charsharat	170	100	60	10
Kurigram	Bhurungamari	Pathordubi	Pathordubi	86	39	44	3
Sylhet	Gowainghat	Rustimpur	Bagaiya	39	15	18	6
Gaibandha	Fulchari	Fulchari	Fulchari	17	13	3	1
Total (%)				**100%**	**37%**	**57%**	**6%**

From color data analysis result (**Table 3-28**) it is observed that 57% of the total surveyed pond has the normal water quality in terms of color, 37% of the total surveyed pond has the good water quality and 6% 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 **Figure3-44** respectively.

Figure 3.44: 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 **lookup tables (3-29 to 3-34)** 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 **Lookup Table 3-35**. 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 Lookup **Table 3.29**.

Table 3.29: Criteria for % of vegetation coverage of the pond

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

Table 3.30: 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 3.31: Criteria for physical color of pond water, (V3)

Water color	Score
Good	1
Normal	0.5
Bad	0

Table 3.32: 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 3.33: Weights of different indicators

Indicator Parameter	Weights
V1	0.2
V2	0.3
V3	0.2
V4	0.3

Table 3.34: 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 3-35**. 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.

Table 3.35: Village wise apparently potential ponds

District	Upazila	Union	Village	Total Pond	No of Potential ponds	
					Potential Score, VF	Potential class
Barishal	Hijla	Memania	Induria	75	0.25	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
Chattagram	Mirsarai	Ichakhali	Charsharat	170	0.25	Low/ Less
Kurigram	Bhurungamari	Pathordubi	Pathordubi	86	0.24	Low/ Less
Sylhet	Gowainghat	Rustimpur	Bagaiya	39	0.24	Low/ Less
Gaibandha	Fulchari	Fulchari	Fulchari	17	0.24	Low/ Less

Water Resources Map

Water resource mapping is an important geographical tool for water management. Mapping has been widely used in scientific research and practical applications for a long time. Water resources map of eight villages of disaster prone has been generated by GIS. All maps are providing below-

Induria

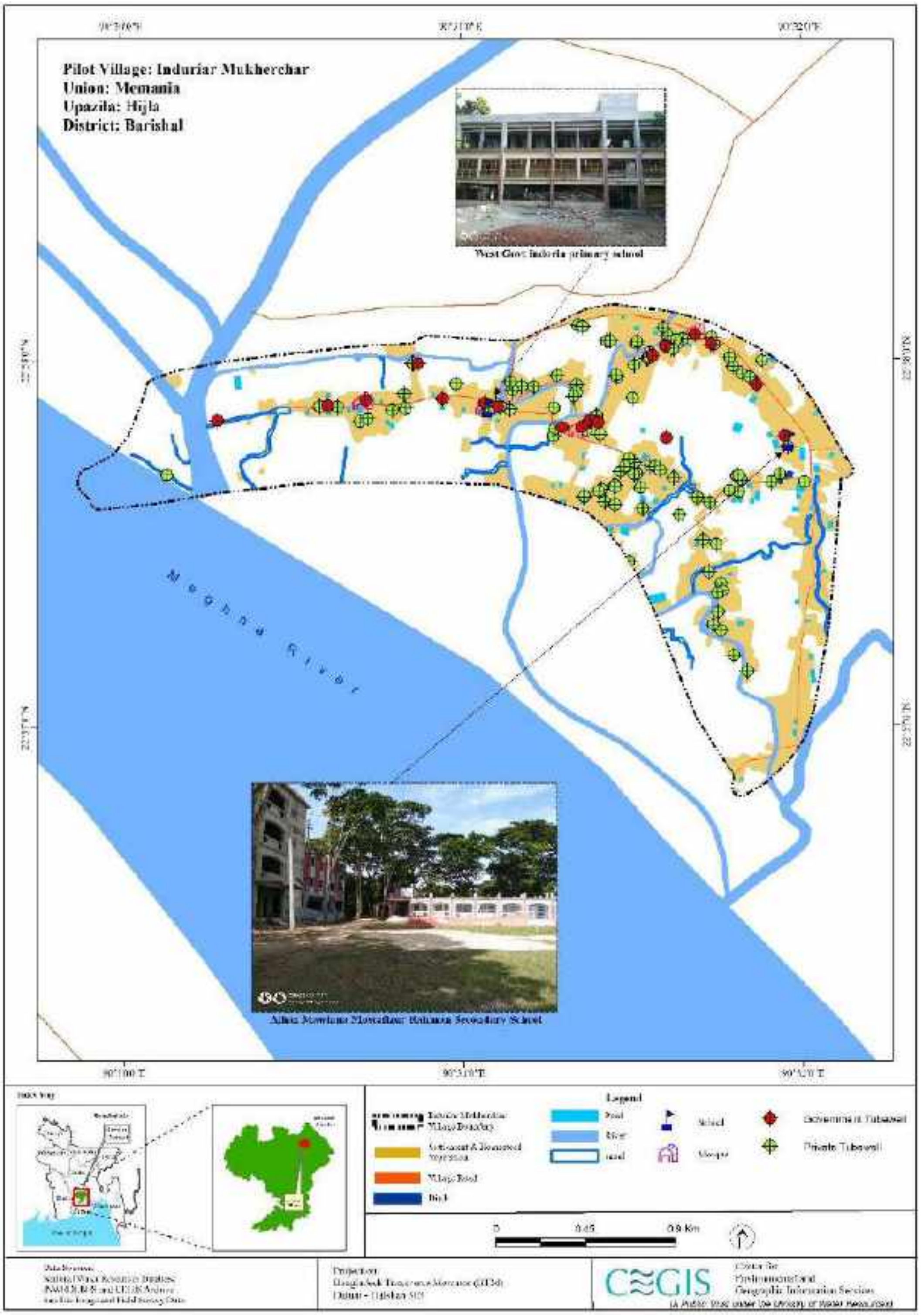


Figure 3.45: Water Resources Map of Induria Village

Charsharat

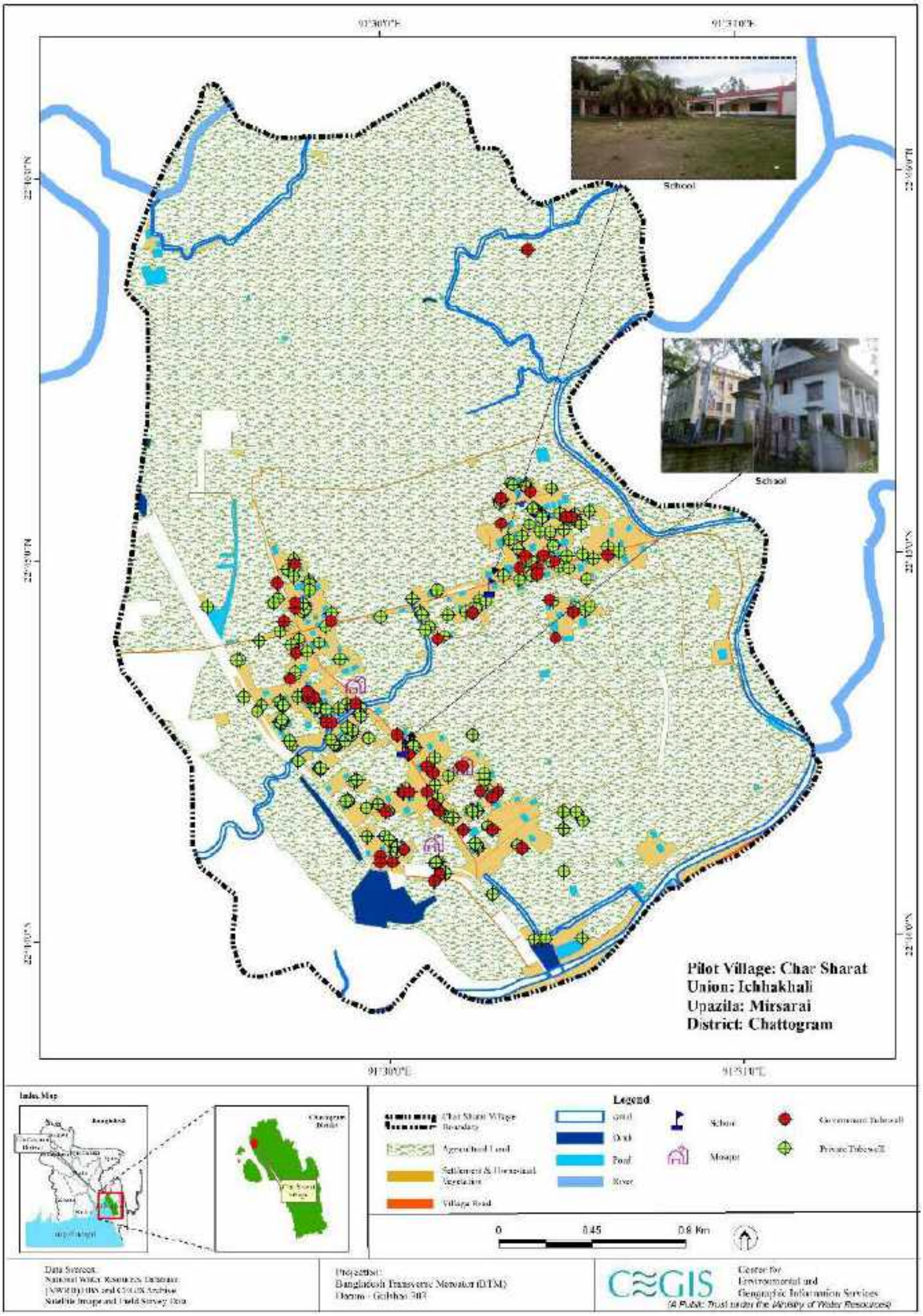


Figure 3.46: Water Resources Map of Charsharat Village

Fulchari

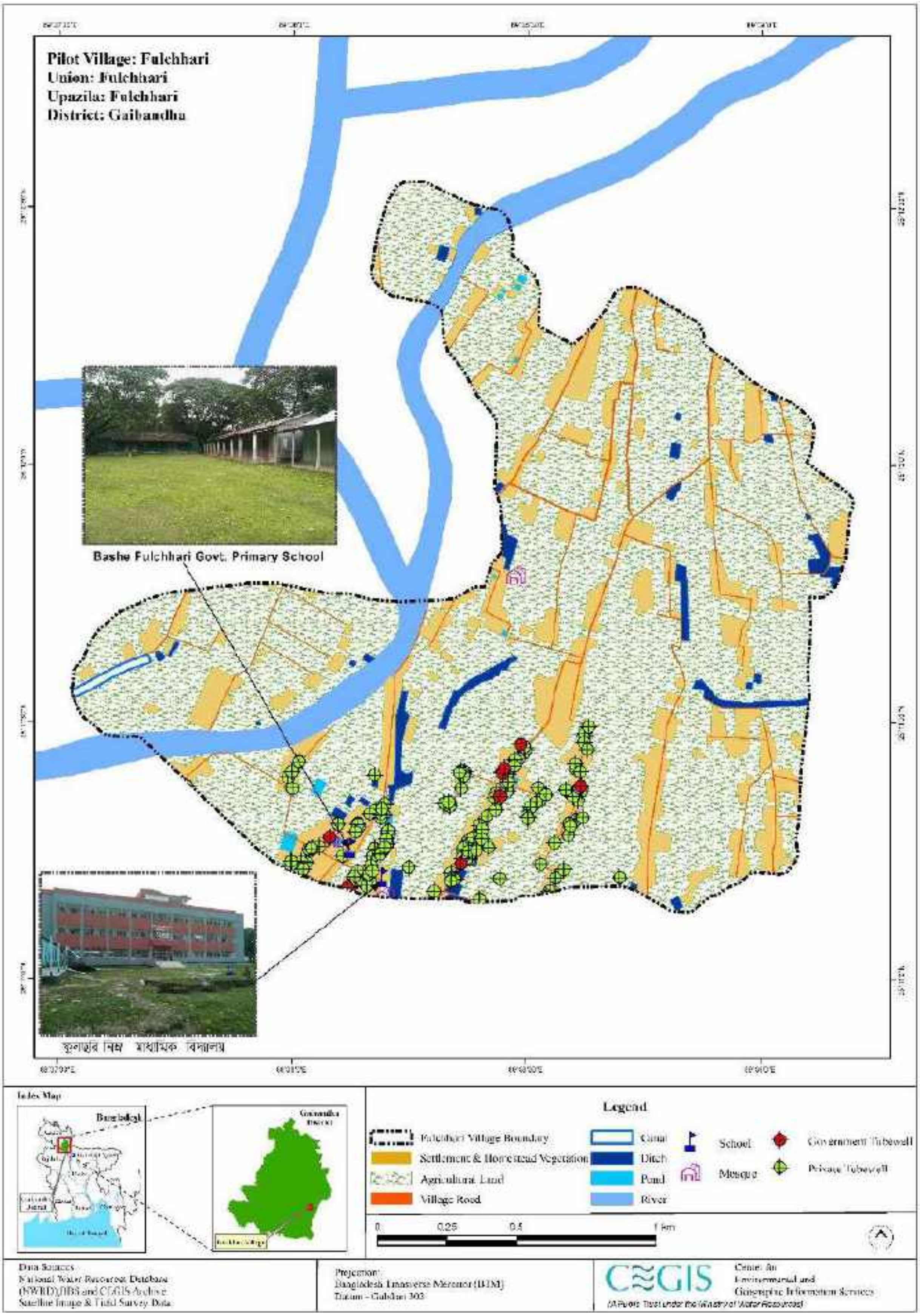


Figure 3.47: Water Resources Map of Fulchari Village

Tipna

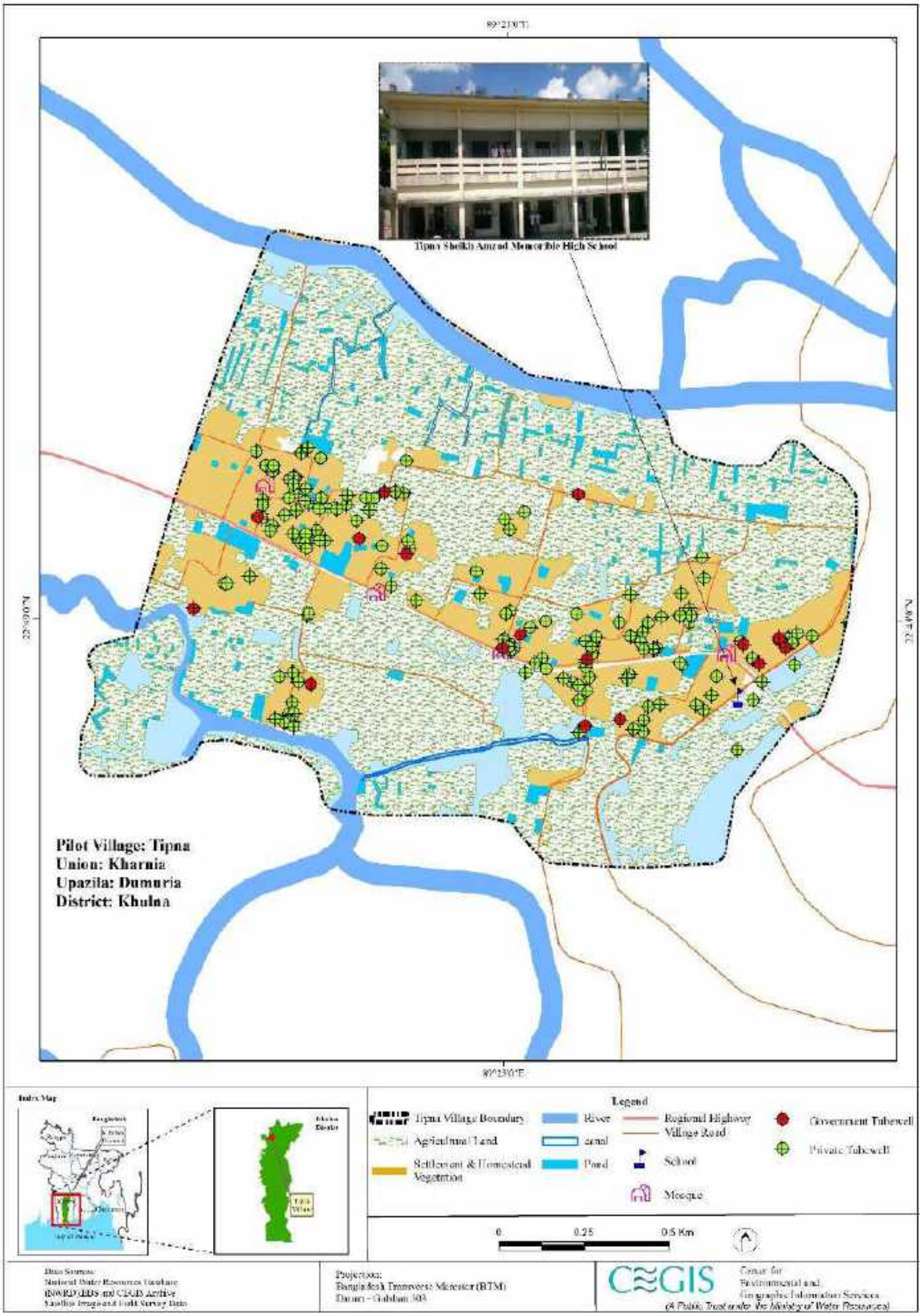


Figure 3.48: Water Resources Map of Tipna Village

Pathordubi

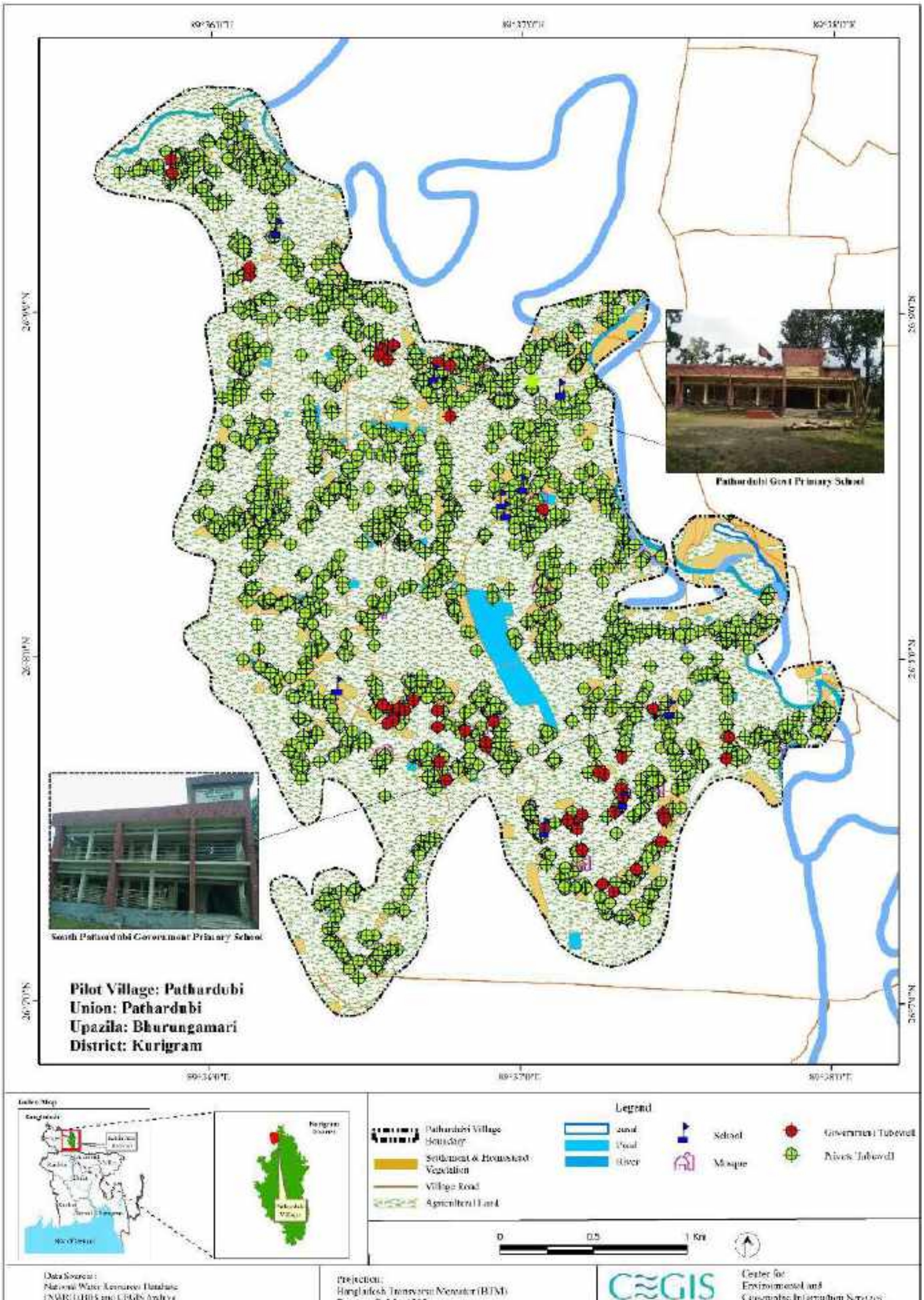


Figure 3.49: Water Resources Map of Pathordubi Village

Datinakhali

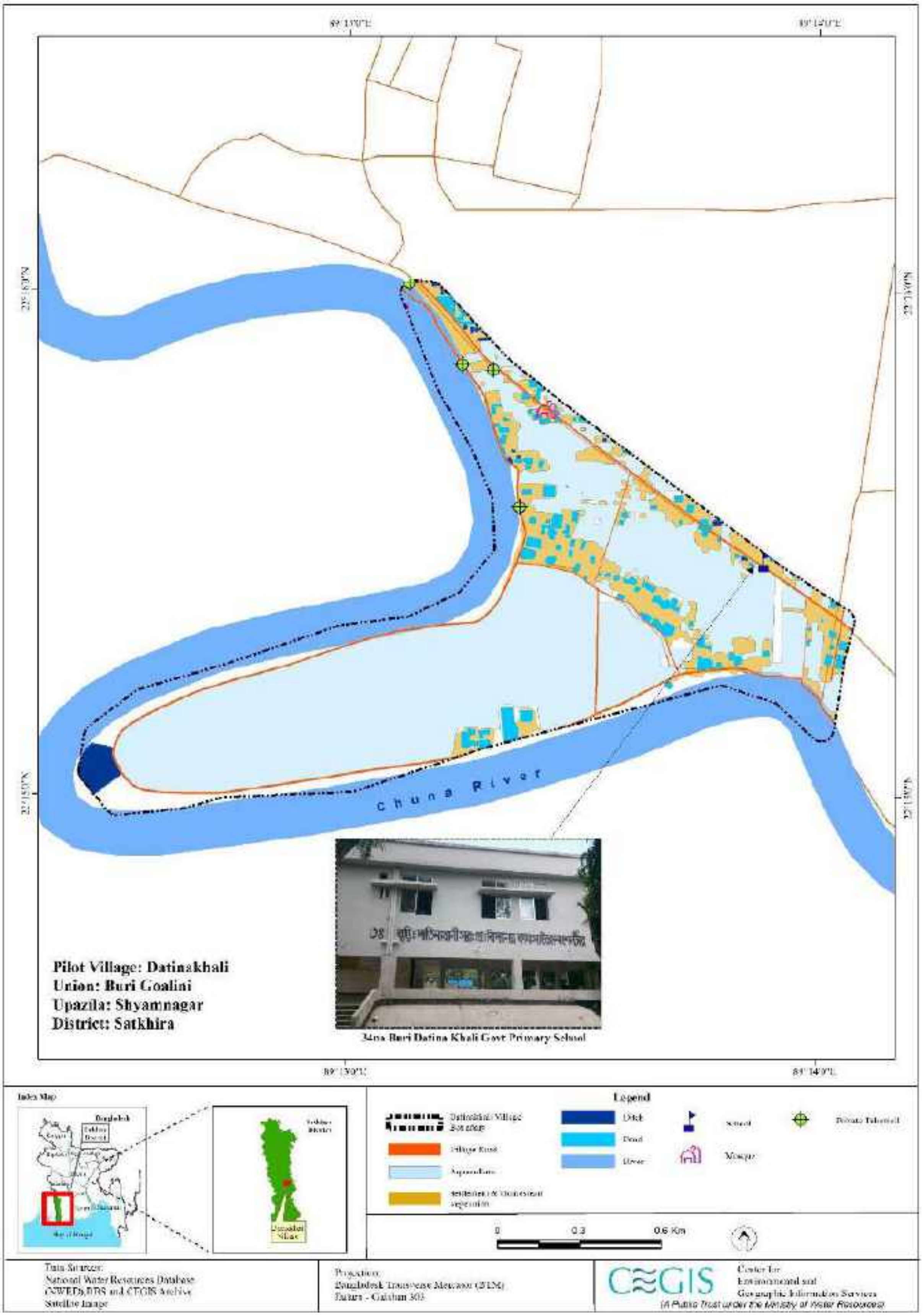


Figure 3.50: Water Resources Map of Datinakhali Village

Shimulbank

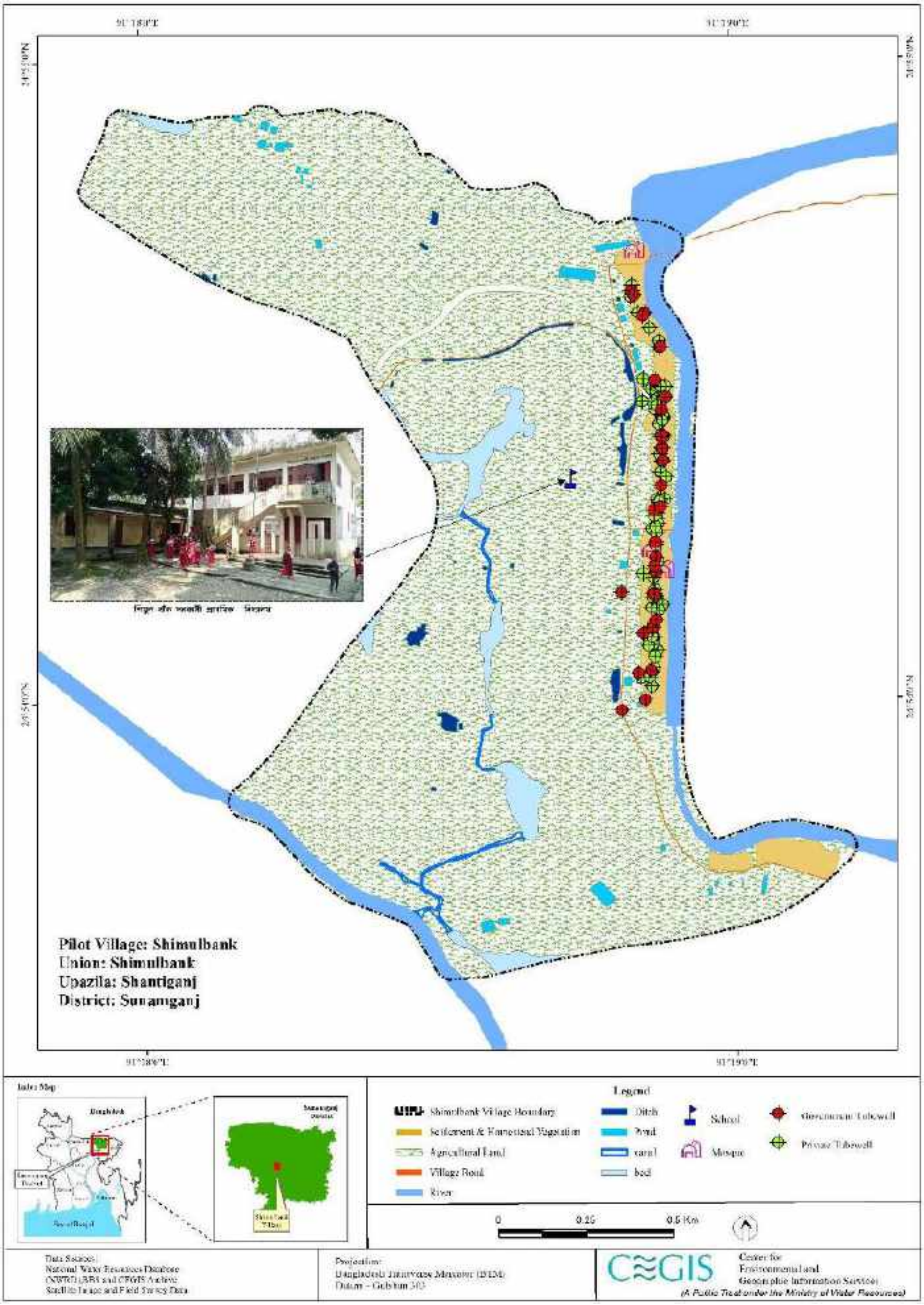


Figure 3.51: Water Resources Map of Shimulbank Village

Bagaiya

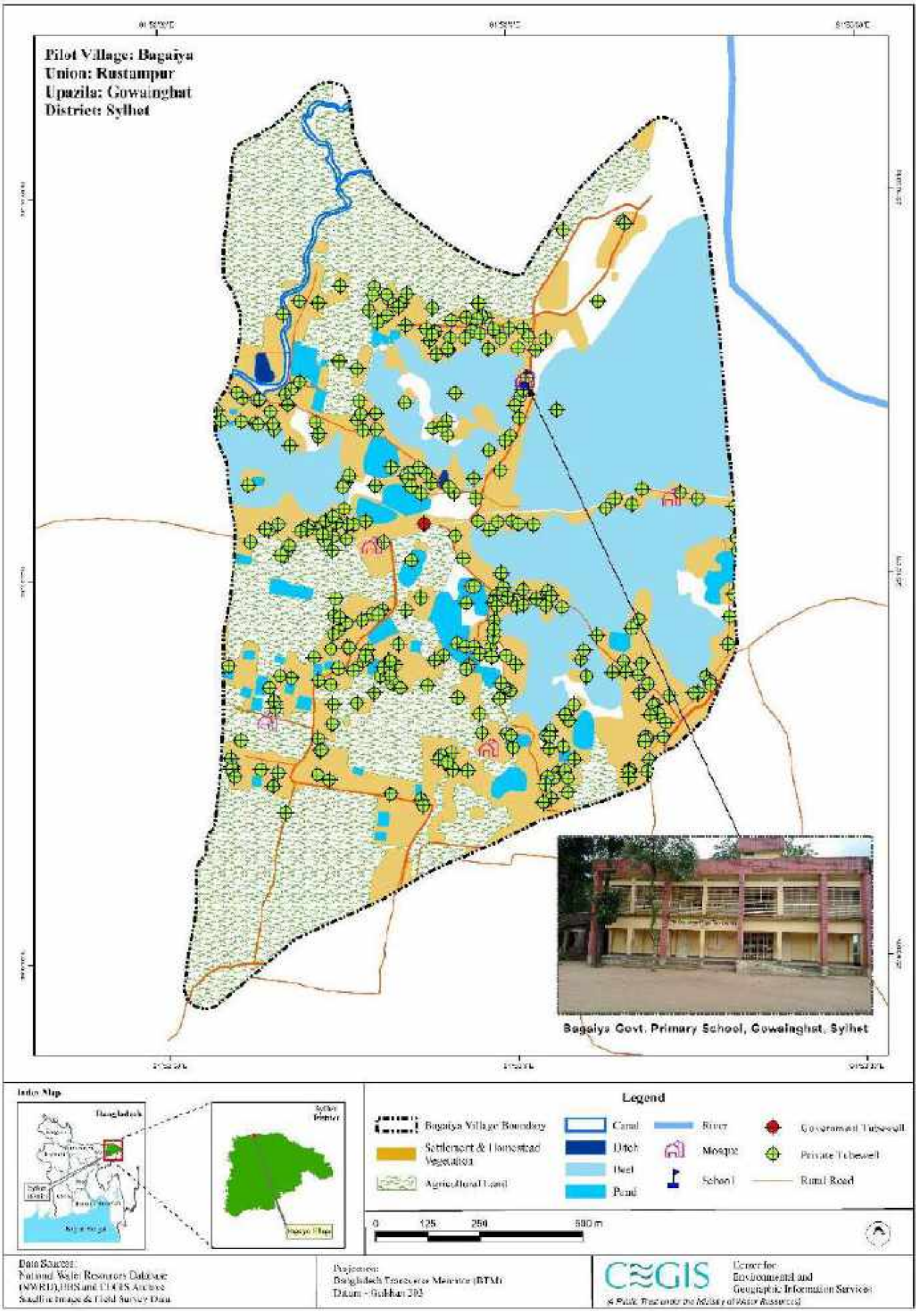


Figure 3.52: Water Resources Map of Bagaiya Village

Dot Density Map

Dot density map is an essential element to understanding the overall view of the village. Using this map we can easily know the amount of water body present in the village and the coverage of water availability. Dot density map of eight villages of disaster prone has been generated by GIS. All maps are providing below.

Induria

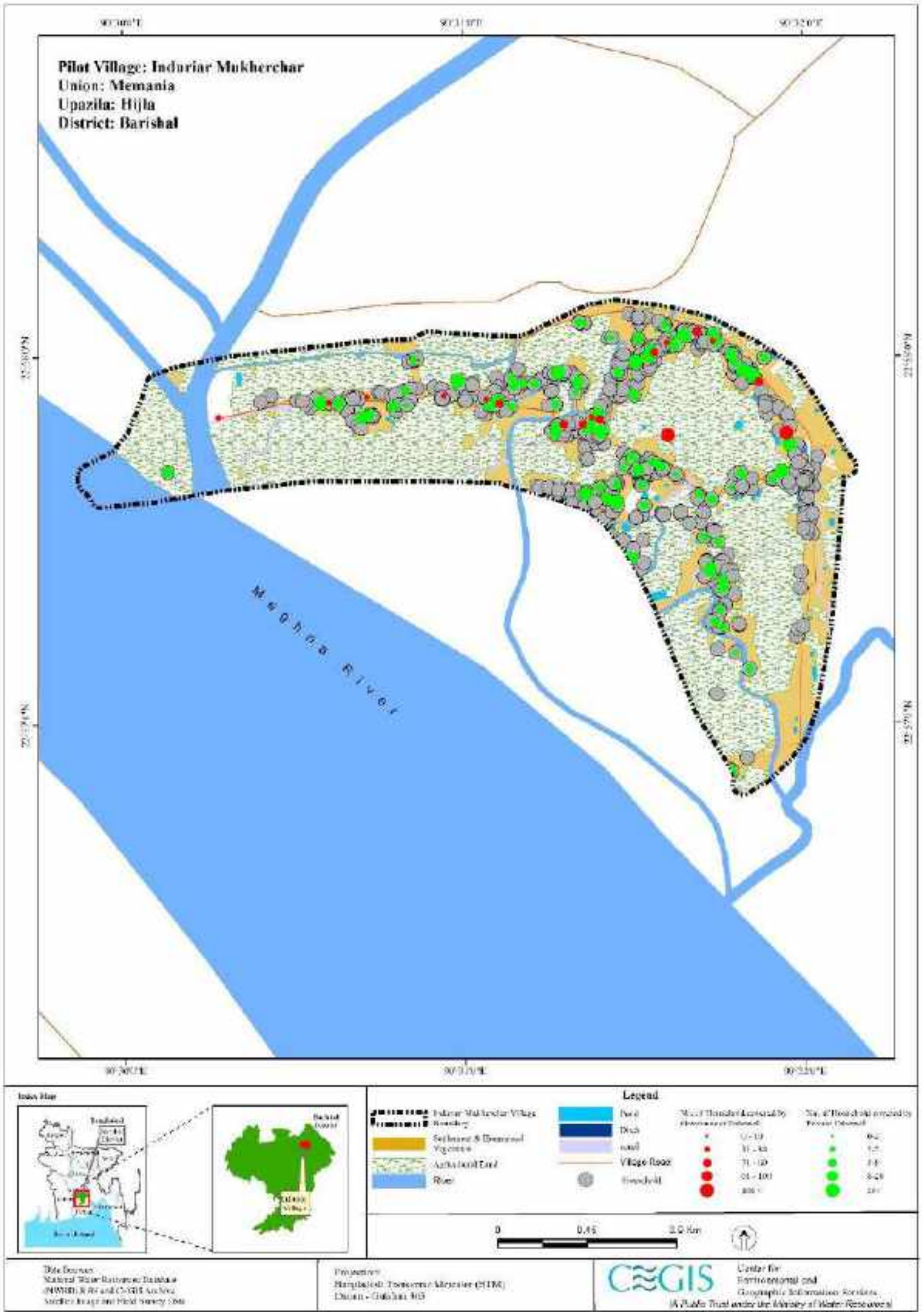


Figure 3.53: Dot Density Map of Induria

Charsharat

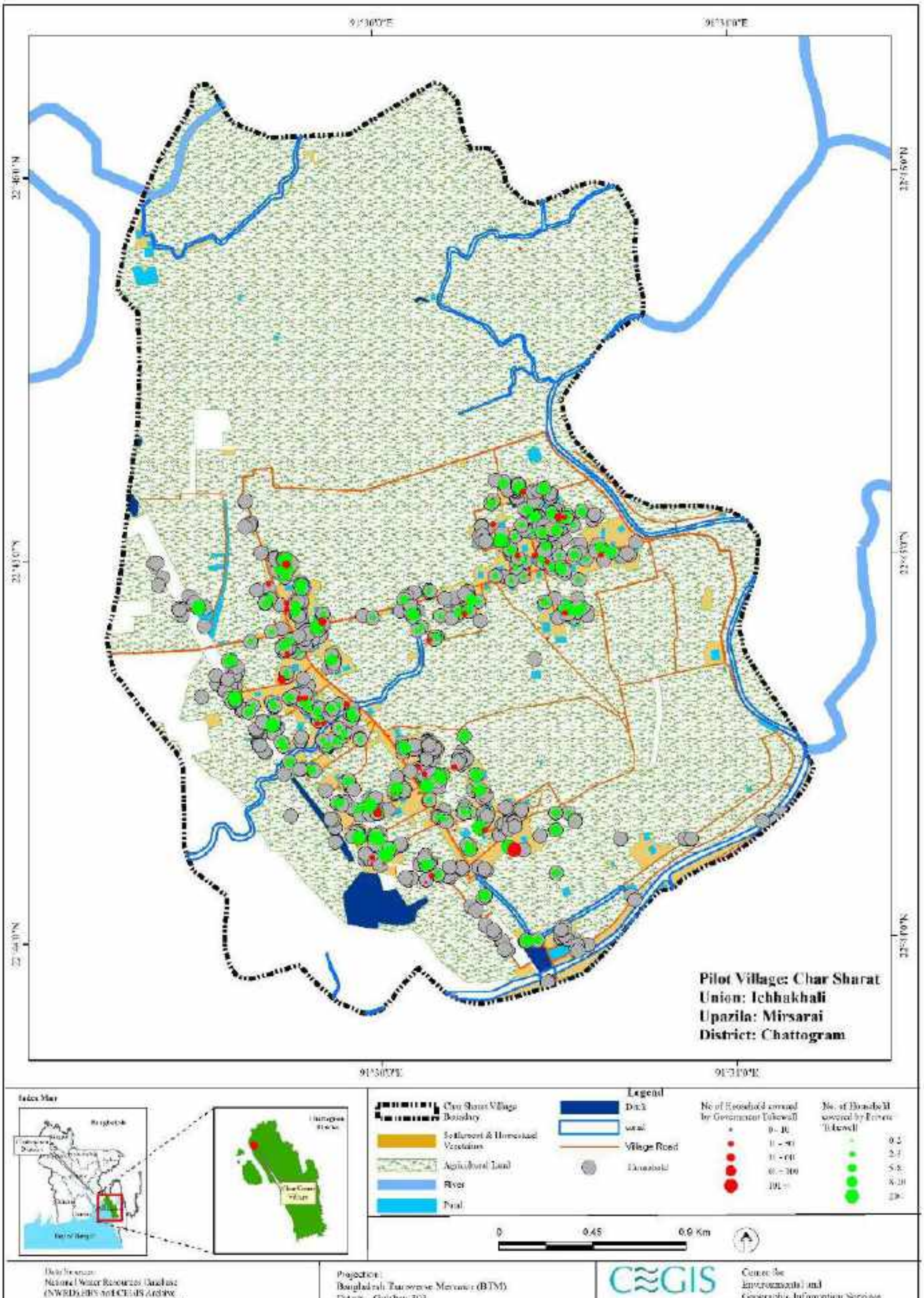


Figure 3.54: Dot Density Map of Charsharat

Fulchari

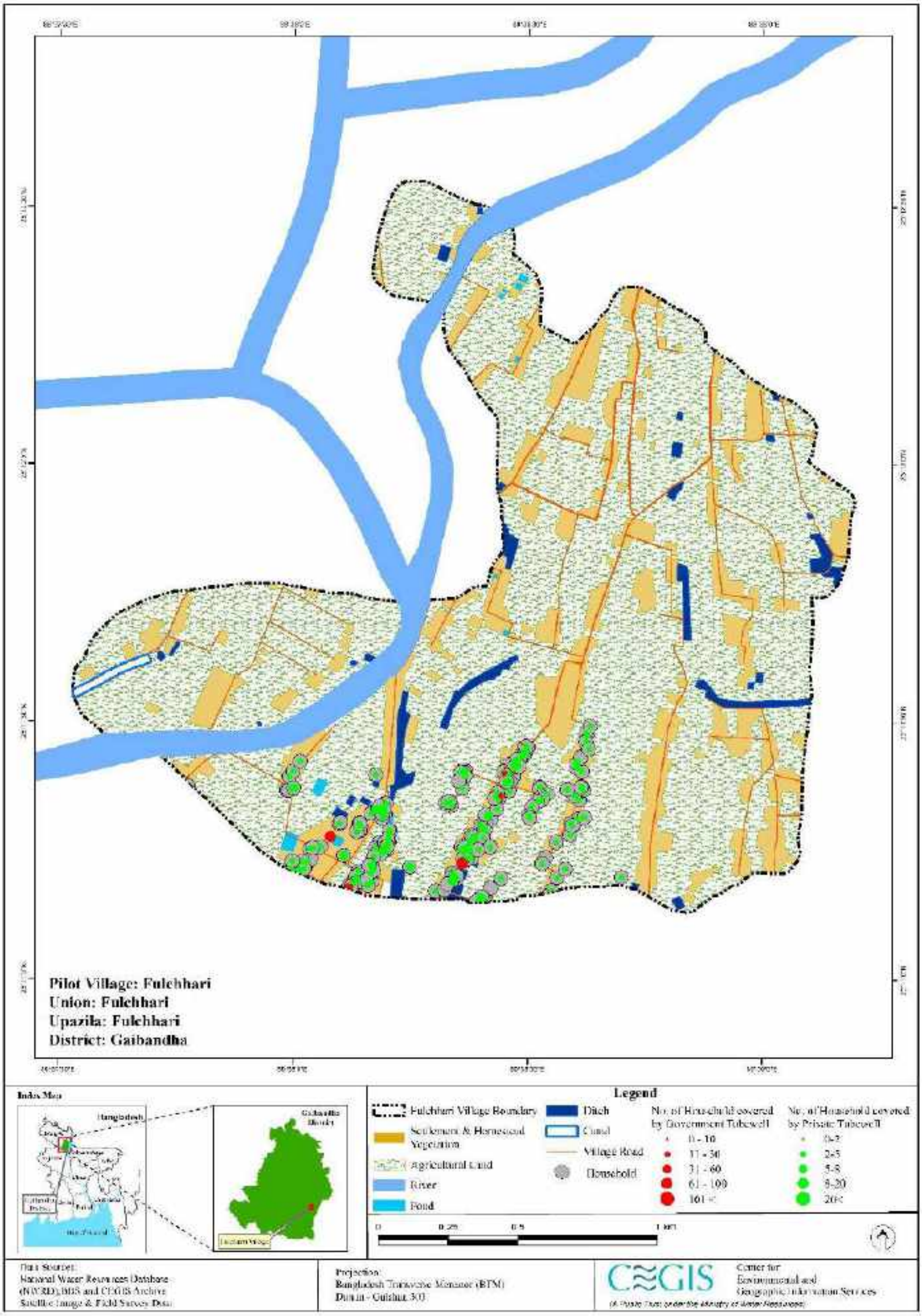


Figure 3.55: Dot Density Map of Fulchari

Tipna

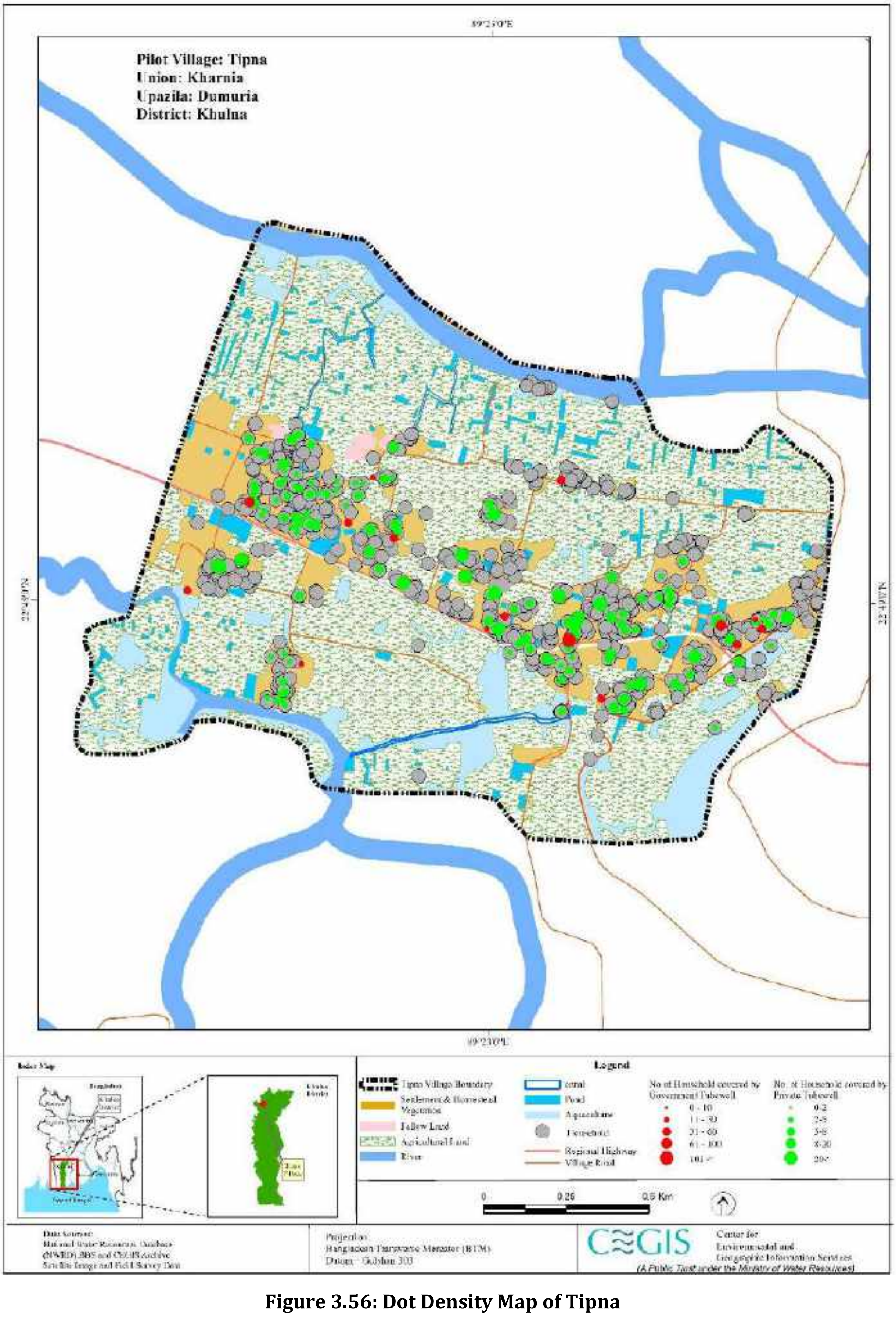


Figure 3.56: Dot Density Map of Tipna

Pathordubi

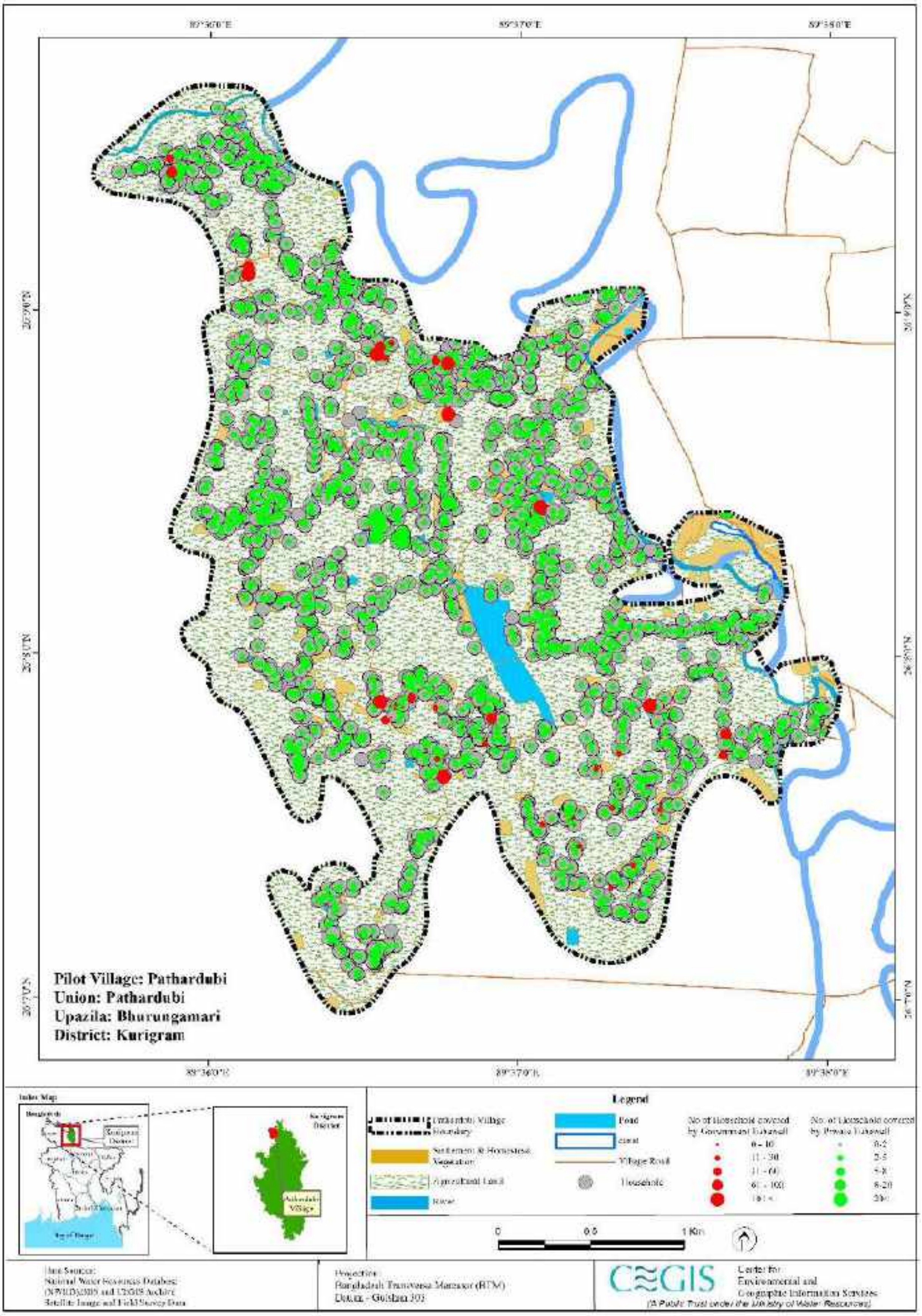


Figure 3.57: Dot Density Map of Pathordubi

Datinakhali

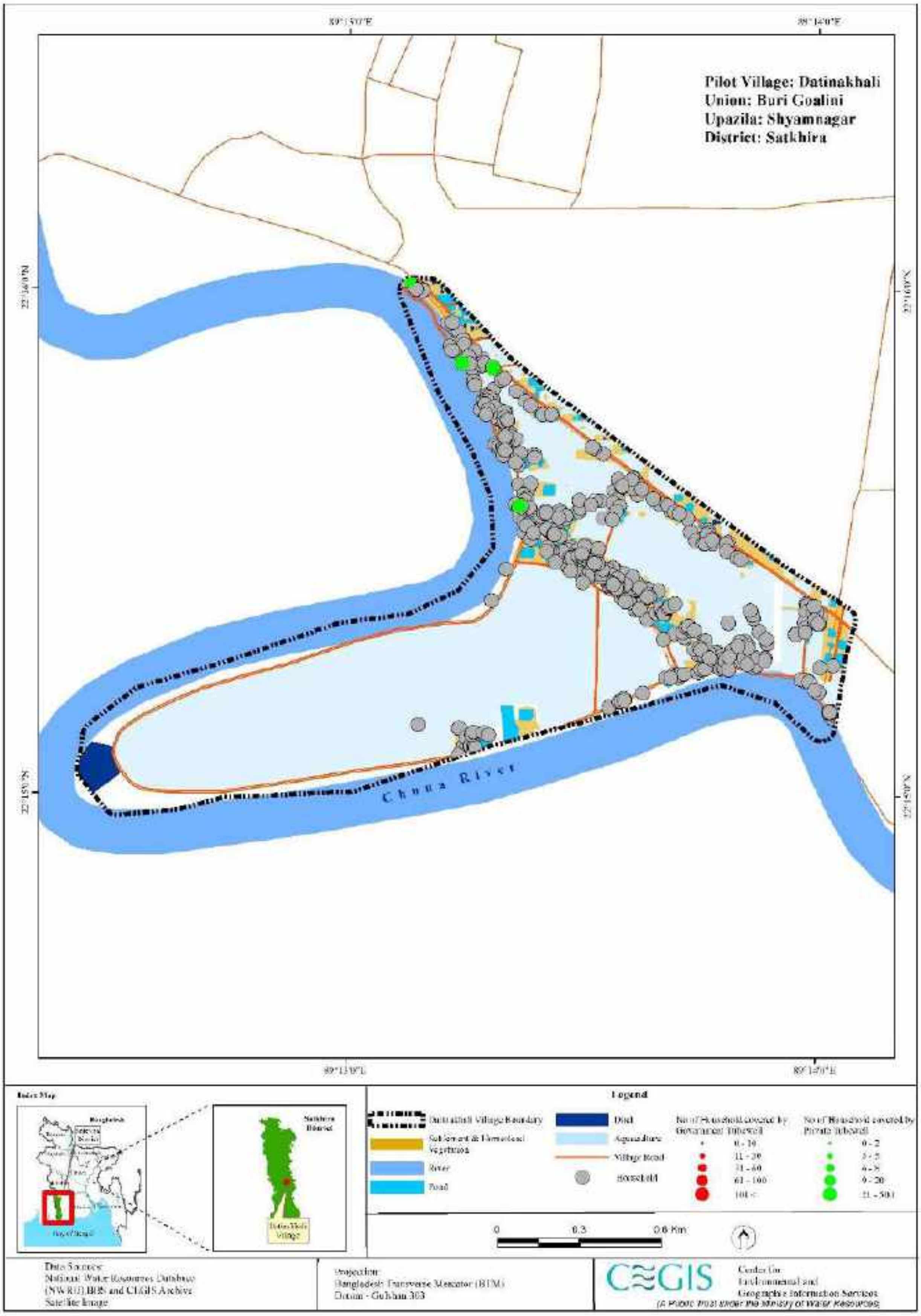


Figure 3.58: Dot Density Map of Datinakhali

Sunamganj

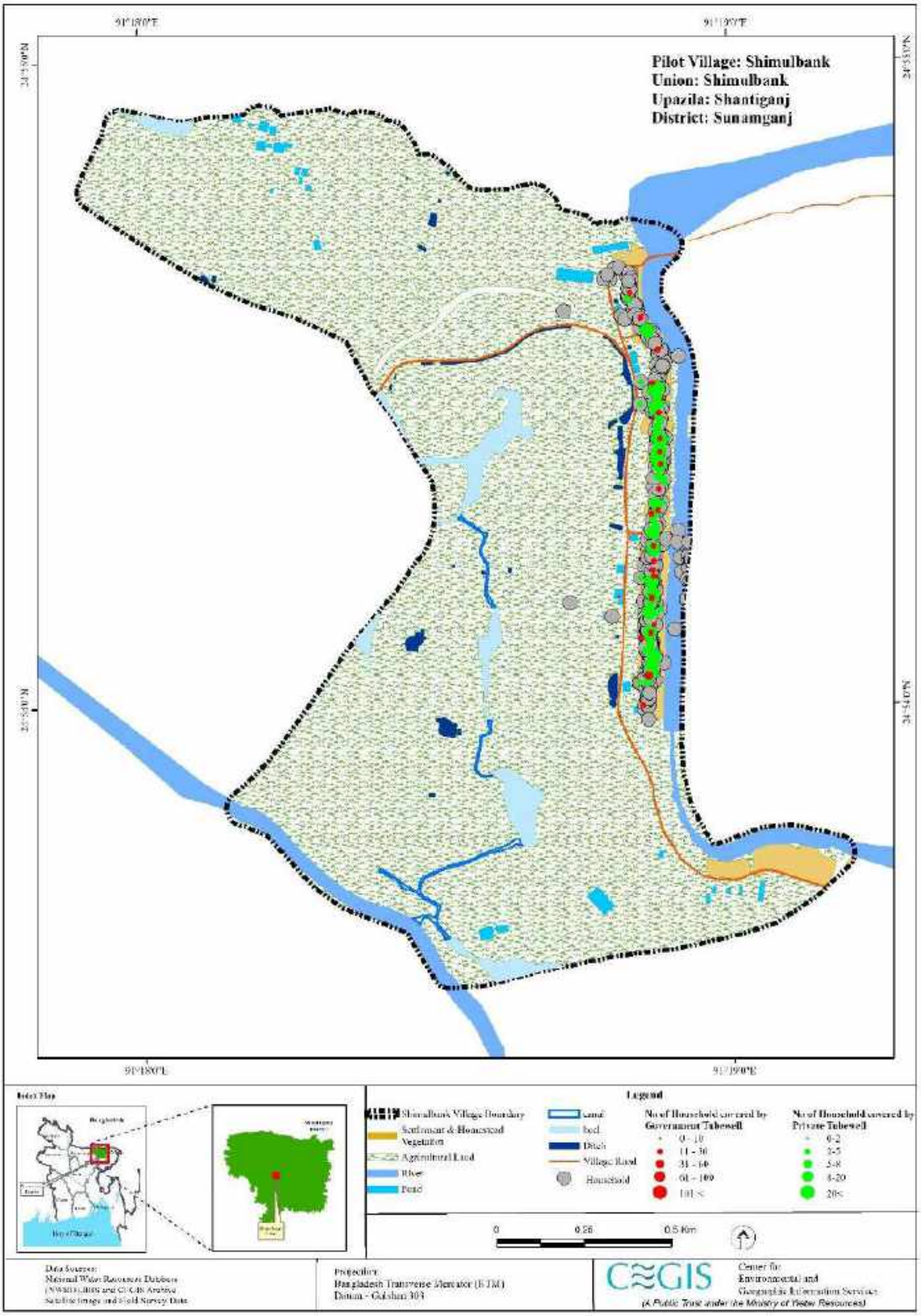


Figure 3.59: Dot Density Map of Shimulbank

Bagaiya

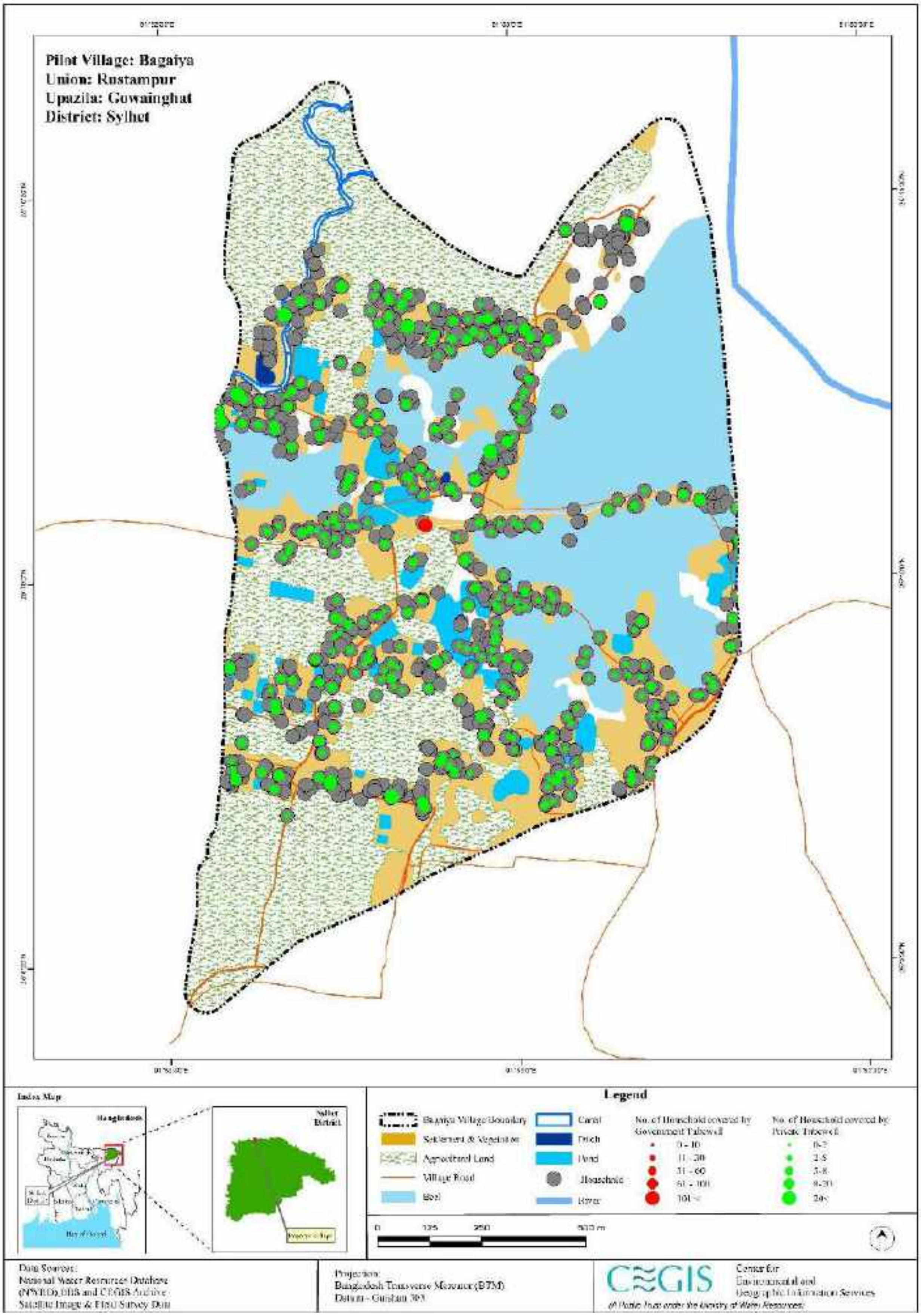


Figure 3.60: Dot Density Map of Bagaiya

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 eight villages in the disaster-prone 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 eight villages in the disaster-prone 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 equipment 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 eight villages in the disaster-prone area.

Induria, Barishal

25 mini-piped water supplies have been proposed in Induria. The intervention ID-7 has been assigned to a maximum household. The intervention ID-8 has been assigned to a minimum household. The average number of households per intervention is 14, and the average distance between households and interventions is 59 meters. The average distance is close enough to deliver water immediately. 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 five mini-piped water supply, distributed among three planning blocks in Induria village, are the proposed intervention, depending on the necessity for the technologies.

Figure 3.61: Planning block in village Induria

Fulchari, Gaibandha

15 mini-piped water supplies have been proposed in Fulchari. The intervention ID-3 has been assigned to a maximum household. The intervention ID-5, 14, 15 has been assigned to a minimum household. The average number of households per intervention is 4, and the average distance between households and interventions is 28 meters. The average distance is close enough to deliver water immediately. Due to the proximity of the intervention to the household, the time required to reach the water. Source will be less than one minute. Fifteen mini-piped water supply, distributed among three planning blocks in Fulchari village, are the proposed intervention, depending on the necessity for the technologies.

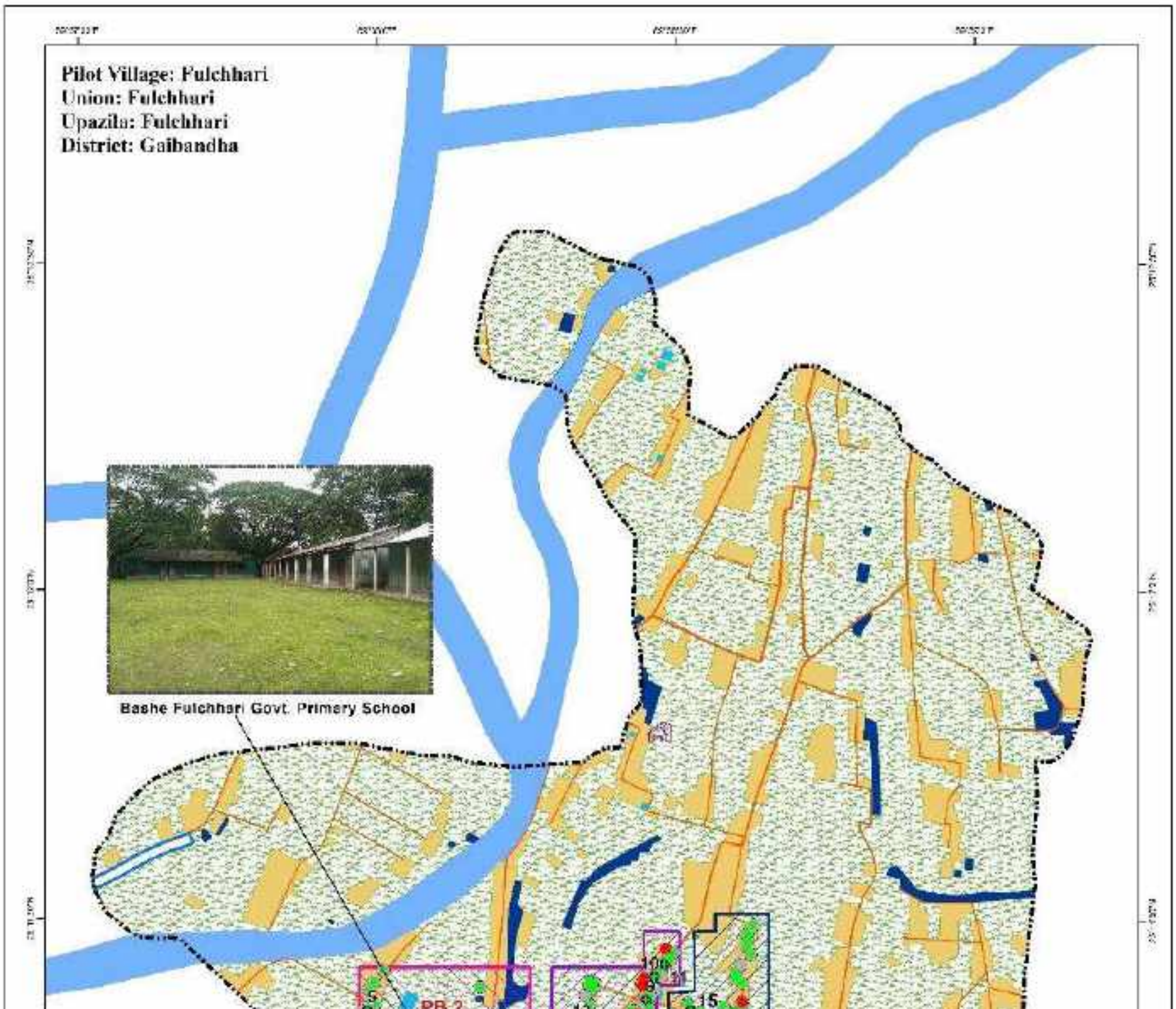


Figure 3.62: Planning block in village Fulchari

Tipna, Khulna

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.

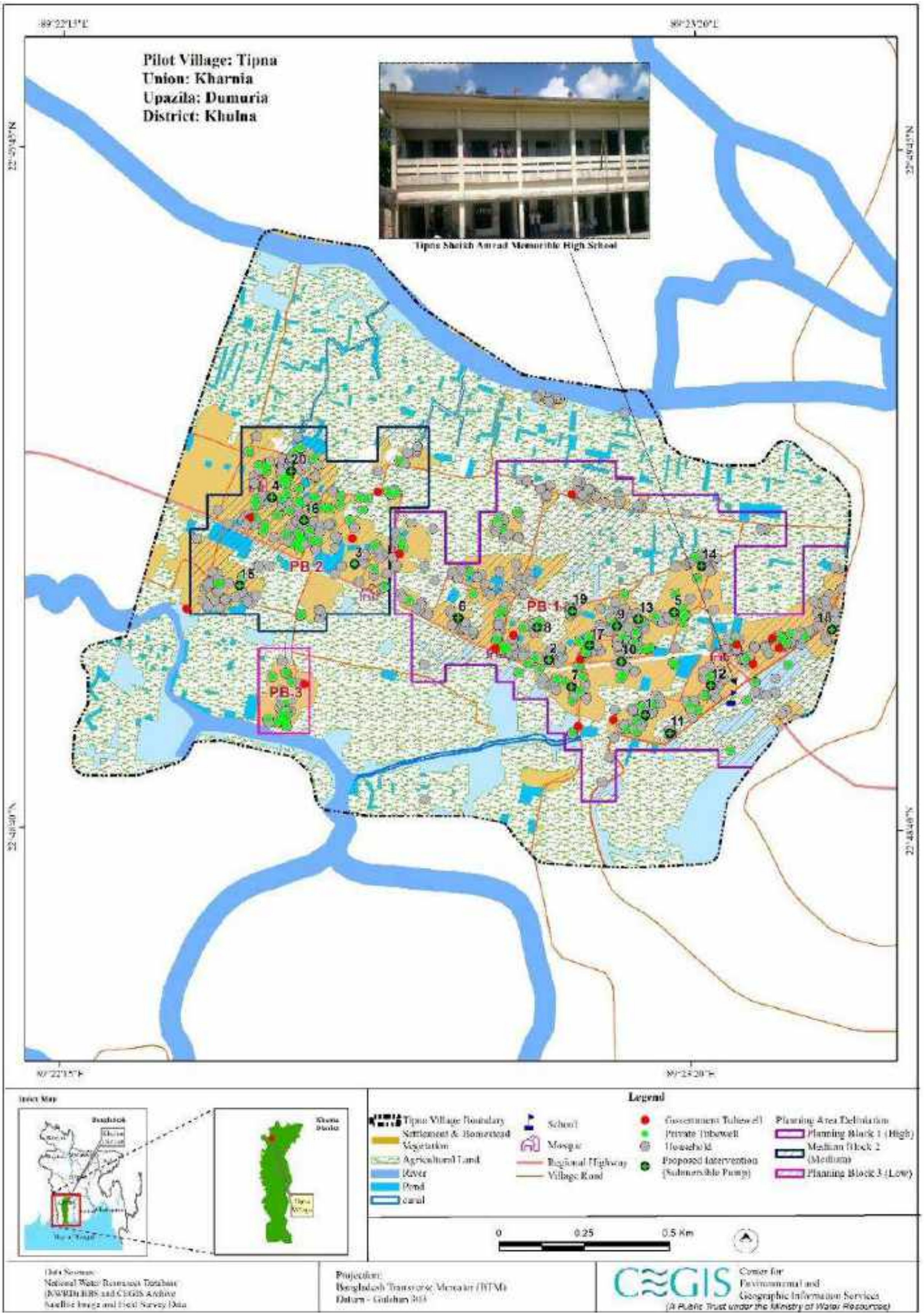


Figure 3.63: Planning block in village Tipna

Pathordubi, Kurigram

In Pathordubi, 80 submersible pumps have been proposed instead of the average of six households. The intervention ID-32 has been assigned to a maximum of 19 households. Intervention ID-54 has the fewest households, two, with an average distance of 75.15 m from the service point. The average number of households per intervention is 6, and the average distance between households and interventions is 62 meters. The proximity of the intervention to the household facilitates the water reach time by less than a minute. Eighty submersible pumps with tube wells are distributed among three planning blocks in Pathordubi village.

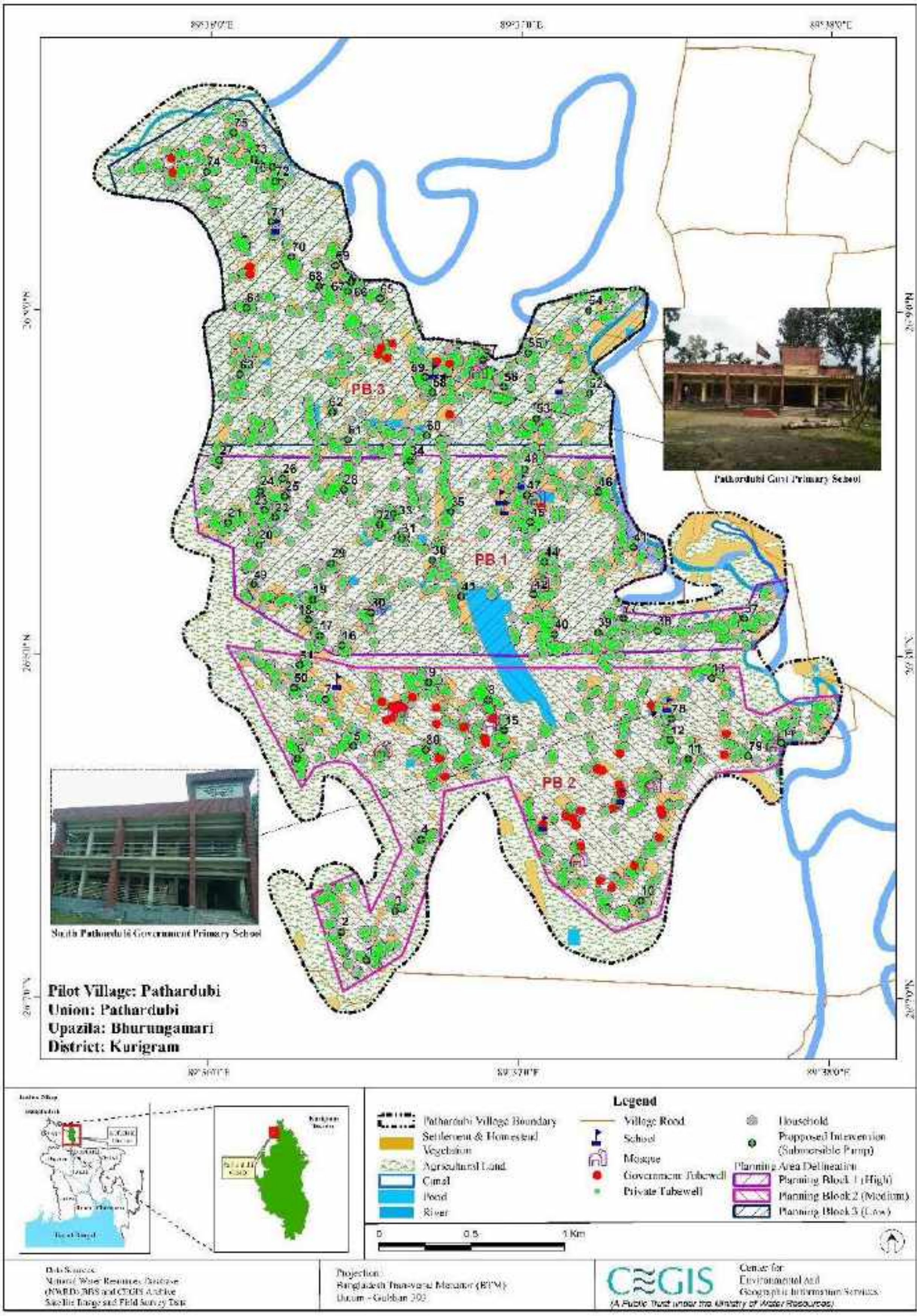


Figure 3.64: Planning block in village Pathordubi

Datinakhali, 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.

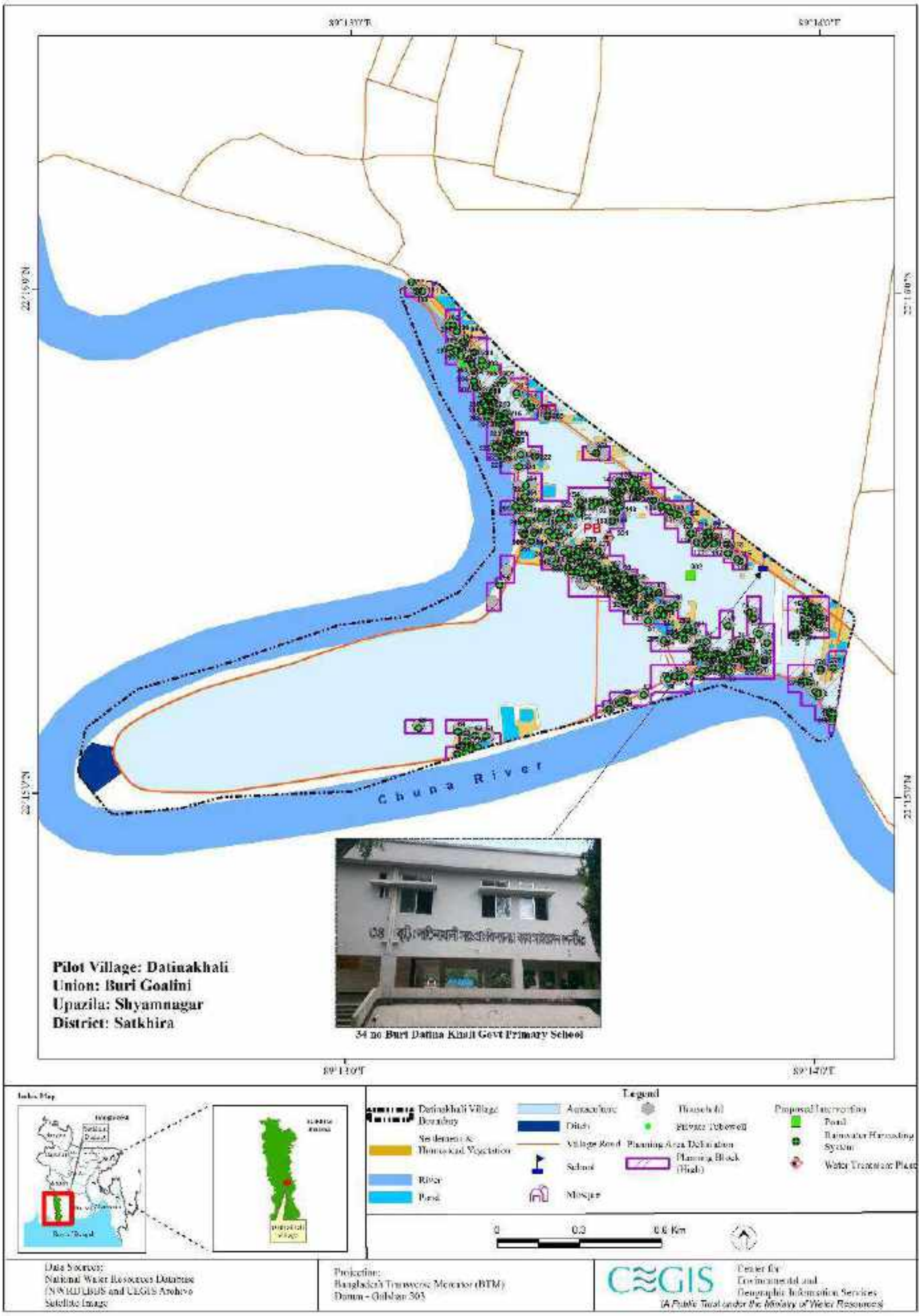


Figure 3.65: Planning block in village Datinakhali

Charsharat, Chattagram

25 mini-piped water supplies have been proposed in Induria. The intervention ID-7 has been assigned to a maximum household. The intervention ID-8 has been assigned to a minimum household. The average number of households per intervention is 14, and the average distance between households and interventions is 59 meters. The average distance is close enough to deliver water immediately. 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 five mini-piped water supply, distributed among three planning blocks in Induria village, are the proposed intervention, depending on the necessity for the technologies.

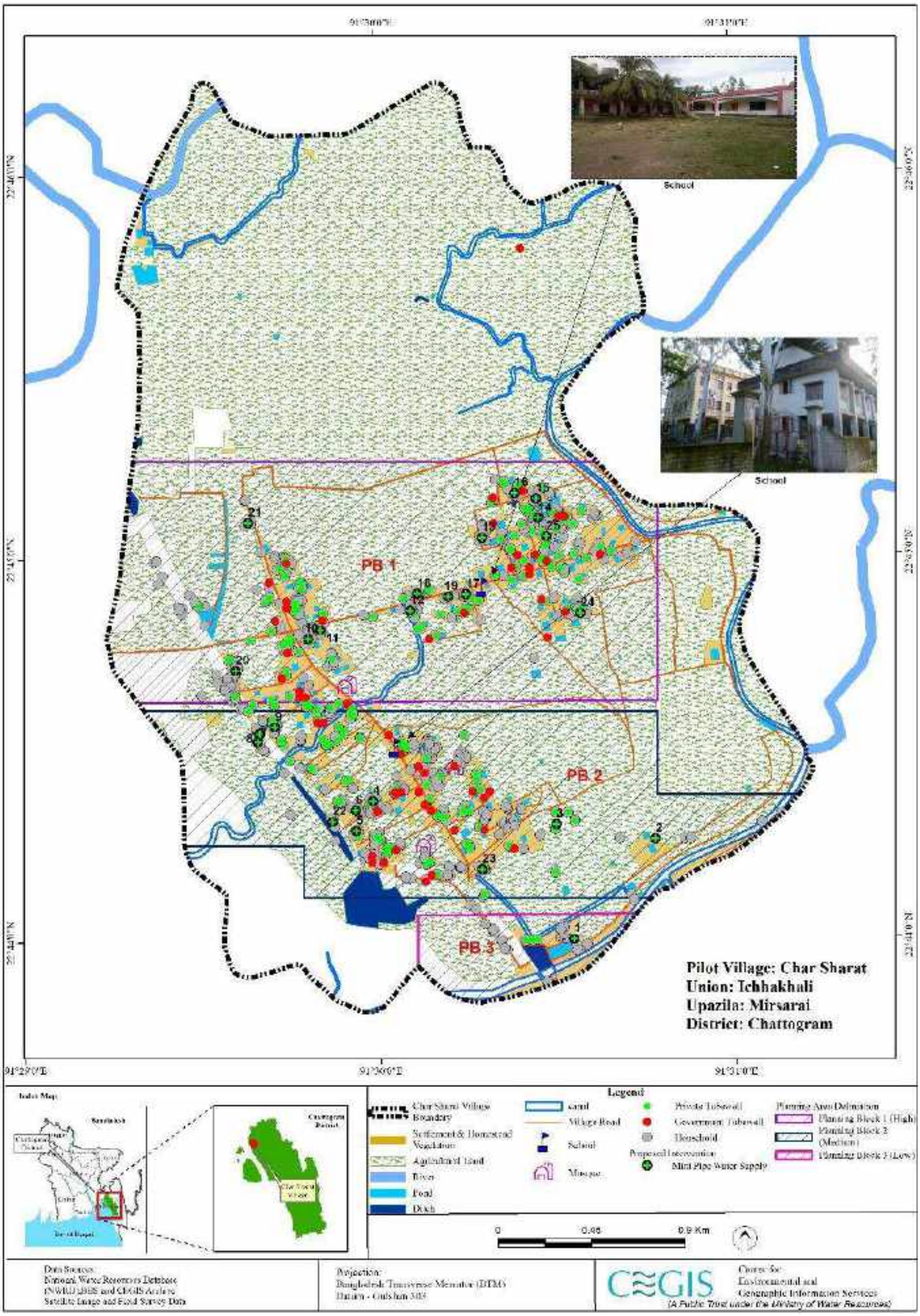


Figure 3.66: Planning block in village Charsharat

Shimulbank, 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.

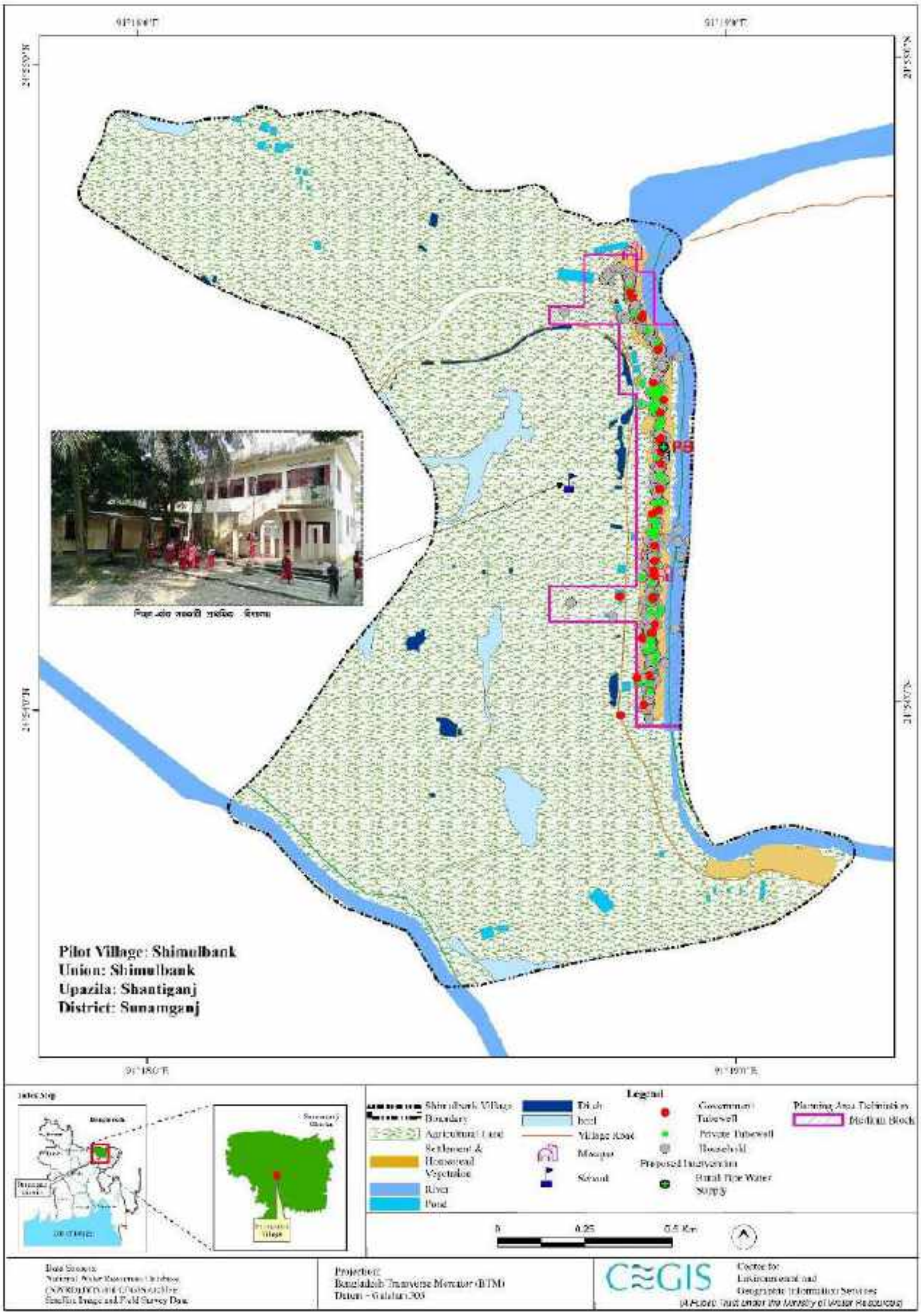


Figure 3.67: Planning block in village Shimulbank

Bagaiya, Sylhet

In Bagaiya, 40 mini piped water supplies have been provided. The average household number against each intervention is 13. The average distance between a household and an intervention is 49 meters. As the water source is not far from home, it can be possible to deliver water immediately. Due to the proximity of the intervention to the household, the time required to reach the water source will be less than one minute. Forty mini-piped water supplies, distributed among three planning blocks in Bagaiya village, are the proposed intervention, depending on the necessity for the technologies.

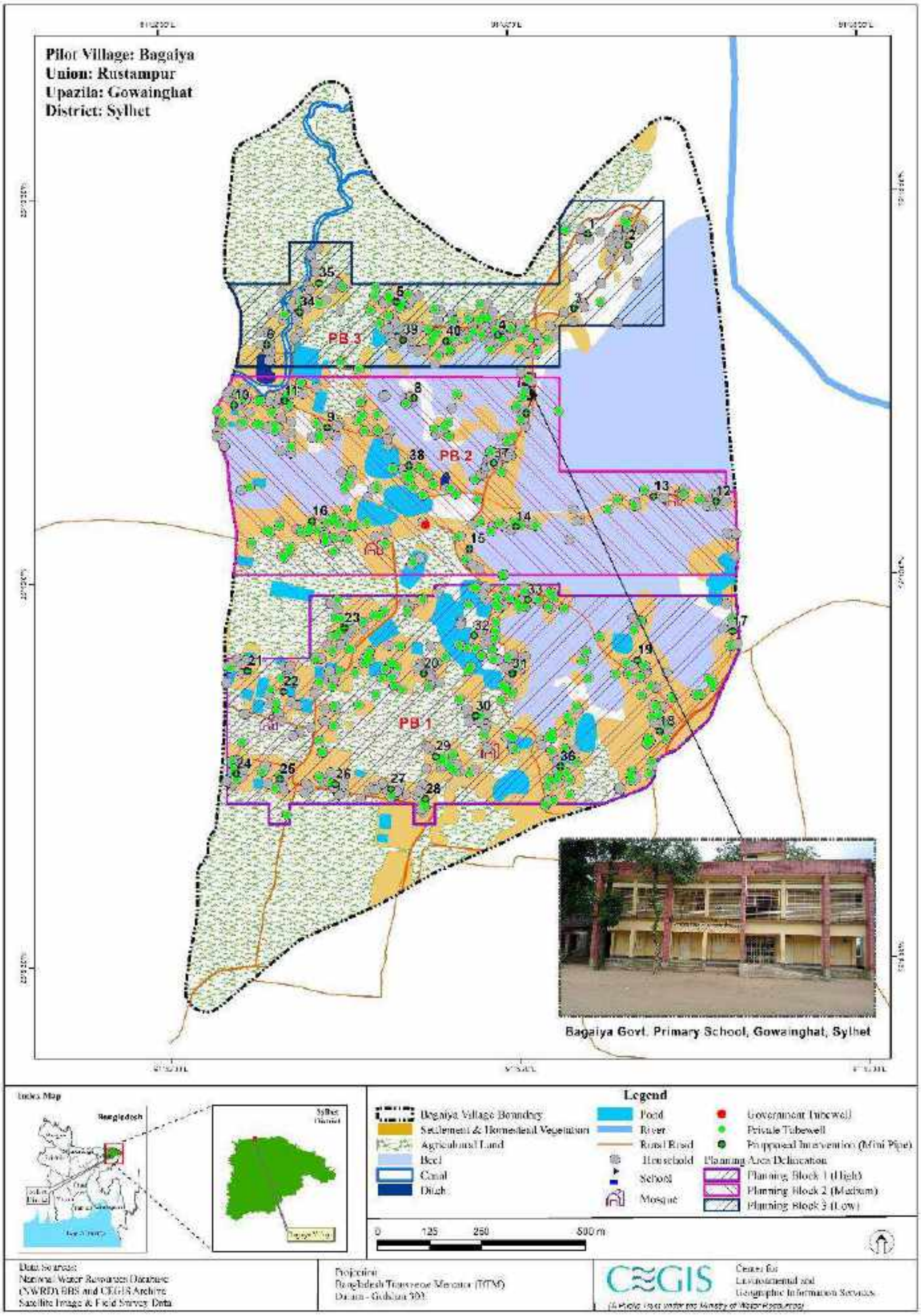


Figure 3.68: Planning block in village Bagaiya

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

The current demand for overall water uses per person-day has been assessed based on data available[1] of disaster-prone pilot villages. The previous two years (2021 and 2020) data are related to population growth[2]. Based on households in the eight villages, the annual average overall water demand for a village is calculated. Details are given in the following **Table 3.36.**

Future demand

After the completion of the project, a 25-year demand forecast was calculated using linear regression model. It says about 30% increase in water is likely to be used due to better living conditions in upper middle income and at the beginning of a higher income country.

Table 3.36: Current Demand for Drinking Water (Litre)

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Barishal	Induria	807	4.2	3389	237258	7117740	854	843	832
Chattogram	Charsharat	676	4.2	2839	198744	5962320	715	706	697
Gaibandha	Fulchari	306	4.2	1285	89964	2698920	324	320	316
Khulna	Tipna	624	4.2	2621	183456	5503680	660	652	644
Kurigram	Pathordubi	2500	4.2	10500	735000	22050000	2646	2612	2579
Satkhira	Datinakhali	993	4.2	4171	291942	8758260	1051	1038	1024
Sunamganj	Shimulbank	382	4.2	1604	112308	3369240	404	399	394
Sylhet	Bagaiya	836	4.2	3511	245784	7373520	885	873	862
Total				**55,104**	**3,857,280**	**270,009,600**	**Avg. 926**	**Avg. 914**	**Avg. 902**

Source: BBS, Statistical Pocketbook, 2021, Household size 4.2 (2018)

Note: Average water demand is estimated considering the natural growth rate of the 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 eight villages, the water demand has been estimated to keep account of the increasing trend over the years. There three observations in the

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

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

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 eight villages are calculated differently. The yearly average overall water demand per village is estimated at five years from 2020- 2045 year. Yearly average overall water demand before the project and after implementation of disaster-prone is calculated for the 2020- 2045 years at five years' gap shown in the following **Table 3.37-3.38.**

Table 3.37: Prior project Implementation Drinking Water Demand and Projection

Year	Yearly Overall Water Demand (lac Litre) after project implementation							
	Induria	Charsharat	Tipna	Pathordubi	Datinakhali	Shimulbank	Bagaiya	Fulchari
2020	832	697	804	2579	554	646	862	316
2025	887	742	856	2747	590	688	920	336
2030	942	787	1182	2915	814	949	978	356
2035	997	832	1250	3083	861	1004	1036	376
2040	1052	877	1319	3251	908	1059	1094	396
2045	1107	922	1387	3419	956	1114	1152	416

Table 3.38: Prior project Implementation Drinking Water Demand and Projection

Year	Yearly Overall Water Demand (lac Litre) after project implementation							
	Induria	Charsharat	Tipna	Pathordubi	Datinakhali	Shimulbank	Bagaiya	Fulchari
2020	832	697	804	2579	554	646	862	316
2025	1153	965	856	3570	590	688	1195	437
2030	1225	1023	909	3788	626	730	1270	463
2035	1296	1082	962	4006	663	772	1345	489
2040	1368	1140	1014	4223	699	815	1419	515
2045	1439	1199	1067	4441	735	857	1494	541

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 eight 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 the survey, latrine types and number identified in the pilot villages. The total latrine number of disaster-prone villages was calculated at 5357 numbers in households (HHs) of 7238. It indicates that some of the HHs do not have any latrine. About 26% of the HH have not any latrine. In the following Table, pit latrine i.e., single pit appears about 3596 and ventilated improved pit (VIP) stands at 612 number. Pit latrines need more cost for frequently cleaning of feces (waste matter remaining after food has been digested and discharged from bowels) in the pits. These are not environment friendly latrines. The following **Table 3.39** shows the current latrine status in disaster-prone villages.

Table 3.39: 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
Barishal	Induria	496	21	19	26	46	1	1
Chattogram	Charsharat	526	6	95	65	26	0	2
Gaibandha	Fulchari	189	0	1	33	0	0	0
Khulna	Tipna	346	21	35	86	107	0	2
Kurigram	Pathordubi	1283	4	318	208	48	1	0
Satkhira	Datinakhali	292	7	15	47	18	0	0
Sunamganj	Shimulbank	116	15	41	33	59	21	1
Sylhet	Bagaiya	348	3	88	96	136	6	3

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 3.40** shows the current number of conversions of single pit latrine to twine pit latrine[4].

The previous two years (2021 and 2020) data have been estimated for demand projection. They are related to the population growth[4] rate and behavior of the people in current sanitation concerning the national economic growth rate. In this regard, economic expansion (GDP growth rate) of about 5 percent of FY 2020-21 has been calculated for the previous data. Based on the assumption of gradually improved economic conditions, the earlier number of single-pit latrines was drawn down to the current number of single-pit latrines to convert into twine pits. Based on DPHE data, the current latrine type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following **Table 3.40.**

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

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

Table 3.40: Current Sanitation of Disaster-prone and Adjacent Area

District	Village	Number of household (hh)	HH size (4.2)	Number of Persons		Complete Twin Pit Latrine	Total Twin Pit Latrine	Number of converted twin pit Latrine			Number of complete twin pit Latrine		
					Converted twin Pit Latrine			Year 2022	Year 2021	Year 2020	Year 2022	Year 2021	Year 2020
Barishal	Induria	807	4.2	3389.4	415	230	645	415	435.75	457.5375	230	227.0484	224.1346
Chattogram	Charsharat	676	4.2	2839.2	350	195	545	350	367.5	385.875	195	192.4975	190.0272
Gaibandha	Fulchari	306	4.2	1285.2	155	95	250	155	162.75	170.8875	95	93.78085	92.57734
Khulna	Tipna	624	4.2	2620.8	300	145	445	300	315	330.75	145	143.1392	141.3023
Kurigram	Pathordubi	2500	4.2	10500	1260	580	1840	1260	1323	1389.15	580	572.5568	565.209
Satkhira	Datinakhali	993	4.2	4170.6	410	198	608	410	430.5	452.025	198	195.459	192.9507
Sunamganj	Shimulbank	382	4.2	1604.4	195	105	300	195	204.75	214.9875	105	103.6525	102.3223
Sylhet	Bagaiya	836	4.2	3511.2	400	250	650	400	420	441	250	246.7917	243.6246

Based on 2020, 2021, and 2022 years' single pit and new twine pit data, the investment demand for conversion of the single pit to twin pit has been forecasted for 25 years. In this case, the Linear Regression model is used for the projection. As the population increases slowly (1.3 percent or less) with better economic conditions (GDP growth rate of more than 5 percent, 7 or 8 percent), the single pit will have become down in number. Thus, the demand for conversion is estimated to decrease over the years. These are shown in the following **Table 3.41.**

Based on 2020, 2021, and 2022 years' single pit and new twine pit data, the investment demand for conversion of the single pit to twin pit has been forecasted for 25 years. The predicted result is tabulated below at the 5 years gap from 2020-2025 to understand the conversion number of the single pit latrine.

Table 3.41: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine							
	Induria	Pathordubi	Fulchari	Charsharat	Datinakhali	Tipna	Shimulbank	Bagaiya
2020	458	1389	171	386	452	331	215	441
2025	351	1067	131	296	347	254	165	339
2030	246	745	92	207	243	177	115	237
2035	140	424	52	118	138	101	66	135
2040	34	103	13	29	33	24	16	33
2045	0	0	0	0	0	0	0	0

A linear trend with a downward direction is found from the forecasted result for the individual village for 25 years, shown in **Annex II.** It shows before implementation, the future average demand for conversion of the single pit to twine pit latrines in the pilot villages and adjacent areas will decrease year by year.

Future Demand

After the completion of the project, a 25-year demand forecast was carried out using a linear regression model. There would likely be a 30% increase in new twine pit latrines due to better living conditions in upper-middle-income and at the beginning of the higher-income status of the country.

The estimated annual increase in demand for investment in the construction of a new twine pit latrine and the decrease in investment in the conversion of the single pit is shown in the following **Table 3.42**

Table 3.42: After Implementation Conversion of Single Pit and Construction of Twine Pit Latrine

Year	Converted twin pit from single pit								Increase number of new twin oit latrine								Projected Complete twin pit latrine							
	Induria	Pathordubi	Fulchari	Charsharat	Datinakhali	Tipna	Shimulbank	Bagaiya	Induria	Pathordubi	Fulchari	Charsharat	Datinakhali	Tipna	Shimulbank	Bagaiya	Induria	Pathordubi	Fulchari	Charsharat	Datinakhali	Tipna	Shimulbank	Bagaiya
2020	458	1389	171	386	452	331	215	441	224	565	93	190	193	141	102	244	224	565	93	190	193	141	102	244
2025	351	1067	131	296	347	254	165	339	239	602	99	202	206	151	165	260	239	602	99	202	206	151	109	260
2030	246	745	92	207	243	177	115	237	329	831	136	279	284	208	150	358	253	639	105	215	218	160	116	275
2035	140	424	52	118	138	101	66	135	349	879	144	295	300	220	159	379	268	676	111	227	231	169	122	291
2040	34	103	13	29	33	24	16	33	368	927	152	312	316	232	168	400	283	713	117	240	243	178	129	307
2045	0	0	0	0	0	0	0	0	387	975	160	328	333	244	176	420	297	750	123	252	256	187	136	323

After the implementation of the project, it is estimated that the investment in constructing a new twine pit latrine varies differently for different villages. 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 in the project. The related graphs after the project implementation have been presented in **Appendix III**.

4. Intervention and Options for Water Supply and Sanitation

4.1 Options for Intervention

Bangladesh represents one of the most vulnerable countries to the negative effects of climate change. This is due to a variety of geographical and hydrological factors, such as its geographic location, the hydro-meteorological influence of the monsoon and regional flow patterns, high precipitation events, high temperatures with little rainfall, saline water encroachment, natural catastrophes, and so on.

The impacts of climate change on water supply and sanitation directly affect how the country's sustainable development goals would be accomplished, putting the country at risk of achieving poverty reduction, overall public health, and environmental preservation. Bangladesh hopes that by 2021, access to safe drinking water and sanitation will no longer be a luxury.

The goal of the sixth Sustainable Development Goal (SDG) is to ensure that everyone has equitable access to safe and affordable drinking water. Bangladesh has made significant progress in sanitation over the past 25 years, reducing open defecation from 32% in 1990 to 5% today as a consequence of local, national, and global initiatives. With funding from the Annual Development Program (ADP), the Government of Bangladesh (GoB) is implementing a variety of hardware- and software-based programs and projects through the Local State to facilitate the promotion of water supply and sanitation among the vulnerable coastal community.

The Center for Environment and Geographic Information Services is conducting a study called "My Village, My Town" to assess the effectiveness of water supply and sanitation technology in Bangladesh's disaster zone.

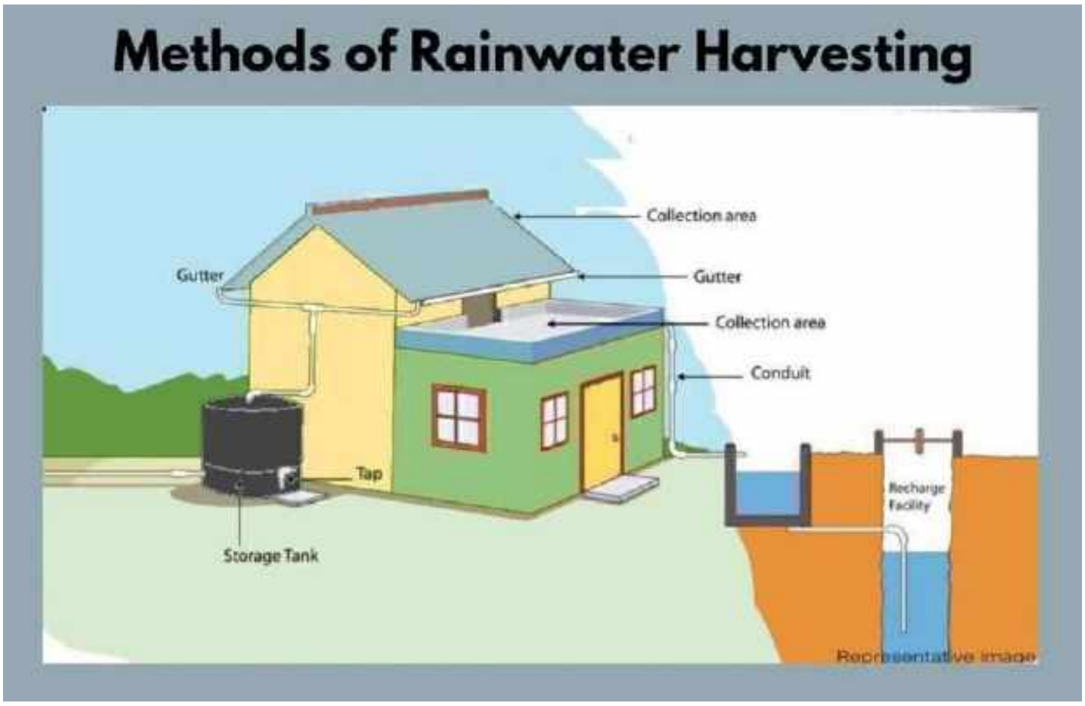
Water Supply

Disaster-prone areas like Induria, Fulchari, Tipna, Pathordubi, and Datinakhali community lack the infrastructure necessary to meet their water demands, particularly their demand for drinking water and sanitation. The technical research team at CEGIS has created an intervention plan to address the issues with both the water supply and sanitation.

In order to address the issue with the water supply, the technical team proposed sustainable and environmentally friendly techniques that are related to both surface and groundwater-based solutions. Collectively, all of the methods are capable of alleviating the existing water supply and drinking water shortages. Below are descriptions of suggested water supply technologies..

Rainwater harvesting

Rather than just allowing the rain to fall naturally, rainwater harvesting (RWH) involves collecting and storing it. About 203 cm of rainfall occurs annually in Bangladesh. Though rainwater is not available all year, rainwater harvesting could be a good source of drinking water. During the dry season, water scarcity is noticeable. In the meantime, rainwater harvesting is a blessing for people.



10 Lines on Rainwater Harvesting

1) Water scarced households and rural areas can take maximum benefit from rainwater harvesting systems.
2) Rainwater harvesting will ultimately bring food security, which will contribute in income generation.
3) Widespread implementation of rainwater harvesting in a large area like a city will ultimately reduce water needs for long term and keep water table intact.
4) Rainwater harvesting if done in a big area such as in whole city, district or a village will help water table to increase.
5) Designing and installing rainwater harvesting systems will also create a number of jobs. Rainwater harvesting industry can become a huge employer to youths.
6) Rainwater can provide an alternate source of water in an area where there is scarcity of water or the water is not suitable for drinking.
7) Dr Rajendra Singh popularly known as "Waterman of India" won "Magsaysay Award" in 2001 for his efforts in water harvesting and water management.
8) In 2001, Tamil Nadu became the first state in India which made rainwater harvesting compulsory to avoid water depletion.
9) In Karnataka, especially in Bangalore it is mandatory to construct rainwater harvesting systems in every building including the new ones.
10) In Rajasthan, many ancient water harvesting sources such as ponds were revived by adopting rainwater harvesting.

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Figure 4.1: Methods of rainwater Harvesting and its advantages

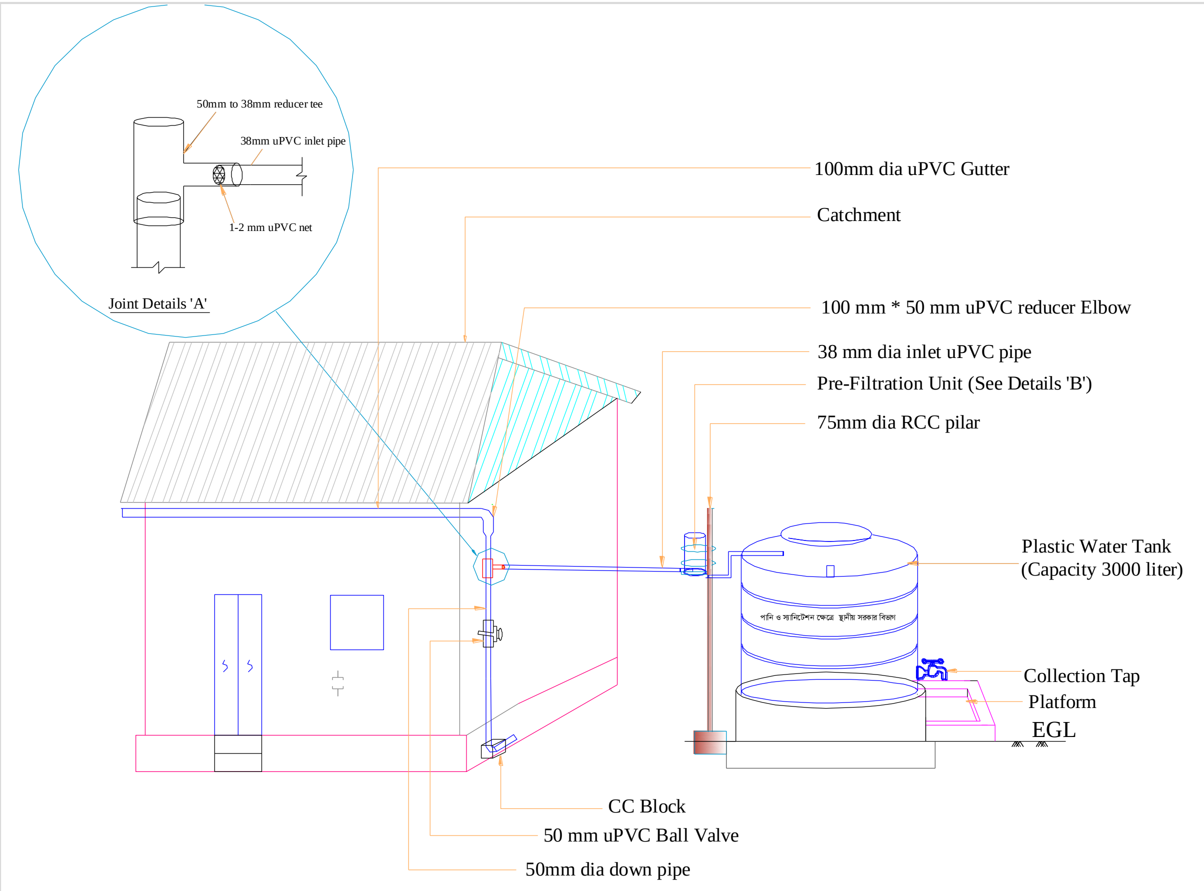

Figure 4.2: Typical drawing of Rainwater Harvesting

Pond Sand Filter

A pond sand filter (PSF) is used to treat surface water and has brick chips and sand chambers organized in series. The removal of suspended materials, as well as floating and sinkable particles, is done via sand filtration. It is a productive method for cleaning fresh or lightly salinized pond water. So it can be effective in coastal regions. A hand-pump tubewell is used to draw the pond's water.

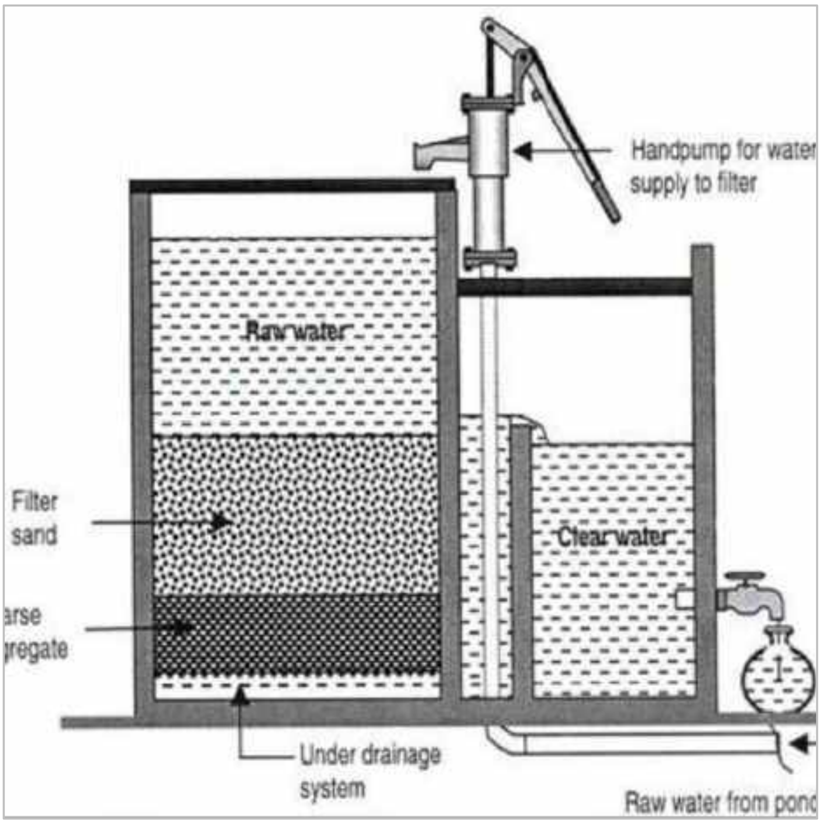

Figure 4.3: Pond Sand Filter

R.O. plant

A production facility where the reverse osmosis process is carried out is known as a "reverse osmosis plant." By forcing water over a membrane, reverse osmosis is a typical technique for purifying or desalinating polluted water. In coastal regions, an RO plant could be a good option for water solutions.

Figure 4.4: RO treatment plant

Water Treatment Plant

Village people are heavily dependent on surface water. Village people depend on pond or river water. They fulfill their domestic demand by using surface water. Some of them even drink pond water. As they don't have other facilities, surface water is a good source for their purposes.

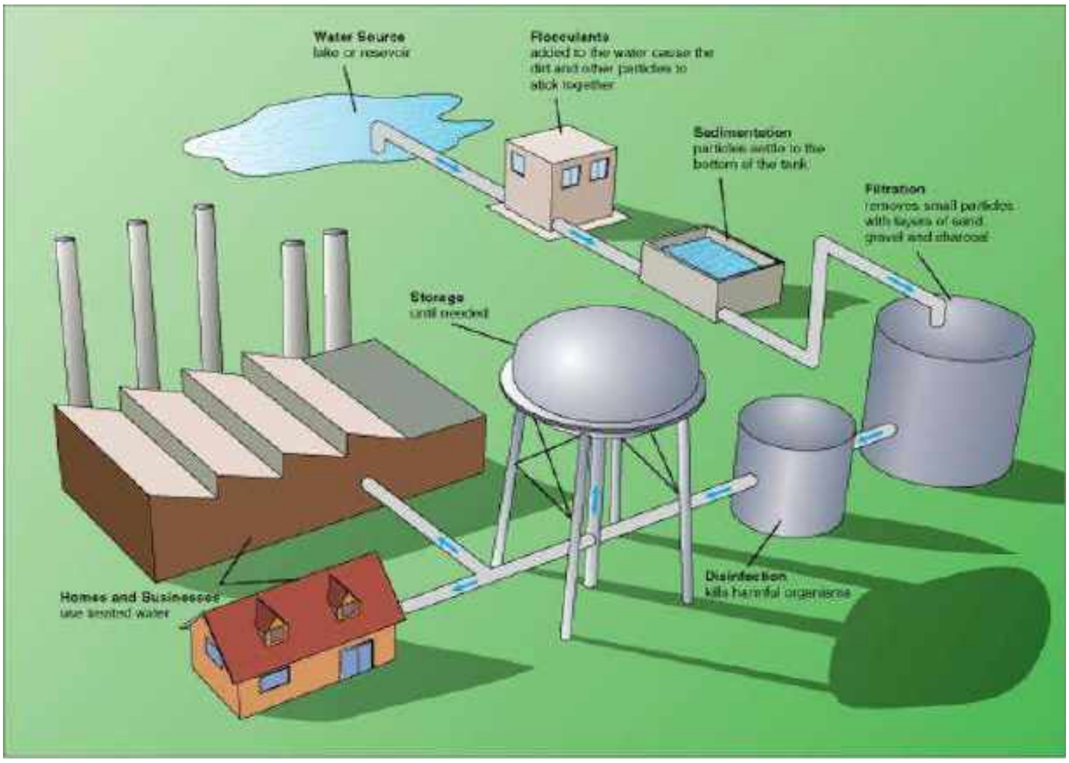

Figure 4.5: Water treatment plant schematic diagram

Iron removal plant with deep tubewell

Iron is the cause of the discoloration in the drinking water distribution system. Systems that remove iron are frequently used to clean groundwater and create drinking water for a range of uses. The clean water is raised to the required purity for drinking water thanks to an iron removal facility..

Figure 4.6: Iron removal technology

6 No. Tubewell

The No. 6 tubewell is a shallow-well suction pump that is regulated by a lever. The screen of the No. 6 tubewell is typically extended to the coarse sand aquifer when installed in collapsible tube wells. It is developed for usage by families. It offers great potential for community-based maintenance and is simple to implement. For the betterment of people, it is a good option because of its near access.

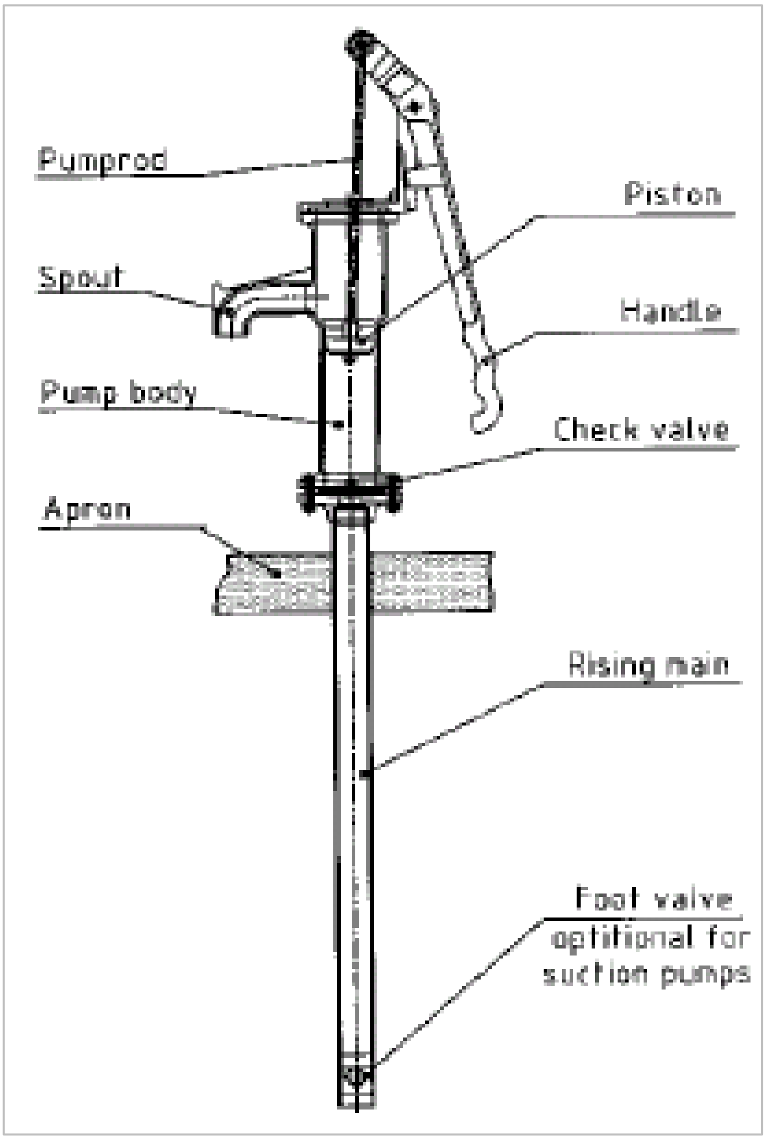

Figure 4.7: 6 No Tubewell

Deep Tubewell

Deep Tube wells have a large diameter and rely on a submersible turbine pump to pump water. In Bangladesh, deep aquifers are generally free of arsenic and iron. Arsenic concentrations in very deep wells typically appear to be low, frequently much less than 0.01 mg/l. Deep tube wells are more effective during drought when surface water evaporates.

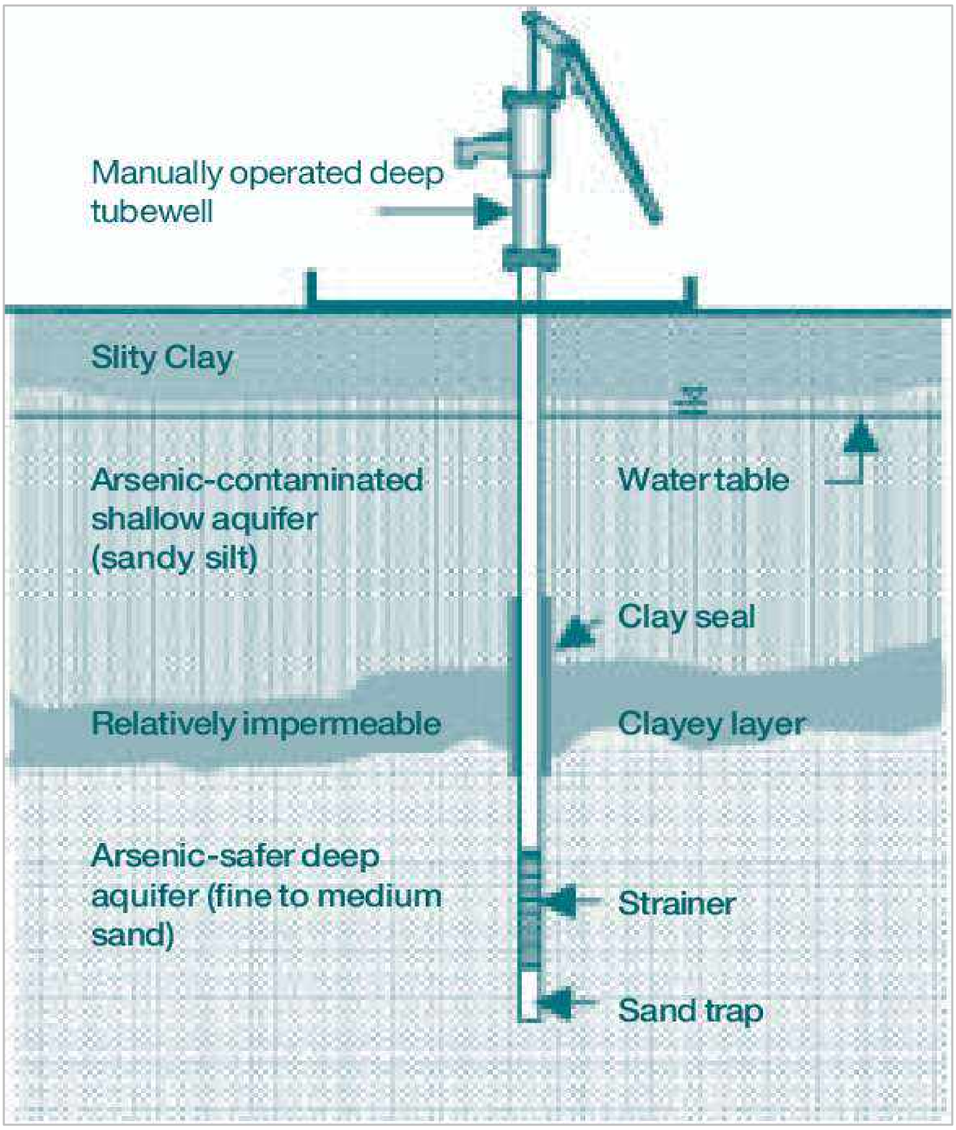

Figure 4.8: Deep Tubewell

Sanitation Option

The selection of technology is based not only on the technical aspects of each technology, but also on factors such as the settlement's permanence, financial costs and affordability, design life, expectations and preferences, institutional capacity, job creation potential, and environmental considerations.

Single Pit Latrine

A single pit latrine is vulnerable. Flies are noticeable to the users in the pit latrine. There is a possibility that it affects groundwater with pathogens and nitrate. Pit emptying is often done in a very unsafe manner. To empty the pits, the cost can be significant compared to the capital costs.

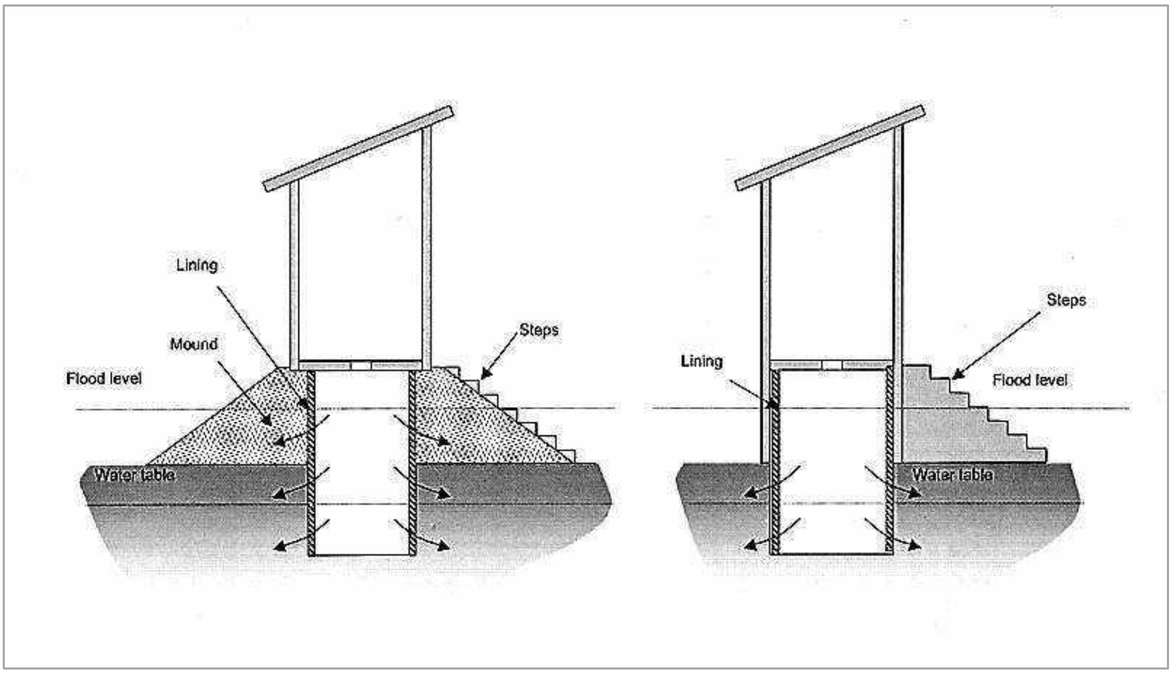

Figure 4.9: Single pit latrine

Twin pit latrine

Twin pit is executable and affordable. A continuous operation system is provided by twin pit latrines. Withdrawal and disposal do not affect the other operation systems. VIP latrine

Through air circulation, the ventilated, improved pit latrine improves sanitation by getting rid of flies and stench. The addition of a chimney forces air currents through the squat hole and into the building. The chimney causes odors to rise and diffuse. Due to the design of the toilet, any flies drawn to the pit through the squat hole will attempt to flee by moving toward the strongest light source, which is the chimney. Because a wire mesh prevents the flies from leaving, they gradually perish and fall back into the pit. It offers better sanitation.

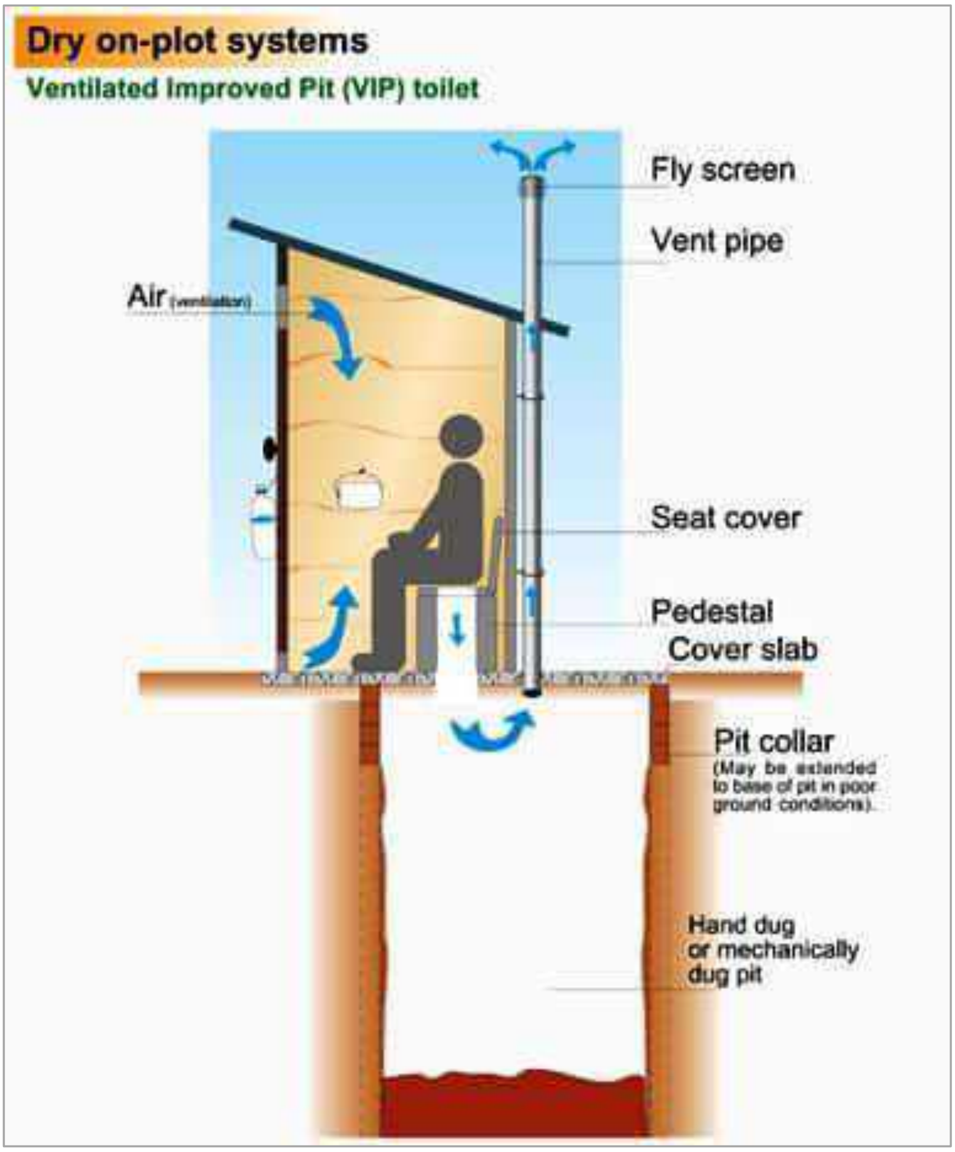

Figure 4.10: Ventilated Improved Pit (VIP) toilet

Flush Latrine

Pour-flush latrines are a better choice when it comes to use, maintenance, and design. They replicate a pit latrine and a septic tank or sewer. Excreta is flushed out of a collection pan, down a short pipe, and into a pit using a small amount of water. The capital cost is low. Before the next user arrives, the previous user's waste is flushed away. Maintenance costs depend on the price of water. So, flush latrines are a good option for sanitation.

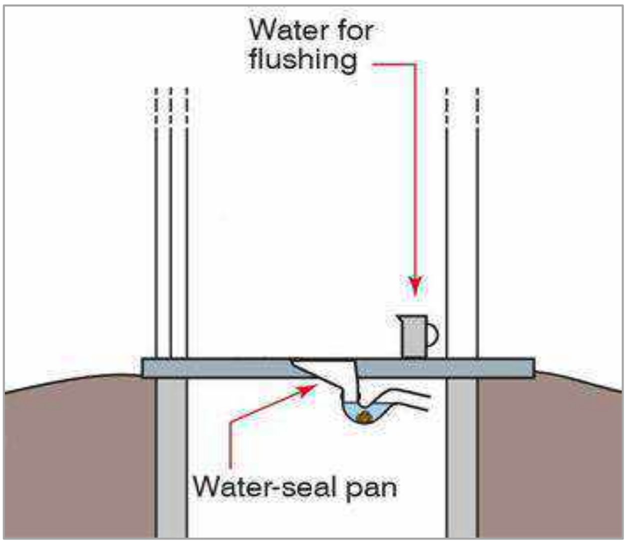

Figure 4.11: Flash Toilet

A single pit is not so good for sanitation. In terms of sanitation conditions, VIP latrines and flush latrines are the best solutions. VIP latrines and twin pit latrines can be provided at all study areas. The primary cost of flush latrines is high, but the maintenance and management system is better. It could be a better solution if other facilities are available.

4.2 Guideline for Proposed Intervention

Some technical intervention has been proposed for disaster prone areas. The guideline of proposed intervention describes below:

Table 4.1: Technical guidelines for the proposed intervention about water supply are tabulated below

SL No.	Intervention	Technical Guideline
1	Rainwater harvesting	Non-pressurized Rainwater Harvesting • A storage tank with a control unit need to provide. • A header tank needs to implement also. • Break tank can be provided at any point in the supply system. • The smallest and most basic levels of control for operating the system are provided by a non-pressurized control panel, which is substantially smaller. Pressurized Rainwater Harvesting • This system might be necessary in buildings with minimal water usage, where there isn't enough room on the roof for a header tank, or for purposes that need a pressurized supply. • By collecting storm water from the roof area, a pressurized rainwater harvesting system boosts the supply of recycled water to non-potable outlets. • The system can deliver water for irrigation, car wash facilities, restrooms, and a variety of other commercial uses.
2	Pond sand Filter	• PSF options will be implemented at the community level. • The pond needs to be large enough and have water accessible all year. • The pond should be set back from latrines and cowsheds.

SL No.	Intervention	Technical Guideline
		• To prevent household, industrial, and agricultural waste from entering the pond, the pond dike should be repaired when necessary, especially before the rainy season. • The pond should be more accessible to the user population, with complete access for women in particular.
3	6 No tubewell	• It is a shallow well lever-operated suction pump. • It can serve maximum 100 people. • Maximum pumping lift is 8 m. But recommended value is 6-7 m. • Shallow aquifer should be separated from deeper aquifer by substantially thick impervious layer.
4	Water treatment plant	• Screening should be done for removing all floating material at the intake point. • Aeration need to be done for removing colors, odors, taste and to kill bacteria up to some extent. • Pond sand filter is an effective approach in the aspect of surface water treatment plant.
5	Mini piped water supply	• Identification of risk through survey around catchment areas for surface and ground water. • Properly select chemicals for water purification and maintain quality of chemicals and proper use. • Adopt measures to control risk of contaminations like reducing pipe leakage, stopping back flow and illegal connections. • Requires larger space than regular Tubewell
6	Iron removal plant	• Total amount of water demand, pressure of water, suspended solid contents, turbidity, pH and most importantly iron and manganese presence in water need to assess first. • To filter the dissolved iron content, it must be converted into suspended form.
7	Deep tubewell	• Deep tubewell can be implemented where iron problem is acute in shallow tubewell. • The casing must be large enough to house the pump and should allow sufficient clearance for installation and efficient operation. • Plastic casing is good due to its resistance to corrosion. • Plastic casing must be made of virgin casing instead of recycle materials.
8	RO water treatment plant	• The assessment of particle size and concentration aids in the selection of appropriate microfiltration prior to the membrane. • High quality filter needs to use as a prefilter

Table 4.2: Technical guidelines for the proposed intervention 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.

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 of Proposed WASH Intervention

The pilot villages have water scarcity and sanitation problems. A geographical issue affecting rural people's water supply. So, some interventions have been proposed for the areas through assessments and people's opinions. People believe that the following interventions will mitigate the crisis they are facing now. Water will be available throughout the year. So they will no longer face a lack of water.

The implementation of the project will ensure safe drinking water and proper sanitation. It helps bring back a healthy life. People suffered from waterborne diseases, which will be mitigated by getting proper drinking water. In some areas, people have to travel far to collect water, which is time-consuming. So, the interventions will help save time by providing them with sufficient water. Some people purify their water. If the intervention has been implemented, they don't need to purify the water. It will save fuel. People get affected by many types of worms due to unconscious sanitation. If proper sanitation can be provided, it will help them overcome the problems. 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 odor and unhygienic condition.

4.5 Socio-Economic Impacts of the Proposed Interventions

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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 are basic human rights.

- In the study area, people are unprivileged and also illiterate. People are unaware of the availability of safe drinking water.So it is the responsibility of the government to ensure safe drinking water and proper sanitation. However, some issues and challenges arise as a result of the conditions.The following issues and challenges have been discussed below:At Induria, an adequate amount of tubewell has been used. Everyone relies on tubewells for their water supply. Only 2.2% of tubewell water is of poor quality. It is primarily due to salinity and iron. Approximately 98.49% of tubewells have water available all year. Water scarcity affects the remaining tubewell from February to April as the water level drops. There are 25 mini piped water supplies available for use here.

- Fulchari is an arsenic and iron prone region. These two issues can be found in this area. 61% of people have their own tubewell. 28% of people get their information from their neighbors. Only 5% of the water is found to be of poor quality. Because of the presence of iron in the water, its quality is poor. The layer contains iron up to 200 feet deep. Arsenic has also been discovered in some areas. Stone can be found above the 200-foot layer. To go beyond 200 feet, different machines must be used. The water layer is only 22–28 feet deep. There are 15 mini-piped water supplies available for use here.
- Tipna is prone to cyclones. It is, however, a tubewell-profitable area. Approximately 90.54% of tubewells have water available year-round. Water scarcity affects the remaining tubewell from March to May as the water level drops. Salinity and iron have been discovered at a shallow depth. The water quality is good above 700 feet. A reserve tank must be installed in the area. The majority of people have access to a toilet. However, some people continue to be without a toilet. For those, public restrooms near highways can be installed.
- Pathordubi is a low-income neighborhood. People are not aware of the importance of sanitation. The sanitation situation in this area is devastating. The depth of the tubewell is in the 450–550 feet range. Water quality is poor in 30.81% of tubewells. It is caused by the presence of iron in the water. In this case, a 100 feet deep tubewell with an iron removal plant has been installed. This area has a stone layer about 250–300 feet down. To go beyond that range, different machines may have to be used.
- Datinakhali is not a successful tubewell area. The saline concentration in the tubewell ranges between 3500 and 4500 PPM. Because of the presence of iron, the quality of the water is poor. Arsenic is a problem in 52.3% of tubewells. Pond sand filters and rainwater harvesting are the primary sources of drinking water. The village protection embankment breaks and flood water rushes through twice or three times a year, flooding the PFS ponds during disasters. Community-based RO plant establishments may be viable options for drinking water in this area. Rainwater harvesting systems are another viable option that the people in that area desire. The sanitation situation in this area is dire
- At Shimulbank, the village contains 70% government tubewells, whose average depth is 650 feet. The main issue is the presence of arsenic (As) in shallow depth tubewell water, but the village has a successful deep tubewell area. The iron and turbidity problem is also remarkable. But the sanitation quality is poor, with only toilets in 59.64% of houses.
- The maximum water source at Bagaiya is the tubewell. Most are shallow tubewells. The main problem in this region is iron. Another problem is the odor. Around 30% of people do not own toilets.
- At Charsharat, the main source of water is a tubewell, which is mainly a deep tubewell (depth ranges between 300-900 ft). Around 63% of people face an arsenic problem. The salinity problem is also remarkable.

4.7 Selected Option for Intervention

Some technologies have been selected by analyzing the current situation and the interventions needed in disaster-prone areas. They are tabulated in the following table.

Table 4.3: Technical solutions related to water supply for disaster prone area

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
• Induria, • Memania, • Hijla, • Barishal	• Elevated installation of tubewell • Region based deep tubewell • Arsenic free tubewell • Pipe water supply	• Mini piped water supply • Rain water harvesting • Submersible tubewell • Water treatment plant • Ring well	• Mini piped water supply
• Fulchari, • Fulchari, • Fulchari, • Gaibanda	• Elevated installation of tubewell • Arsenic free tubewell	• Mini piped water supply • Rain water harvesting • Submersible tubewell • Water treatment plant • Ring well	• Mini piped water supply
• Tipna, • Khurnia, • Dumuria, • Khulna	• Region based deep tubewell • Arsenic free tubewell • Pipe water supply	• Deep tubewell • Rain water harvesting • Water treatment plant • Mini piped water supply • 6 No. tubewell	• Deep Tubewell with submersible pump
• Pathordubi, • Pathordubi, • Bhurungamari, • Kurigram	• Pipe water supply • Arsenic free tubewell	• Deep tubewell • Iron removal plant • Rain water harvesting • Water treatment plant • Mini piped water supply • Ring well	• Shallow tubewell with submersible pump
• Datinakhali, • Burigoalini, • Shyamnagar, • Satkhira	• Piped water supply • Region based deep tubewell	• Rain water harvesting • Pond sand filter • RO plant installation • Water treatment plant • Mini piped water supply • Submersible tubewell • Ring well	• Rain water harvesting • Pond sand filter • River Osmosis (RO) plant installation
• Shimulbank, Shimulbank, Shantiganj, Sunamganj	• Arsenic free tubewell • Elevated installation of tubewell • Piped water supply	• Rural Piped water supply • Deep tubewell • Dug well	• Rural piped Water supply
• Bagaiya, • Rustimpur, • Gowainghat, • Sylhet	• Elevated installation of tubewell • Piped water supply	• Mini piped water supply • Submersible tubewell • Deep tubewell • Ring well • Rainwater harvesting • Water treatment plant	• Mini piped water supply

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
• Charsharat' • Ichakhali, • Mirsarai, • Chattagram	• Elevated installation of tubewell • Piped water supply	• Mini piped water supply • Submersible tubewell • Ring well • Rainwater harvesting • Water treatment plant	• Mini piped water supply

Table 4.4: Technical solutions related to sanitation for disaster prone areas

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
Induria, Memania, Hijla, Barishal	• Pit latrine	• Conversion of single pit latrine to twin pit latrine • Complete twin pit latrine • Flash latrine • Septic tank flash latrine	• Conversion of single pit latrine to twin pit latrine • Complete twin pit latrine
Fulchari, Fulchari, Fulchari, Gaibanda	• Pit latrine • Flash latrine	• Conversion of single pit latrine to twin pit latrine • Complete twin pit latrine • Flash latrine • Septic tank flash latrine	• Conversion of single pit latrine to twin pit latrine • Complete twin pit latrine
Tipna, Khurnia, Dumuria, Khulna	• Pit Latrine • VIP Latrine	• Conversion of single pit latrine to twin pit latrine • Complete twin pit latrine • Flash latrine • Septic tank flash latrine	• Conversion of single pit latrine to twin pit latrine • Complete twin pit latrine
Pathordubi, Pathordubi, Bhurungamari, Kurigram	• Pit Latrine •	• Conversion of single pit latrine to twin pit latrine • Complete twin pit latrine • Flash latrine • Septic tank flash latrine	• Conversion of single pit latrine to twin pit latrine
Datinakhali, Labsa, Shyamnagar, Satkhira	• Pit Latrine	• Conversion of single-pit latrine to twin pit latrine • Complete twin-pit latrine • Flash Latrine • Septic tank flash Latrine	• Conversion of single-pit latrine to twin pit latrine • Complete twin-pit latrine
Shimulbank, Shimulbank, Shantiganj, Sunamganj	• Pit Latrine • Septic tank Latrine	• Conversion of single-pit latrine to twin pit latrine • Complete twin-pit latrine • Flash Latrine • Septic tank flash Latrine	• Conversion of single-pit latrine to twin pit latrine • Complete twin-pit latrine
Bagaiya,	• Pit latrine	• Conversion of single-pit	• Conversion of single-

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
Rustampur, Goainghat, Sylhet	• Septic tank latrine • Flash latrine	latrine to twin pit latrine • Complete twin-pit latrine • Flash Latrine • Septic tank flash Latrine	pit latrine to twin pit latrine • Complete twin-pit latrine
Charsarat, Ichakhali, Mirsarai, Chattagram	• Pit latrine	• Conversion of single-pit latrine to twin pit latrine • Complete twin-pit latrine • Flash Latrine • Septic tank flash Latrine	• Conversion of single-pit latrine • Complete twin-pit latrine

5. Design and Cost Estimation

5.1 Introduction

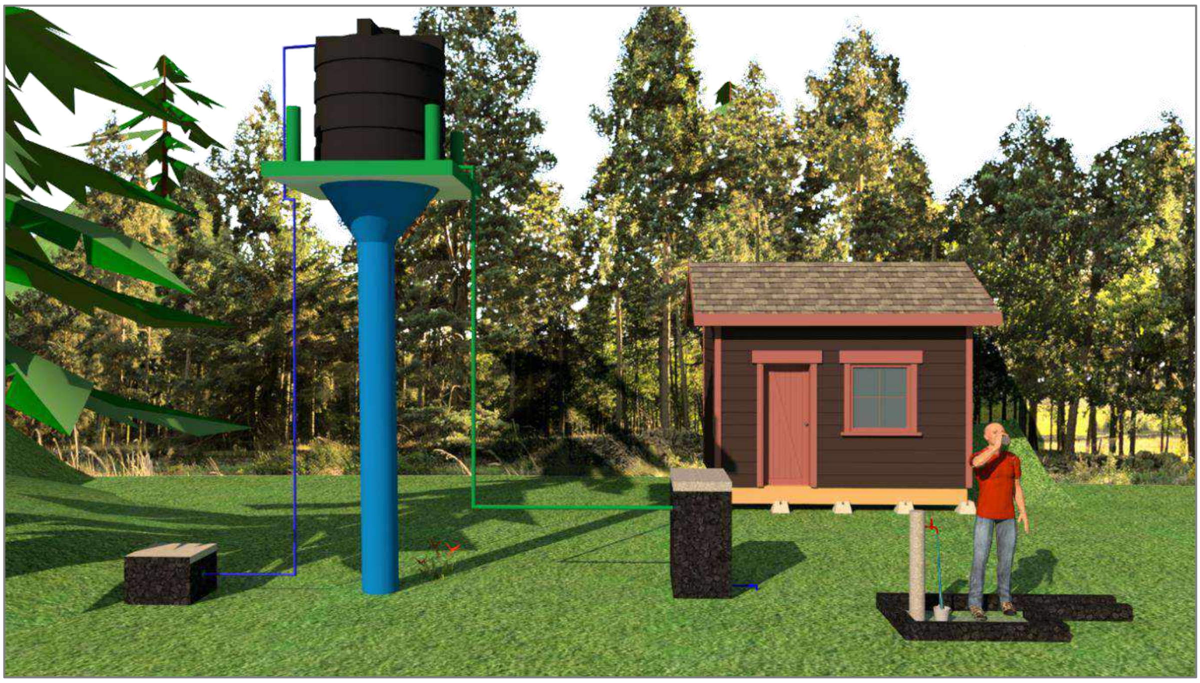
This section covers water availability, accessibility, water sources, water supply design, sanitation design, climate change risk assessment, water point maintenance, water quality, ownership of water source, and problem faced in access to and collection of water in the project areas and also different 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 eight disaster-prone villages are given below:

Mini Piped Water Supply Scheme

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 Liter, 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 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

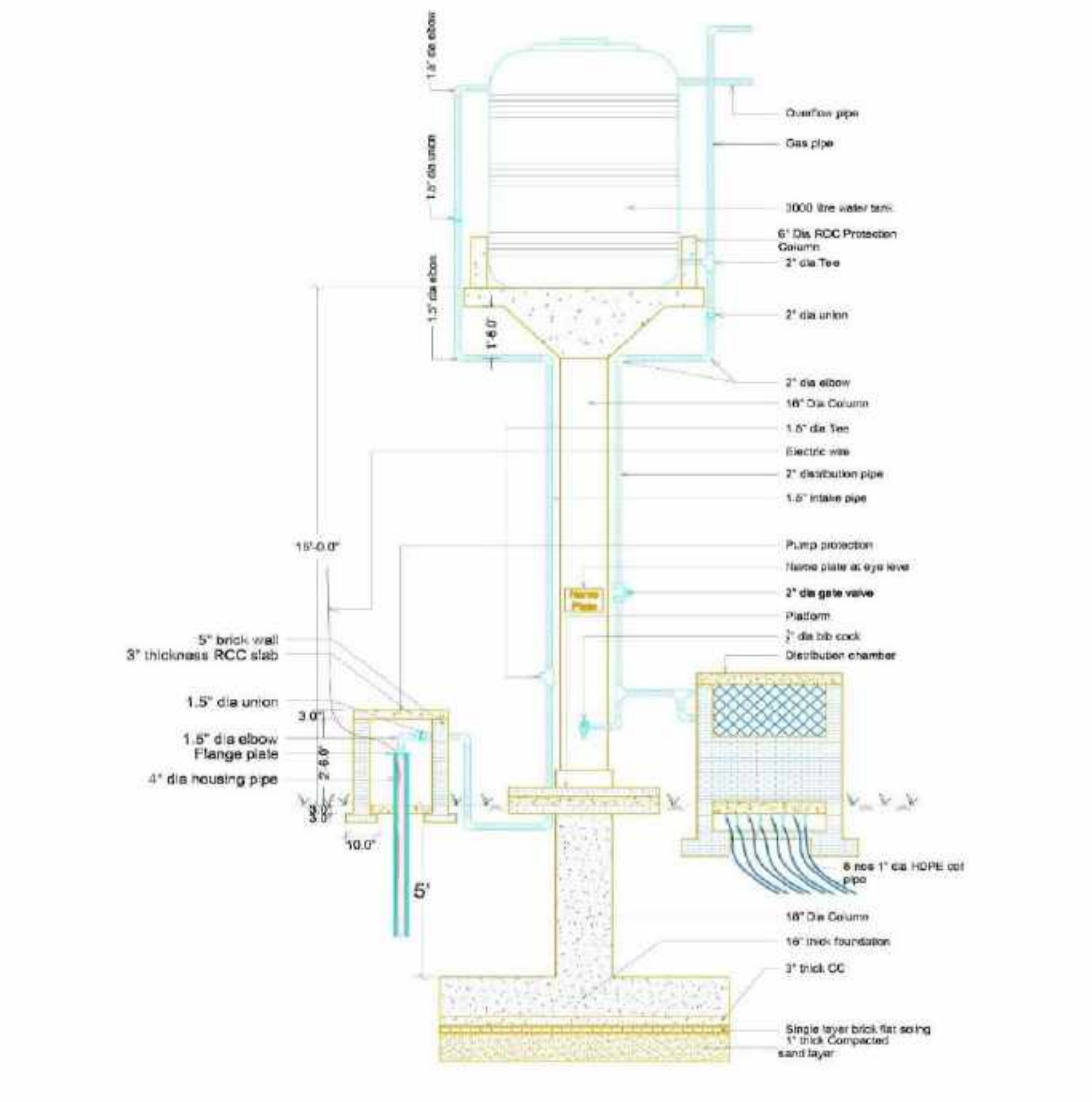
Area wise Technical Feasibility

Name of Feasible Area	Mini piped Water supply
Induria, Memania, Hijla, Barishal	25
Bagaiya, Rustampur, Gowainghat, Sylhet	40
Fulchari, Fulchhari, Fulchhari, Gaibandha	15
Charsharat, Ichhakhali, Mirsarai, Chattogram	25

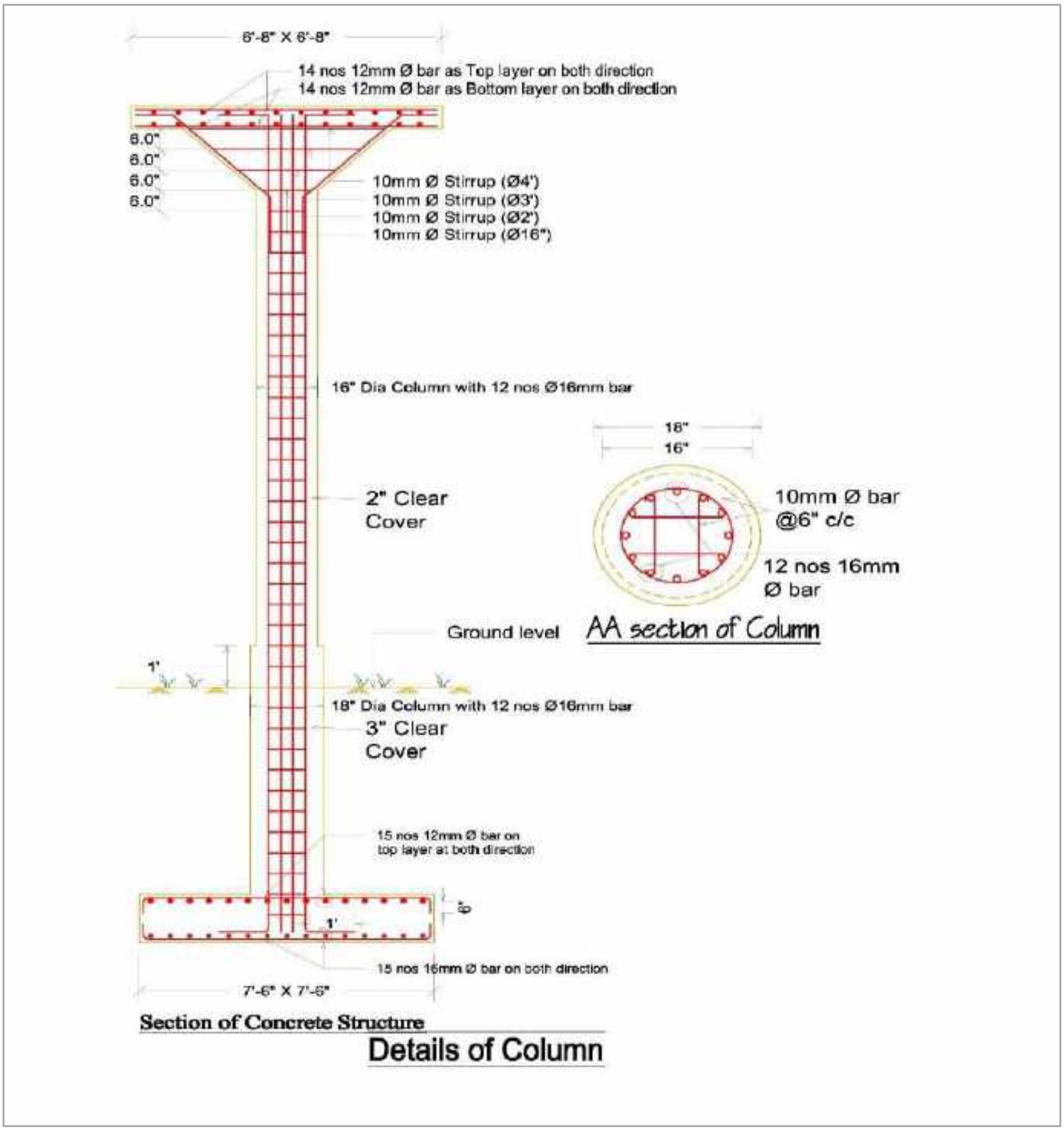
Design Considerations

- Tubewell depth is to be considered as per water availability and quality
- 1.5 HP Submersible Pump is Proposed, but can be changed as per field condition
- Water Tank capacity is 3000 Liter (Tank must be food graded)
- Tank platform is assumed 15 feet high from the ground to ensure sufficient pressure at all water collection points
- Structural Design is based on BNBC 2020
- Valve chamber has 10 connections with HDPE coil pipe connection

Schematic Drawing



Mini Piped Water Supply Scheme



Rain Water Harvesting

Introduction

Water is considered an everlasting free source that can be acquired naturally. Demand for processed supply water is growing higher due to an increasing population. Sustainable use of water could maintain a balance between its demand and supply. Rainwater harvesting (RWH) is the most traditional and sustainable method, which could be easily used for potable and non-potable purposes both in residential and commercial buildings. This could reduce the pressure on processed supply water which enhances the green living. This paper ensures the sustainability of this system through assessing several water-quality parameters of collected rainwater with respect to allowable limits. A number of parameters were included in the analysis: pH, fecal coliform, total coliform, total dissolved solids, turbidity, NH3–N, lead, BOD5, and so forth. The study reveals that the overall quality of water is quite satisfactory as per Bangladesh standards. RWH system offers sufficient amount of water and energy savings through lower consumption. Moreover, considering the cost for installation and maintenance expenses, the system is effective and economical.

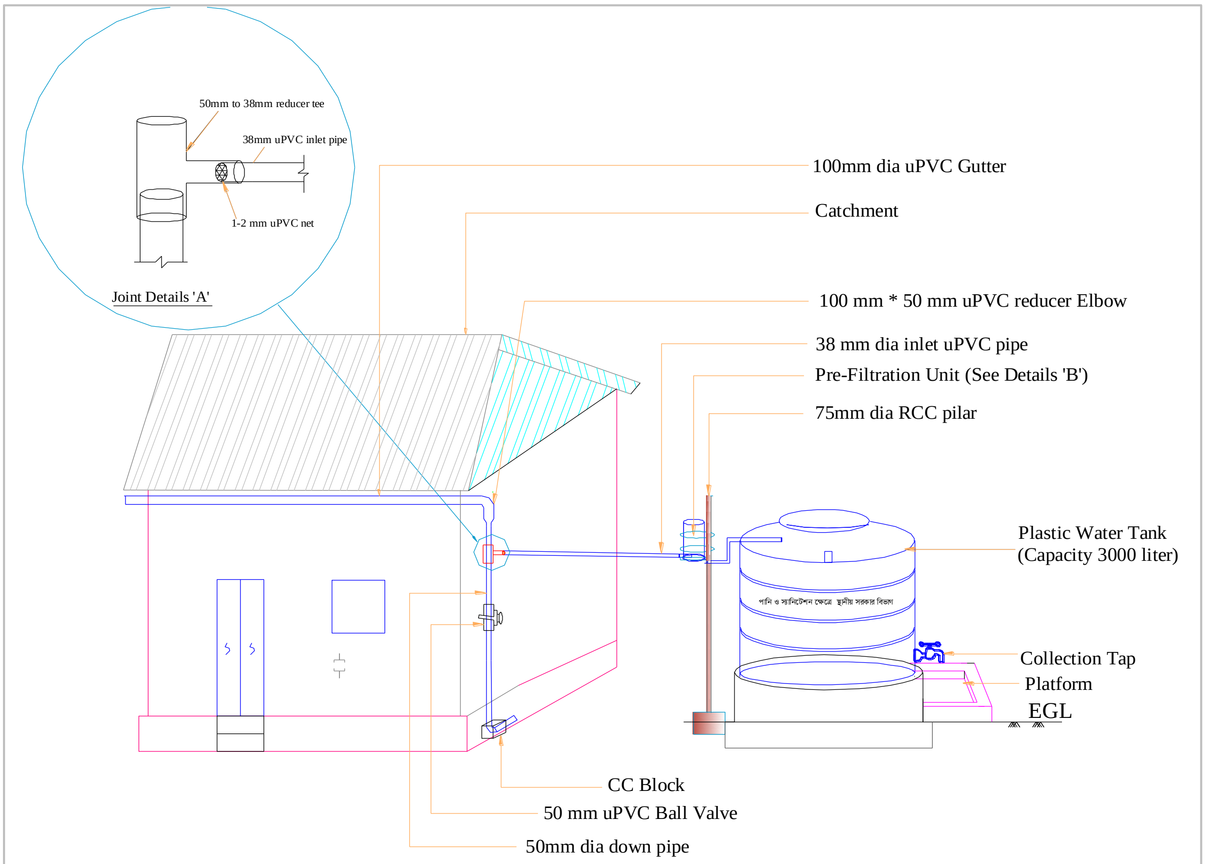
Technical Guideline

1. Water Demand Criteria
    a. Generally 5-10 litres/capita/day
    b. In school, the water demand may be taken as 2-3 litres/student/ per day
    c. Alternative water source but far in distance: potable only source-adopt 5 litres/capacity/day
    d. Contaminated water source not suitable for drinking purpose without considerable treatment: consider potable only source-adopt 5 litres/capita/day
    e. No water source nearby or source is very far (>1 km) from settlement-Consider adaptive water source - adopt 10 litres/capita/day
    f. Availability of seasonal water source but the condition prevails at all other periods as above - adopt provision of b, c, and d
2. Calculation of Required Water and Available Water
3. First Flush Diverter
4. Storage Tank
5. Treatment of Rainwater

Area wise Technical Feasibility

Area	Technology Quantity
Datinakhal, Labsa, Shyamnagar, Satkhira	Rainwater harvesting – 300

Schematic Drawing



Typical drawing of Rain Water Harvesting

Water Treatment Plant (RO plant)

RO systems are most preferred water and important purification technologies to remove contaminants. It partially permeable membrane to remove ions, unwanted molecules and larger particles from the water. Reverse osmosis can remove many types of dissolved and suspended biological as well as chemical species. R.O plants have great importance in the residential and commercial industry to ensuring public health and smooth operation. It helps commercial plants with good quality water for processing resulting in smooth production. Millions of people depending on R.O plants for clean water supply worldwide. Many residential complexes also set up R.O plants this is necessary to overcome inadequate clean water supply.

In this Study RO Plant is proposed due to the salinity in village Datinakhal, Labsa, Shyamnagar, Satkhira.

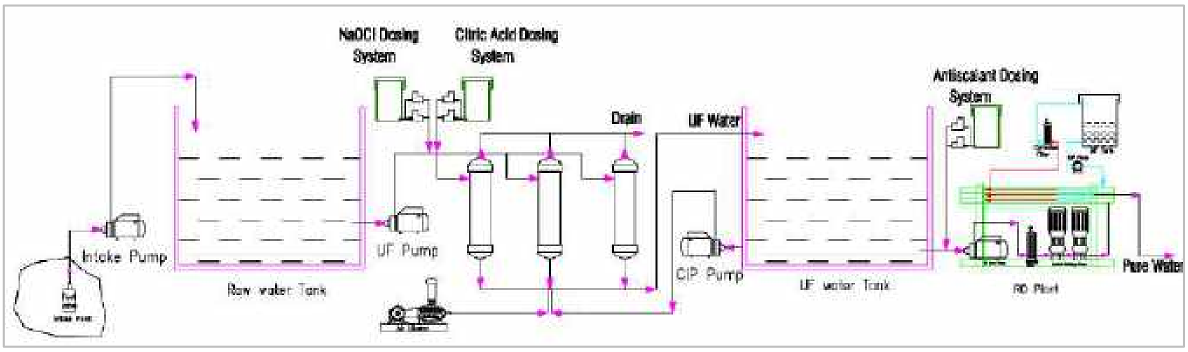
Design Considerations

- Plant Capacity is considered 4000 LPH / or 40,000 Liter per Day (10hrs Operation)
- Population of Datinakhal, Labsa, Shyamnagar, Satkhira is around 1000 families.
- Assumed per capita Drinking water Demand 10 Liter
- Reverse Osmosis Technology is Considered
- Pretreatment method is Pressure Vessel (Multigrade Filter Vessel and Activated Carbon Vessel)

Area Wise Technical Feasibility

Area	Technology Quantity
Datinakhal, Labsa, Shyamnagar, Satkhira	Water treatment plant(RO plant) – 1

Schematic Drawing



Solar Operated Pond Sand Filter (Solar PSF)

United Nations Children's Emergency Fund (UNICEF) and Department of Public Health Engineering (DPHE) have been establishing PSF to purify pond water in saline affected coastal areas since 1983 (DPHE and UNICEF 1989). The PSFs which are made with brick, cement, sand, brick chips, net, hand tubewell, pvc pipe, filter media, etc. are established on the edge of pond to supply drinking water, in particular, in the salinity or arsenic-affected areas. Yokota et al. (2001) stated that PSFs can reduce both coliform and general bacteria, but it may not remove 100 % of pathogen from heavily contaminated surface water. Rahman et al. (2001) mentioned that the PSF system, being a low-cost technology, with very high efficiency in turbidity, colour and bacterial removal, may be considered as an alternative water supply system for small rural communities. The Southwest coastal region of Bangladesh has been severely facing pure drinking water crisis due to saline water intrusion on one hand and arsenic content of groundwater on the other where PSFs have been installed as an alternative water supply system. Hence, this paper first investigates the present water demand (cooking and drinking) and supply scenario in the study area and socioeconomic aspects of PSFs. In addition, it evaluates the performance of PSFs in supplying safe drinking water through water quality analysis.

An alternative and popular option of potable water supply in coastal belt and arsenic prone areas is the Pond Sand Filter (PSF). It is a package type slow sand filter unit developed to treat surface water, usually pond water for domestic water supply. Slow sand filter is installed near or on the bank of pond, which does not dry up in the dry season. The water from the pond is pumped by a manually operated hand tubewell to feed the filter bed, which is raised from ground, and the treated water is collected through tap(s). It has been tested and found that the treated water from a PSF is usually bacteriologically safe or within tolerable limits.

Technical Guideline

1. Area Selection:

- The areas not feasible for DHTW (Deep Hand Tubewell) installation due to hard layer or non-availability of suitable aquifer producing acceptable quality and quantity of water.
- The area where the shallow aquifer is contaminated with arsenic or salinity in the ground water
- The area where there is no available safe water sources and where the sources are far

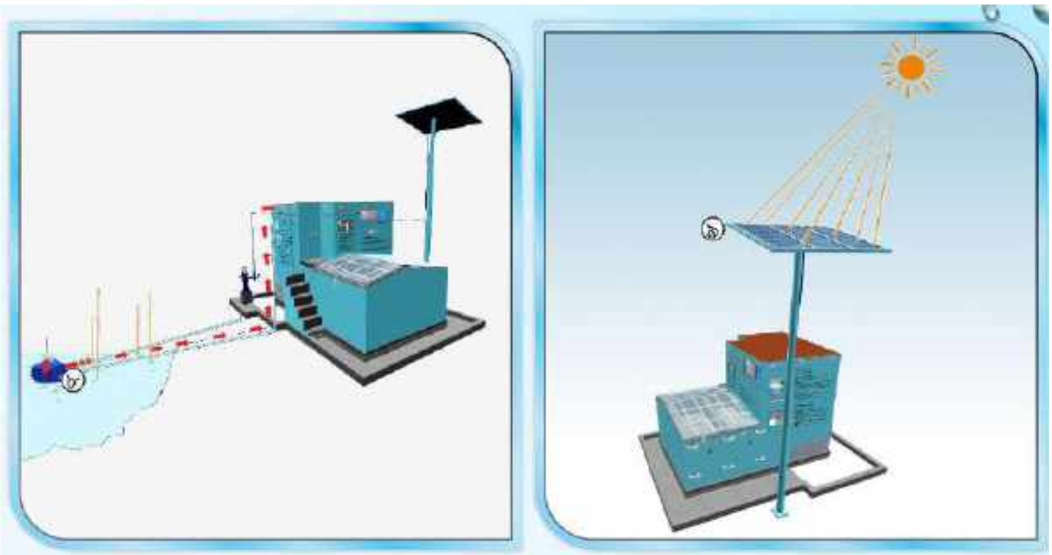
2. Selection of ponds

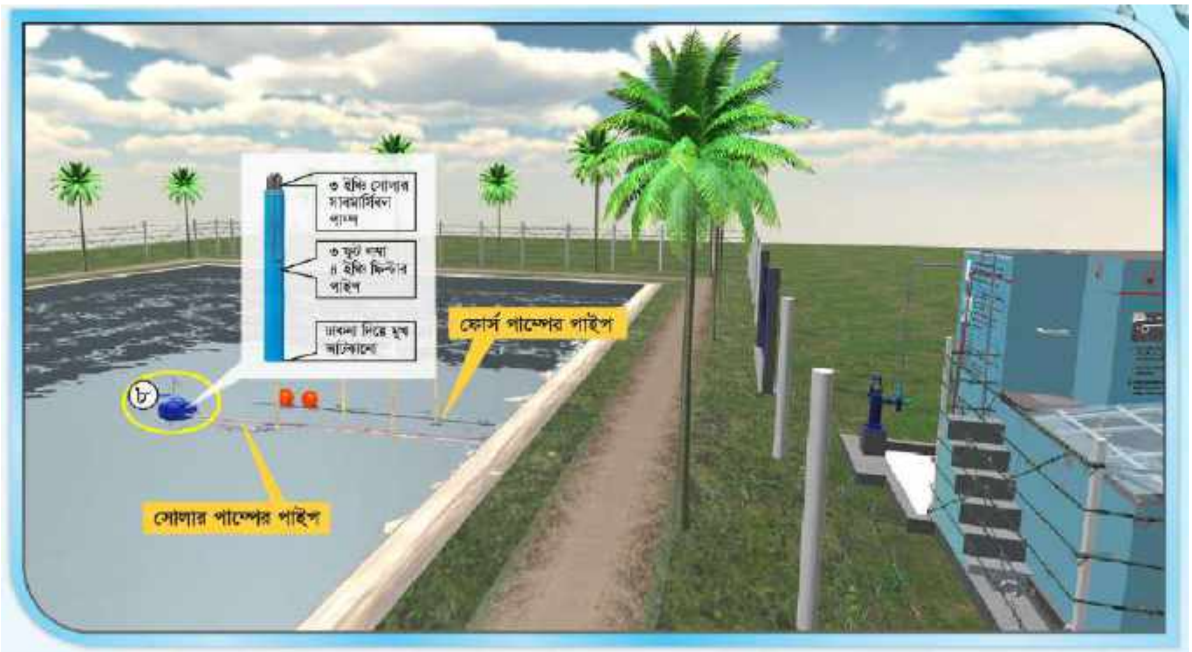
- The pond should be large and water remains available throughout the year.
- The pond will not be used for washing and bathing purposes.
- The pond will not be used for pisciculture and in no way any fertilizer or any chemical will be used in pond water for any purpose. But natural fish can grow by itself without any external influence/support
- The pond dike should be repair as & when require, particularly before rainy season to protect agricultural, domestic and other waste runoff into the pond.
- The pond should be at a safe distance from latrines and cowsheds.
- Duck or any kind of poultry rearing in hanging shed over the pond must be prohibited.
- The salinity of the water shall not exceed 600 ppm at any time of the year.
- The pond should be closer to the user community and particularly the women must have full access.
- Necessary measures should be taken to keep free from cattle washing, bathing and other domestic material washing like-plate, glass, bowl etc. in the pond.

Area wise Technical Feasibility

Among 15 villages under this study Datinakhali Village of Burigoalini Union, Shamnagar Upazilla, Satkhira District has the potential requirement of Solar Operated Pond Sand Filter.

Schematic Drawing





Deep Tubewell with Submersible Pump

Deep/shallow Tubewells with submersible pump are of large diameter (15.24-20.32 cm) and pump water by a submersible turbine pump. Pumps are constructed mainly of stainless steel or fiberglass screens and GI pipe as blind pipe and housing pipe.

Depending upon the suitable water level both Shallow and deep tubewells with submersible pump is used.

With the increasing availability of electricity throughout the country, rural community is inclining towards using submersible pump

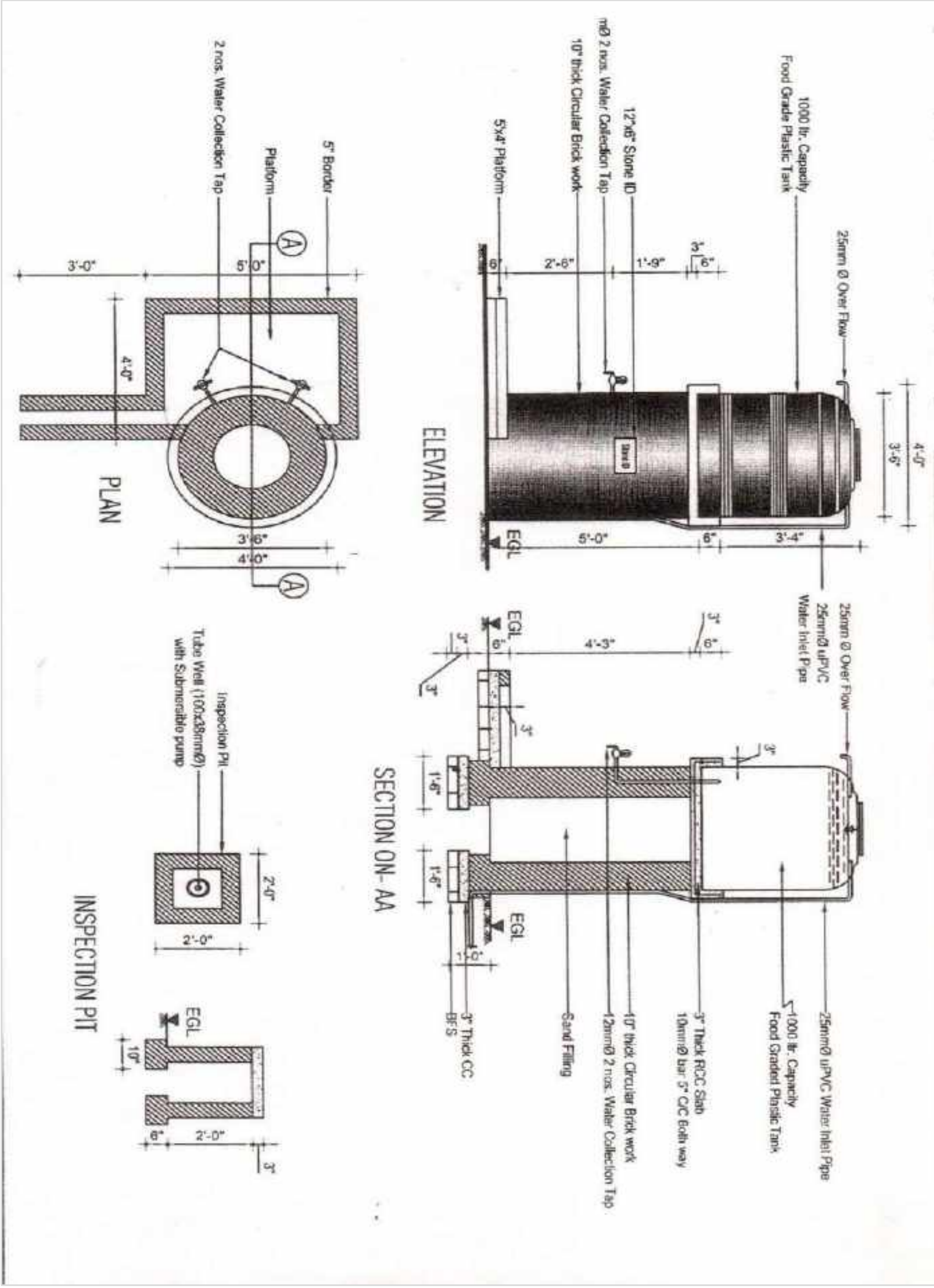
Technical Guideline

- Electric Connection is must
- TW should be at least 1 km away from nearest flowing river
- TW platform must be higher than the maximum flood level of that Area
- Must Serve at least 10 families per TW
- Minimum Distance between two TWs
  - 2 Deep TW must be at least 2500 ft apart from each other,
  - Every Shallow TW must be at least 1700 ft away from a Deep TW.
  - Shallow TWs should be at least 800 ft apart from each other.

Area wise Technical Feasibility

Name	Tubewell with Submersible Pump
Tipna, Kharnia, Dumuria, Khulna	Submersible tubewell – 20
Pathordubi, Pathardubi, Bhurungamari, Kurigram	Shallow tubewell with Iron removal plant – 80

Schematic Drawing



Rural Piped Water Supply Scheme (Source Surface Water)

1. A Brief Theory of Design of Water Supply Network

Water transmission is the transport of water from one location to another by means of conduits, canals, aqueducts or tunnels. Water may be required to be transported from source to Treatment plant or treatment plant to consumers. Water distribution system refer to that part of the water supply system which receives water from a pumping station, elevated reservoir or from conduits and delivers to consumers distributed over an area. In piped water supply systems, water transmission is usually achieved by a single conduit where distribution is done by a network of pipelines. The part of the pipeline which conveys bulk amount of water through a single Pipe called "transmission main" and the part in which pipes are arranged to distribute the conveyed water to different consumption points is called distribution network or system. The transmission and distribution systems include storage reservoir, pipes, valves, hydrants, house connections and standpipes etc.

The main purposes of the construction of water transmission and distribution pipelines are

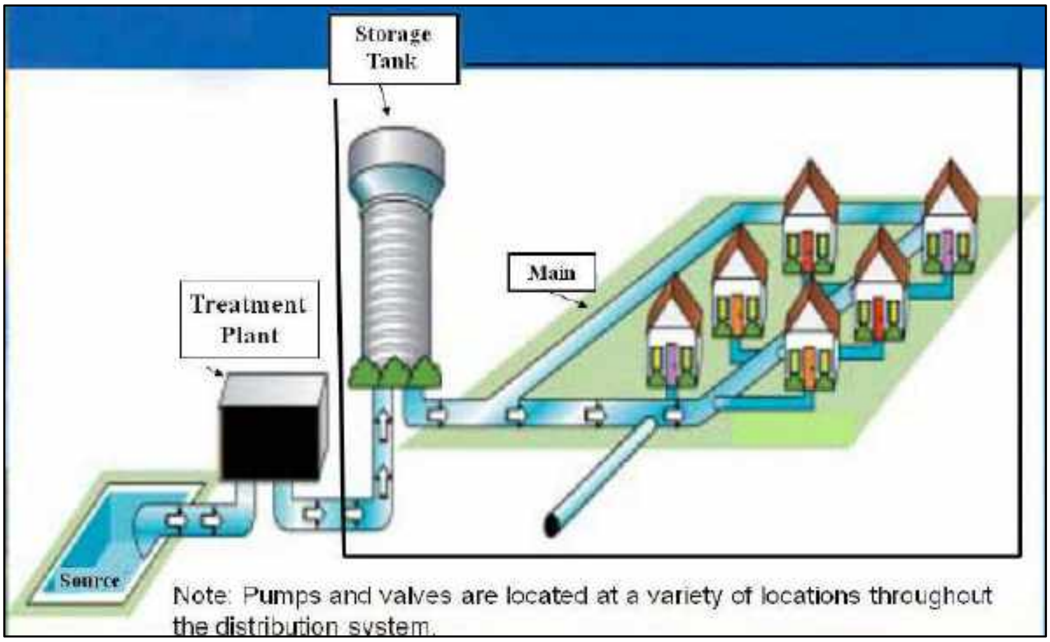
- To make water available in close proximately to the consumers.
- To supply water in adequate quantities according to the demand of the consumers.
- To supply water with adequate pressure.
- To regulate water supply as per requirement.

2. Classification of Transmission and Distribution Systems

Water transmission and distribution are classified in three ways according to the methods involved as:

- Gravity-flow system
- System with direct pumping and
- System with pumping and storage

A gravity system is adopted when the source of supply is at a sufficient elevation with respect to the consumption points. In the gravity-flow system shown in Figure.1, water is conveyed by gravity and no energy is required to operate it. In the system with pumping, water is pumped into the transmission main or distribution system. The energy thus imparted by pumping into the system causes flow and provides residual pressure required at the consumption points. A system with pumping and storage is ca' ed a direct-indirect or dual system. When the demand rate exceeds the rater of pumping, the flow into the distribution system is caused by pumping and by the elevated reservoir. When the pumping rate exceeds the consumption rate, the excess water is stored in the reservoir. The elevated reservoir can feed the distribution network when the pump is not in operation.



The advantage and disadvantage of the three systems are presented in **Table 1.1**.

Table 5.1: Advantage and disadvantage of transmission and distribution systems

System	Advantage/Disadvantage
Gravity-flow system	**Advantage** 1. Requires no energy to operate as water is conveyed by gravity 2. No pump is required and there are very few moving parts 3. Construction, operation, and maintenance are simple **Disadvantage** 1. Not applicable in flat countries where and elevated source of water supply is not available 2. Water loss by leakage and wastage is comparatively higher as the system remains under constant pressure.
Direct pumping system	**Advantage** 1. Water can be pumped only when required 2. Low water loss due to system leakage **Disadvantage** 1. Direct pumping at a uniform rate is not able to meet varying water demand and maintain required pressure under varying rates of consumption, 2. A power failure means breakdown of the system 3. Maintenance and operation costs are high, 4. Inflow of water through leaks may cause water contamination during non-pumping hours
Pumping with storage system	**Advantage** 1. The system is more reliable and can cope with fluctuation of water demand 2. The pumps can be operated at rated capacity, resulting in higher efficiency and economy of operation

System	Advantage/Disadvantage
	3. Reasonable pressure can be maintained with varying water demand and there is no possibility of inflow of polluted water in the system. **Disadvantage** 1. Relatively higher initial cost 2. Comparatively higher loss due to leakage and wastage

The consultant has designed the pipe network using sophisticated software. The same has been submitted in a separate volume.

3. Field Research

For designing a new piped water supply system or extension of the existing ones, a survey questionnaire was prepared for gathering necessary pertinent information and data from the proposed intervention sites (Shimulbank, Shimulbank, Shantiganj, and Sunamganj). The information and data were on the following:

1. Area and shape,
2. Industry type,
3. Land use,
4. Road,
5. Drain,
6. Hydrogeology/bore log,
7. Water sources,
8. Water quantities supplied,
9. Water quality,
10. Ancillary installations (OHT, Pump),
11. Connections (Industry, Commercial),
12. Power sources,

A team of hydrogeologists also worked in gathering hydro-geological information and visited production wells for the purpose and talked to the concerned. A separate report on sustainable water source is being prepared.

Normally, surface water is grossly contaminated and needs extensive treatments while groundwater is relatively safe and require minimal of treatment to arrive at Bangladesh Drinking Water Quality Standards. The field engineers engaged for gathering the above interacted with local DPHE authority and Beza. They assisted the FEs in surveying existing and proposed routes of pipelines with GPS machine. The surveyed alignment was later verified by plotting the data into google earth and later it was incorporated into GIS for map preparation.

4. Design Approach

4.1 Water Source Identification

Design consideration and design criterion along with option assessment have been made thorough field investigations, "Mathematical Modeling" and laboratory tests of water quality before recommending for preferred water supply source.

Assessment of available potential source of surface water for water supply system for the Village was carried out by Field survey. Nearby water source a River where water is available round the year. But the river water quality test result not known that water contains concentration of BOD5, COD, NH_3 and NH_4. Also this river is very far from village. Considering socio economic condition, health aspect, high investment cost, lack of technical knowhow, and additional cost of O&M for SVVTP, Surface water is not recommended for supply.

On the other hand, ground water is found satisfactorily good in quantity. But to emphasis on the surface water it is more feasible to use in this village. Moreover, this area is flood prone hoar area. So, in case of flood fresh water is scarce. A treatment Plant would be more helpful to the populous than direct ground water pumping.

Finally, Surface water source is recommended for the proposed water supply system with Treatment Plant.

4.2 Water Supply Network Map

Water distribution pipe network models within the Village boundary for the year 2040 have been developed using the latest user-friendly software named "Bentley Water gems". Network has been designed for the system having ground water as source of water supply without treatment plant.

Based on the above network analysis prepares the phased pipe network system the ''Network" is then phased out for the years 2040 based on Core area. Population and coverage by percentage of the population. Based on this broad outline, detailed map has been prepared showing pipe network, Junction points, and Sluice valve. Washouts etc.

Location of water source (surface water / ground water) is an important factor in designing pipe network. It is to mention here that where ground water quality is within the acceptable limits, treatment plant is not provided and water would be pumped and overhead tank to be through in to the pipe network or distribution system in this case, location of intake station is shown on the map as "individual point source".

During Demarcation of the coverage area of phase (Year 2040) all the proposed site of Intake station is shown in the map. During implementation period Village authority will finalize the activation of PIW depending on site availability.

5. Design Considerations

5.1 Estimating Water Demand for Shimulbank Village

Total Household in Consideration = 462

Household Quantities	Person per House	Present Population	Population in 20 years	Per Capita Water Demand (lpcd)	Waste (%)	Total Consumption (liter per day)	Peak Factor	Total Demand including Peak Factor (liter per day)
462	5.7	**2633.4**	**3239**	**70**	**15**	**260739.5**	**1.5**	**391109**

Population Growth Rate = 4% (in rural areas of Bangladesh)

Population Prediction			
Year	2022	2032	2042
Population	2634	2921	3239

5.2 Design Parameters

Hydraulic design analysis of the water supply distribution network can be computed manually by using Hardy-Cross method, Newton Raphson Method or by computer aided appropriate soft wares. The following parameters were set for designing the network:

- A minimum flow velocity of 0.3m/s in pipeline
- A maximum flow velocity of 3m/s in pipeline
- Type of pipe material would be uPVC, with minimum pipe size 50mm and their value of "C" in the Hazen-Williams Equation, 150, should be used in network analysis for new pipes
- A minimum Pressure of 3.0m head i.e. 29.4KPa should be available at the far end of the network during average demand.
- A minimum earth cover on the pipeline should be 1.0m from the top of the pipe to the finished road surface.
- Pumping Time __10 hrs.____

5.3 Design Program Run

5.3.1 Design Program Run (Overhead Tank to Network)

The network is considered to be fed with this 1 Overhead Tank. The ground elevation (from datum) of the Overhead Tank is 8.61m. Following the physical survey, a total of 2.9km pipeline is drawn. The model was run considering 1 surface water source (river) and after running through several trial and error processes pipe sizes have been finalized. Once layout plan of the sources, the routes of the piped network, demand, and elevation and design parameters are set, the consultant used WaterGEMS Software for hydraulic design of the piped network of Shimulbank Village. With several trials for balanced flow, head, flow velocity and available pressure at various nodes were generated.

5.4 Design Outputs

The design output tables are attached below.

Junction Table

Junction ID	Elevation (m)	Zone	Demand (L/Day)	Hydraulic Grade (m)	Pressure (m H2O)
J-1	8.79	N/A	28,377	24.48	16
J-2	9.68	N/A	23,110	23.58	14
J-3	9.96	N/A	48,438	23.36	13
J-4	13.41	N/A	100,000	22.21	9
J-5	9.93	N/A	16,689	21.52	12
J-6	8.56	N/A	31,544	15.1	7
J-8	9.98	N/A	53,156	14.47	4
J-9	11.51	N/A	90,000	19.37	8

The details of proposed network as per design are attached below.

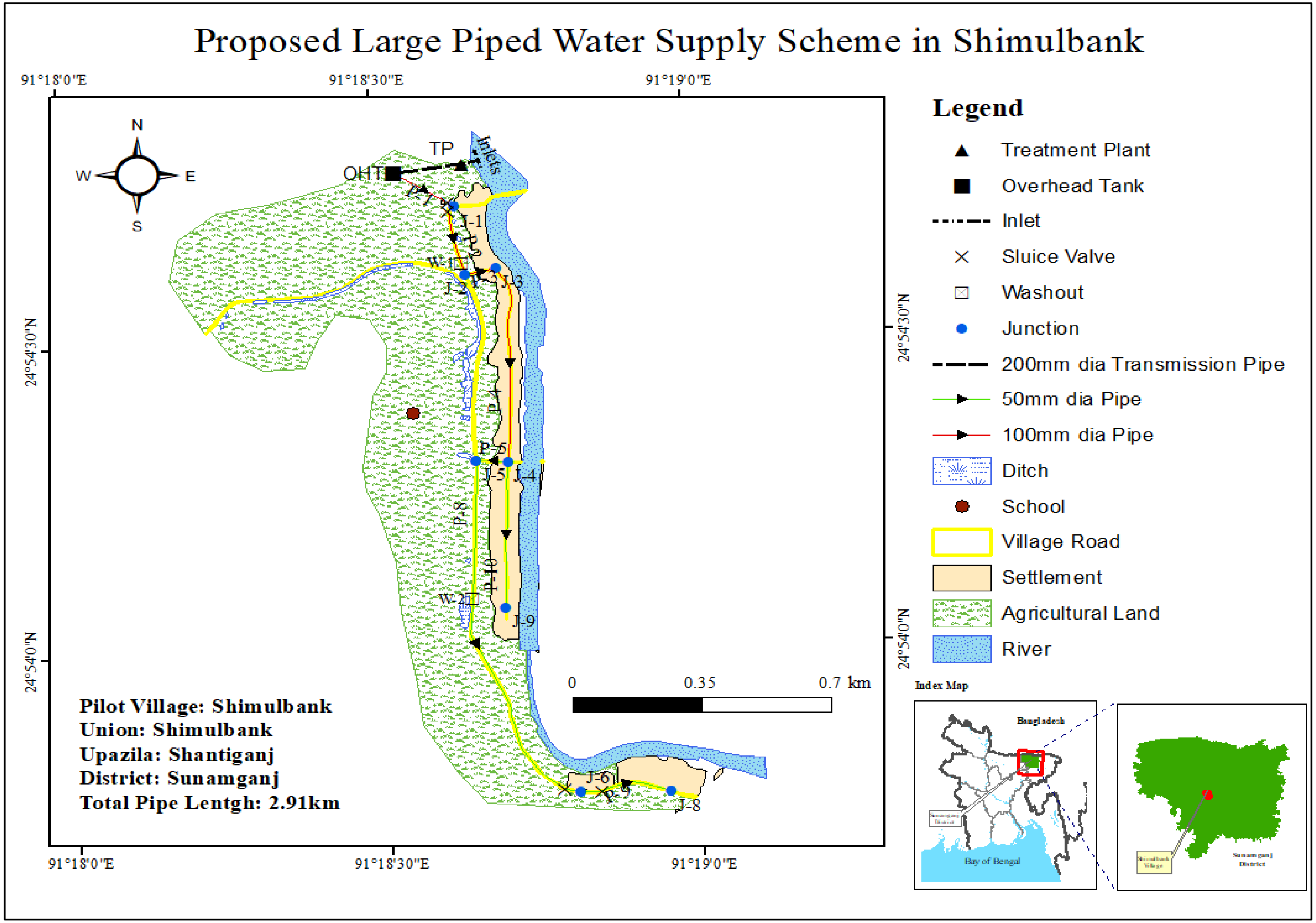


Figure 5.1: Proposed Large Piped Water Supply Scheme in Shimulbank

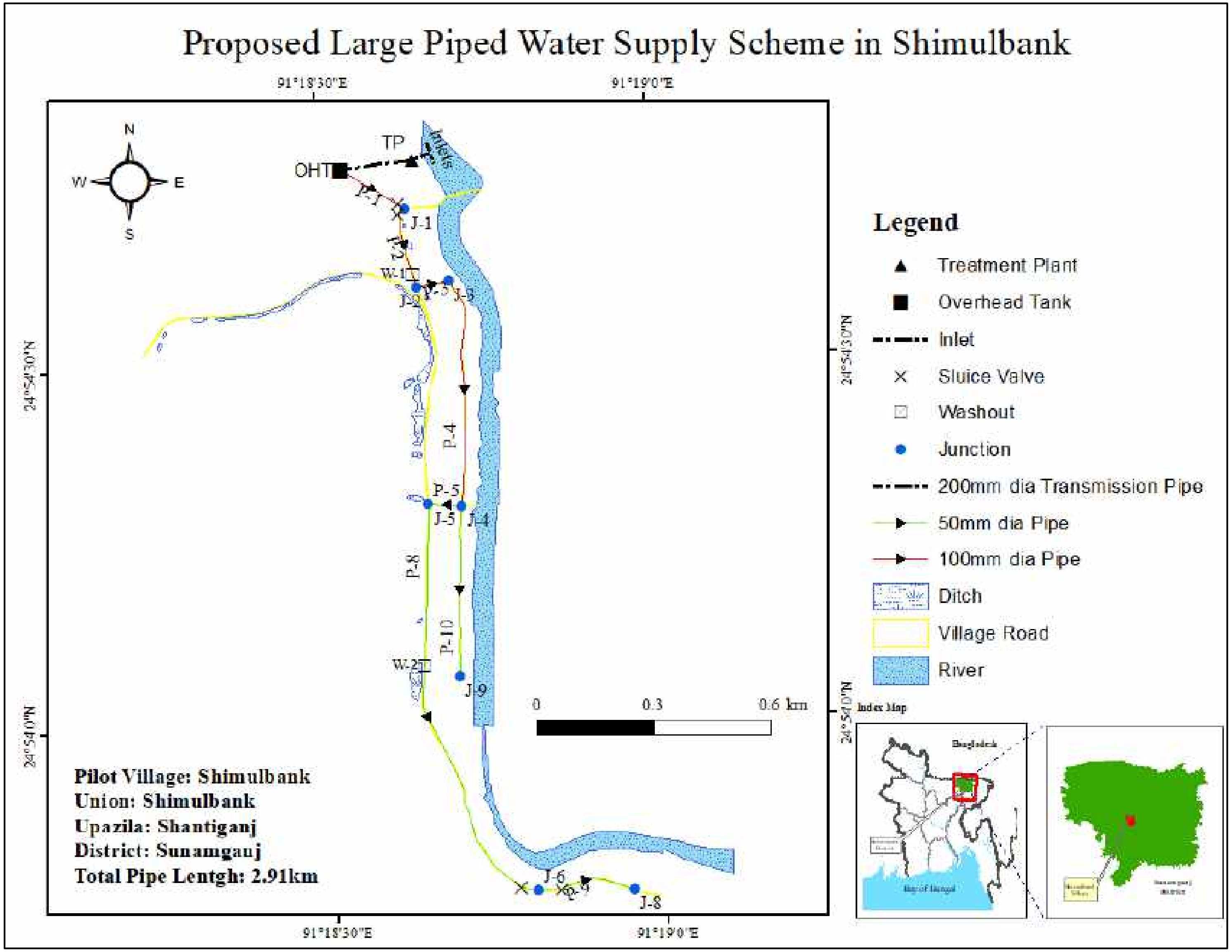


Figure 5.2: Detailed Pipe Network for Piped Water Supply Scheme in Shimulbank Village

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									

6. 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 5.3: Intake Pontoon Station

7. 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.

Area Wise Technical Feasibility

Name	Rural Piped Water Supply
Shimulbank, Shimulbank, Shantiganj, Sunamganj	1

5.3 Sanitation Design

Single Pit to Twin Pit Latrine

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.

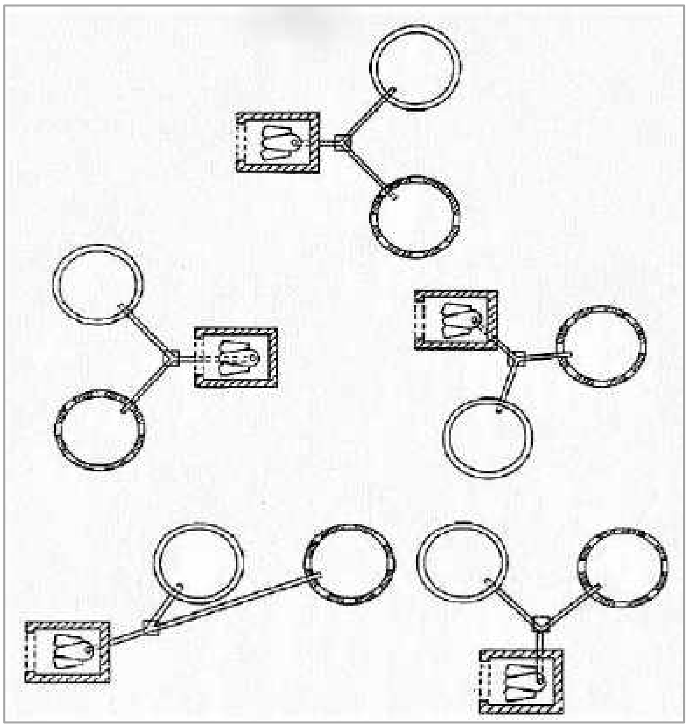
Double pit latrine systems address many of the problems inherent in the single pit latrine design. When the first pit fills, users divert the waste stream to the second pit and allow the contents of the first pit to decompose. Users thus move the superstructure from one pit to another, or redirect the 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.

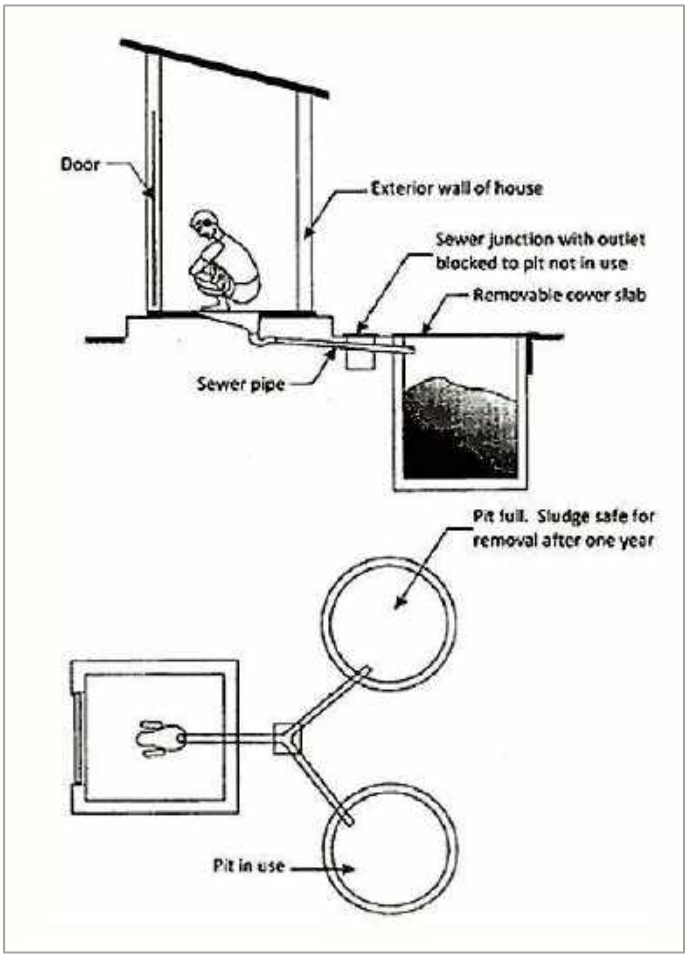
Given the limitations of single pit latrines and the health hazards associated with emptying fresh excreta, the converting single pit to double pit pour-flush latrine system may greatly improve sanitation in areas like Bangladesh. Householders may be less resistant to use latrines that offer a feasible solution (and a beneficial byproduct) 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.




Door
Exterior wall of house
Sewer junction with outlet blocked to pit not in use
Removable cover slab
Sewer pipe
Pit full. Sludge safe for removal after one year
Pit in use

Schematic Drawing

Twin pit latrine

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.

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)

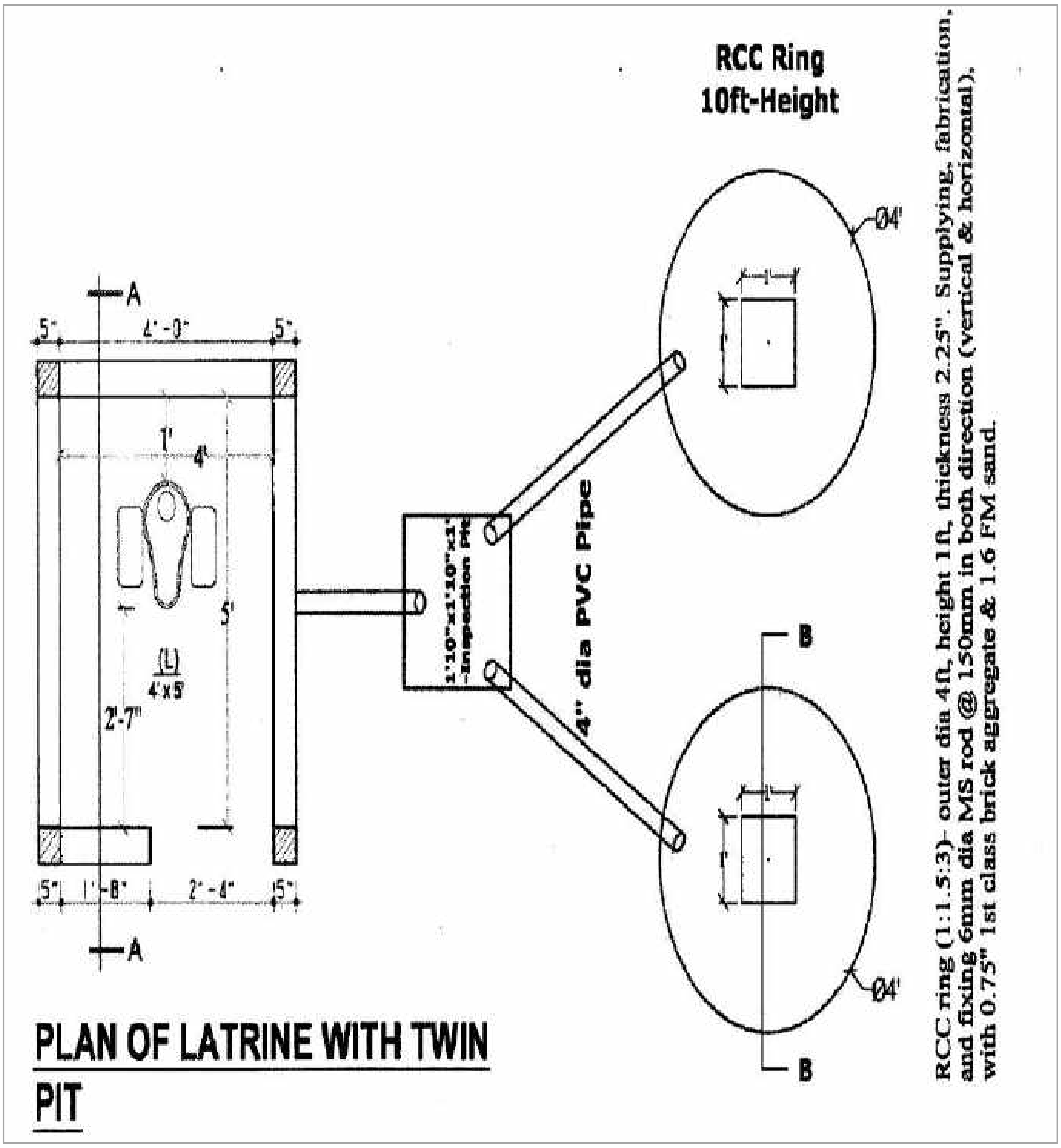
=0.045 m^3 /p/yr (Under dry condition, Roy et al., 1982)

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

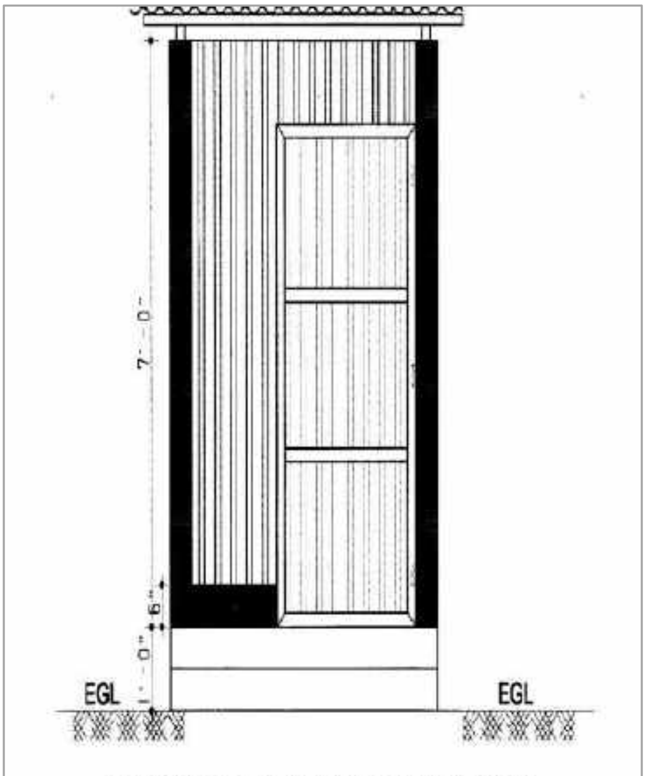
=0.09 m^3 /p/yr (where anal cleaning materials like stones, mud balls, corn-cobs and cement bags are used and which are not readily decomposed) **;** and

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

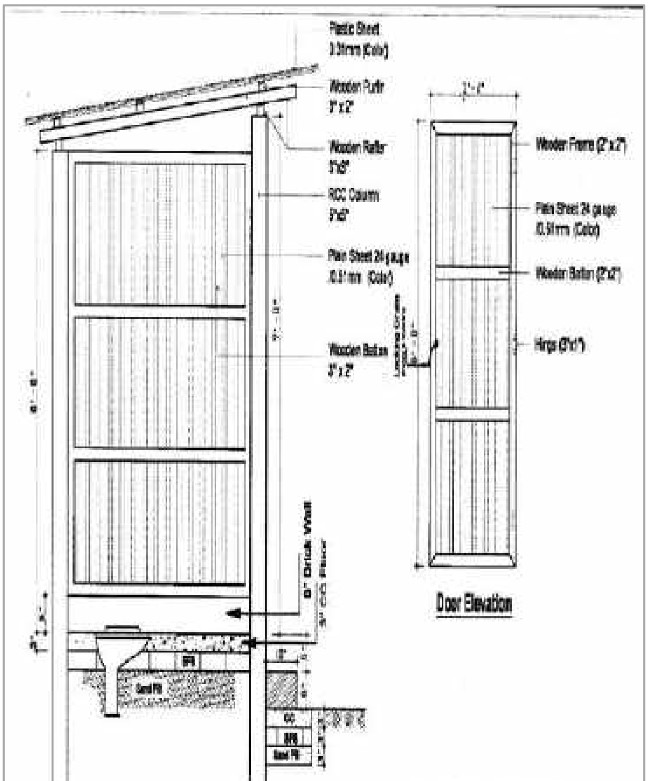
Soil	**Infiltration Capacity/m2/day**	
	Sewage	**Sullage**
Sand	50	200
Silts and Loam	30	100
Clay	10 or less	50 or less


RCC Ring
10ft-Height
Ø4'
A
5"
4'-0"
1'
4'
5'
(L)
4'x5'
2'-7"
1'-8"
2'-4"
1'10"x1'10"x1'
-Inspection Pit
4" dia PVC Pipe
B
RCC ring (1:1.5:3)- outer dia 4ft, height 1ft, thickness 2.25". Supplying, fabrication, and fixing 6mm dia MS rod @ 150mm in both direction (vertical & horizontal), with 0.75" 1st class brick aggregate & 1.6 FM sand.
PLAN OF LATRINE WITH TWIN PIT

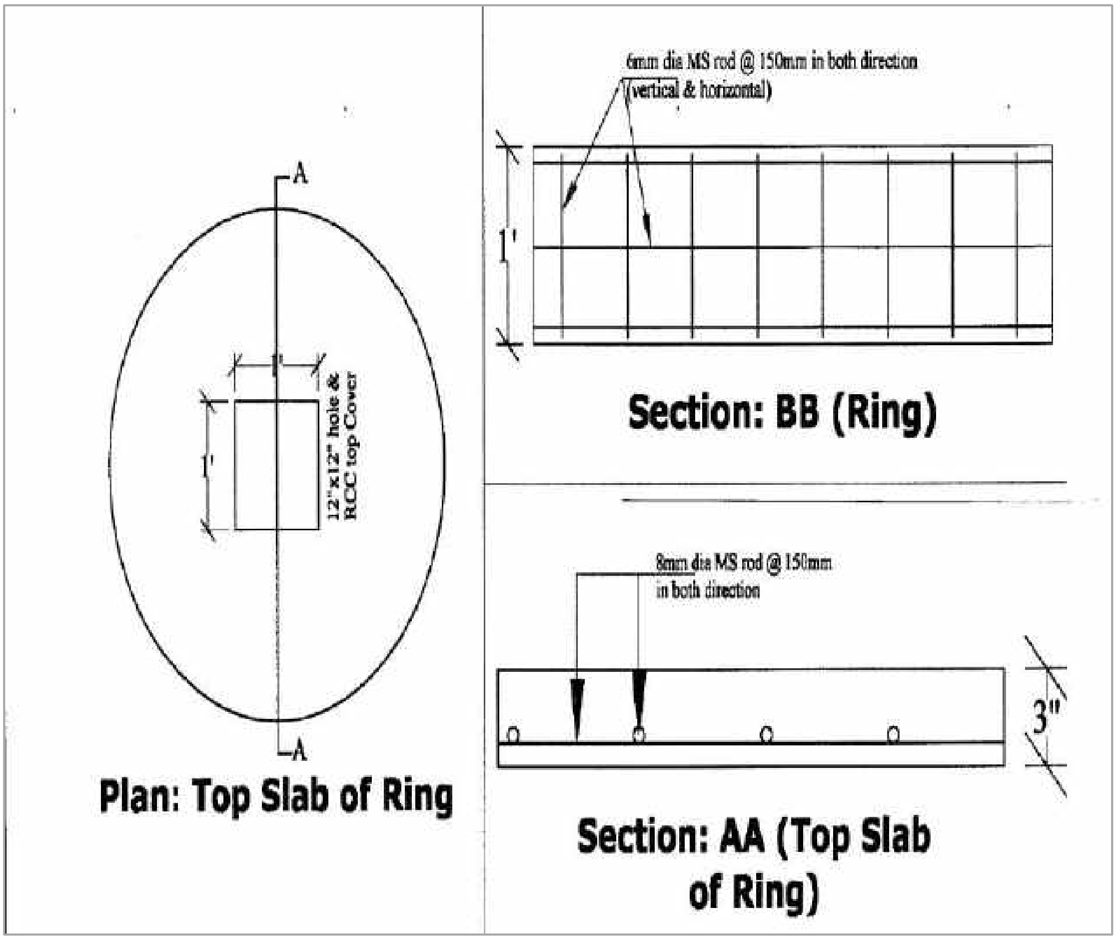
Schematic Drawing

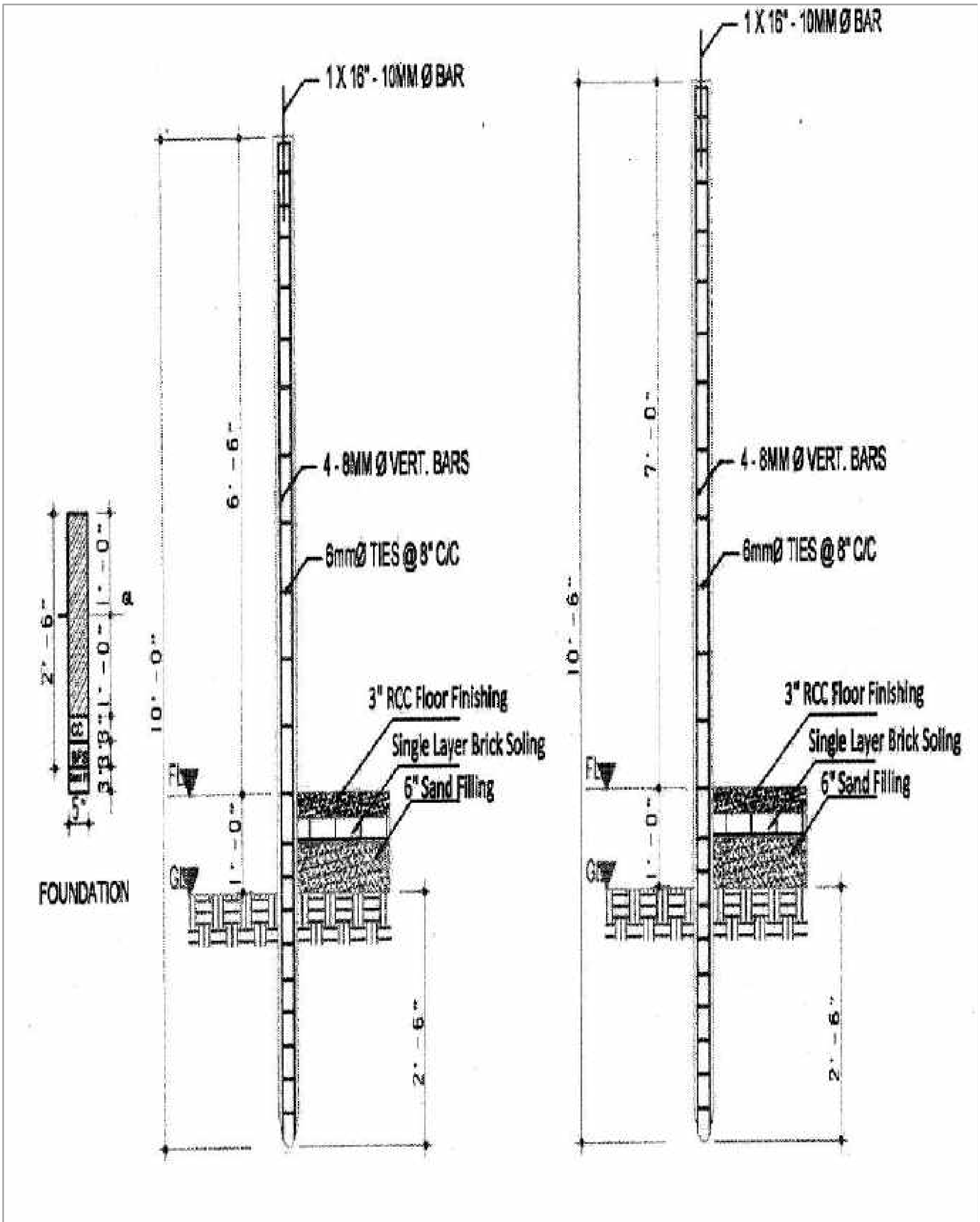


FRONT ELEVATION OF LATRINE



A-A SECTION


A
A
1'
1'
12" x 12" hole & RCC top Cover
Plan: Top Slab of Ring
6mm dia MS rod @ 150mm in both direction (vertical & horizontal)
1'
Section: BB (Ring)
8mm dia MS rod @ 150mm in both direction
3"
Section: AA (Top Slab of Ring)



DETAIL OF R.C.C POST

5.4 Cost Estimation

The cost estimation of the water supply of plain land is described below:

Mini Piped Water Supply

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
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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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. (Upto 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 prefreably 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 untill 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) within TW and suction and delivery pipe commissioning etc all complete as per	item	1.00	25,000.00	25,000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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 rtc 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) elcetric 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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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. 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	no(s)	1.00	1,950.00	1,950.00
Part-C	**Construction of Superstructure with platform; RCC Structure Hight: 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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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
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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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
17	**Paint:** Exterior premium acrylic emulsion paint of approved best quality and color 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. upto 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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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
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 nu, 40 mm dia ball cock, 12 mm dia over flow pipe with all other necessary	no(s)	1.00	29,250.00	29,250.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	fitting etc all complete as per direction of Engineer in Charge.				
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
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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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 in all respect as specification and of the E/C. 25 mm HDPE pipe.	m	800.00	70.00	56,000.00
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.	LS	1.00	1,000.00	1,000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	(This item include material cost, labour charge and carrying charge).				
33	**Operation and Maintenance**	n/a	0.00	0.00	0.00
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**

Village wise Cost

Village	Number of mini piped water supply	Total cost for one mini piped water supply	Total Cost
Induria	25	492,589.20	1,23,14,730
Charsharat	25	492,589.20	1,23,14,730
Fulchari	15	492,589.20	73,88,838
Bagaiya	40	492,589.20	1,97,03,568

Rain Water Harvesting

Detail Estimate

Technology: Rain Water Harvesting System

Sl. No.	Item of Works	Unit	Quanty	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

Sl. No.	Item of Works	Unit	Quanty	Unit Rate (BDT)	Total (BDT)
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 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. (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, leveling 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
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	m^2	0.20	837.00	167.40

Sl. No.	Item of Works	Unit	Quanty	Unit Rate (BDT)	Total (BDT)
	materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). . (Platform)				
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
	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

Sl. No.	Item of Works	Unit	Quanty	Unit Rate (BDT)	Total (BDT)
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
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

Sl. No.	Item of Works	Unit	Quanty	Unit Rate (BDT)	Total (BDT)
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**

Village Wise Cost

Village	Number of rain water harvesting	Total cost for one rain water harvesting	Total Cost
Datinakhali	300	50,969.42	1,52,90,826

Water Treatment Plant

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 labor 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				

Estimate for Saline Water Treatment Plant (Capacity 4000 LPH)					
	7. Brand: Wil0/Dynamic/Grundfos/CNP or Equivalent				
	8. Country of origin: EU / China or equivelent.				
	All complete as per instruction of Engineer-in charge. (including cost of all materials labor andtransportation, 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:				
	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 equivelent.				
	All complete as per instruction of Engineer-in				
	Charge. (including cost of all materials, labor 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				

Estimate for Saline Water Treatment Plant (Capacity 4000 LPH)					
	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				
	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.				

Estimate for Saline Water Treatment Plant (Capacity 4000 LPH)					
	4. Pipes and fittings: pneumetic.				
	5. Power requirement of motor: 220 volt. 50 Hz, 16W				
	6. Brand: Pulsafceder/seko				
	Country of manufacturing: USA/Italy. or equivelent.				
	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
	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.				

Estimate for Saline Water Treatment Plant (Capacity 4000 LPH)					
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, labor and transportation, VAT and IT)				
10	**RO Pressure Tube:**	Pc.	16	25,000.00	400,000.00
	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")				
	5. Brand: Code line/Gfiber				
	6.Countiy of origin: EU/ USA or equivelent.				
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, laborand transportation, VAT and IT)				
11	**RO membrane:**	Pc.	16	30,000.00	480,000.00
	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/Equivelent				
	Specification:				
	Performance:				
	Permeate Flow: 9.1 m3pd				
	Salt Rejection: Nominal 99.7%				
	Minimum 99.5%				
	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				
	Maximum Feed Flow: 1.6 GPM				
	Minimum Ratio of Concentrate to				

Estimate for Saline Water Treatment Plant (Capacity 4000 LPH)					
	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:**	Lot	1	50,000.00	50,000.00
	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.				
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, labor and transportation, VAT and IT)				
13	**Electric Control Panel:**	Set	1	50,000.00	50,000.00
	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, selctor switch and any other related accessories,				
	All complete as per instruction of Engineer-in Charge. (Including cost of all materials, labor and transportation, VAT and IT)				
	Brand : Schneider/Tokaimi/ABB/Simen/LS				
	Origin: USA/EU/Japan/China or equivelent.				
14	**Skid for Desalination plant:**	No.	1	20,000.00	20,000.00
	MOC: SS 304 hollow box (Thickness- 1.5mm)				
	Box Size: 1.5"X 1.5" inch				

Estimate for Saline Water Treatment Plant (Capacity 4000 LPH)					
C	**TREATED PURE WATER SECTION**				
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**

Village Wise Cost

Village	Number of RO plant	Total cost for one RO plant	Total Cost
Datinakhali	1	4,458,000.00	44,58,000

Solar Operated Pond Sand Filter (Solar PSF)

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, preparation 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 materials cost, labor 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.	m^3	7.39	129.00	953.52
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) downgraded) including supply and underlaying polythene and compacting	m^3	1.78	8557.00	15249.30

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	properly and all works have to be completed using sweet water as per drawing and direction of the Engineer-in-charge				
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
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	m^2	75.17	499.00	37509.16

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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).				
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,	m^2	4.71	1332.00	6273.05

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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				
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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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
	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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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 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).	sqm	20.00	190.00	3800.00
	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)	L.S.	1	1000.00	1000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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.				
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. (This item includes materials cost, labour charge, carrying charge with VAT, Income Tax & Profit). (Berger Smart Blue (RO) or code no- 5T1101 Open Sky)	Item	40.45	265.00	10719.33
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	Set	1	200000.00	200000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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. 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	Set	1	9500.00	9500.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	(Nos of post as per required). all complete as per direction of the engineer in charge.				
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
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
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	Per Package	1	50,000.00	50,000.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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).				
Part-D: Pond Excavation and Prevention of Water Inundation					
1	Pond is to be excavated as per the design approved by the project directors 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/=				

Village Wise Cost

Village	Number of Pond sand filter (PSF)	Total cost for one Pond sand filter (PSF)	Total Cost
Datinakhali	1	42,66,000	42,66,000

Deep Tubewell with Submersible Pump

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

PART-01(Tube-Well)					
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

PART-01(Tube-Well)					
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				

Part 02 - (Superstructure)					
	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
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

Part 02 - (Superstructure)					
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)				
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	22.00	kg	79.000	1,738.00

Part 02 - (Superstructure)					
	minimum elongation after 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 accessorise 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

Part 03 - (Submersible Pump with plumbing works)					
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**

Village Wise Cost

Village	Number of Deep tubewell with submersible pump	Total cost for one Deep tubewell with submersible pump	Total Cost
Tipna	14	117,425.04	16,43,951

Shallow Tube well (100mm) with Submersible Pump

Average Depth: 61 m

PART-01(Tube-Well)					
Sl No	**Item of Works**	**Quantity**	**Unit**	**Unit Rate (BDT)**	**Total (BDT)**
1	**Mobilization :** All kinds of materials/equipments to the site for installation of 100mm dia Tube Well with supplying of casing pipe, boring pipe, construction of derrick and dismantling the same, cleaning the site after completion of work, restore the unused departmental materials to the departmental store etc. all complete as per direction of the Engineer-in-Charge	1	LS	500.00	500.00
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.(This item includes materials cost, labour charge, carrying charge etc. Material test fee is included in rate, Lapping will not be including in measurement of depth)				-
	Drilling & Materials including fitting & Fixing:				-
	i) 100 mm dia 3.65 mm thickness GI pipe	0.5	m	770.00	385.00
	ii) 0-52 m -100 mm dia uPVC (Class-D) Pipe.	52	m	585.00	30,420.00
	iii) 52-58m-100 mm dia uPVC Filter (Class-E) (Slot opening 8-10)	6	m	695.00	4,170.00
	iv) 58-61 m -100 mm dia uPVC (Class-D) sand trap with end cap	3	m	650.00	1,950.00
	vi) solvent cement (100gm Tube)	1	P/Tube	180.00	180.00
3	**Clay Sealing, Sand Filling and Local/bored Soil Filling**				-

PART-01(Tube-Well)					
Sl No	**Item of Works**	**Quantity**	**Unit**	**Unit Rate (BDT)**	**Total (BDT)**
	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.	36	m	5.00	180.00
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					**41,895.00**

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
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

Part 02 - (Superstructure)					
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)				

Part 02 - (Superstructure)					
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 300 (RB 300 /RB 300W: complying BDS ISO 6935-2:2006) ribbed or deformed bar produced and marked according to Bangladesh sandard, with minimum yield strength, fy (ReH)= 300 MPa but fy not exceeding 330 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)					
Sl. No.	**Item of Works**	**Quantity**	**Unit**	**Unit Rate (BDT)**	**Total (BDT)**
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 & fixingwithin 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

Part 03 - (Submersible Pump with plumbing works)					
Sl. No.	**Item of Works**	**Quantity**	**Unit**	**Unit Rate (BDT)**	**Total (BDT)**
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 accessorise 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 (30mx2)	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
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 , 25mm dia over flow pipe with all	1.00	no	11,000.00	11,000.00

Part 03 - (Submersible Pump with plumbing works)					
Sl. No.	**Item of Works**	**Quantity**	**Unit**	**Unit Rate (BDT)**	**Total (BDT)**
	other necessary fitting etc. All complete as per direction of E/C				
	Making plumbing line 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. 50mm/25mm Elbow (uPVC)	1.00	no	125.00	125.00
	vi. 25mm dia T (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**

Part 4: Small Column Type Iron Removal Plant (for Submersible TW with Tank)					
Sl. No.	**Item of Works**	**Quantity**	**Unit**	**Unit Rate (BDT)**	**Total (BDT)**
2	Supply fitting and installation of Box type Iron Removal Plant:	1	Nos	10900	10900
	a. 1 nos box Length-24"xWidth-18"x Hight-24" made by 1.5mm Stainless Steel sheet for Filter Media.				
	b. All box and tray should inter connected as per design and drawing with total Length-24"xWidth-18" xHight-24".				
3	Pipe and Sanitary Fittings:				
	a. 1" pvc T	3	Nos	75	225
	b. 1" pvc ball valve	5	Nos	250	1250
	c. 1" pvc union socket	2	Nos	270	540
	d. 4" SS 316 grade socket	1	Nos	1000	1000
	e. 1.5" SS 316 grade socket	2	Nos	500	1000
	f. 0.5" SS 316 grade socket	1	Nos	400	400
	g. 4" to 2" pvc bush	2	Nos	160	320
	h. 2" to 1" pvc bush	2	Nos	140	280
	i. Bibcock: best quality plastic bibcock	1	Nos	125	125

Part 4: Small Column Type Iron Removal Plant (for Submersible TW with Tank)					
Sl. No.	**Item of Works**	**Quantity**	**Unit**	**Unit Rate (BDT)**	**Total (BDT)**
	j. 1.5" pvc filter pipe- 1 m	1	Meter	140	140
	k. 1" pvc pipe	6	Meter	52	312
	l. 1" pvc pipe for Airation	1	Meter	85	85
	m. pvc net	5	sft	40	200
	n. 1" threat elbow	2	nos	70	140
4	Sand: Kustia Sand having property F.M.=1.8 to 2.0, D10= 0.20 to 0.21 and U = 2.1 to 2.5	0.3	m^3	850	255
5	Sand: having property F.M.=1.2	0.1	m^3	647	64.7
6	Gravel:	0.4	m^3	2600	1040
	a. 3/4" Gravel				
	b. 1/4" Gravel				
			Total=		**18,276.70**
	Total (Part 1, 2, 3, 4) BDT				**115,525.74**

Village Wise cost

Village	Number of Shallow Tubewell with submersible pump	Total cost for one RO plant	Total Cost
Pathordubi	80	**115,525.74**	**92,42,059**

Rural Piped Water Supply Cost

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 2 Test tubewells, 2 Production tubewells, 1 Pump Houses, Submersible Pump with Column Pipe, Electric Panel Board etc., electrification with transformer (All the items include VAT, Tax & profit)**		
	Part A	Floating Intake Station & Pumping System	2,729,578.00
	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	3,690,825.00
ITEM-03:	**Estimate for the Construction of HDPE pipe line works**		
	Part A	Pipe line Works	5,159,659.78
ITEM-04:	**Estimate for Construction of 100m3/hr capacity Over Head Tank etc.**		

Sl. No.	Description		Estimated Amount in BDT
	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	7,131,190.93
	Part B	Mechanical Works	
	Part C	Electrical Works	
		Total Cost of Scheme (BDT)	**25,903,909.37**

Village Wise Cost

Village	Number of Rural piped water supply	Total cost for one one rural piped water supply	Total Cost
Shimulbank	1	25,903,909.37	25,903,909.37

Cost estimation for sanitation

Cost estimation for twin pit latrine

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

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	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
5	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.	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. aii	Cum	0.40	6647.00	2658.80

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	complete as per drawing & direction of the engineer-in-charge.				
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
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, themal, 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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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
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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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**

Village wise cost

Village	Number of new twin pit latrine	Total cost for one new twin pit latrine	Total Cost
Induria	230	49,846.64	1,14,64,727
Charsharat	195		97,20,094
Fulchari	95		47,35,430
Tipna	145		72,27,763
Pathordubi	580		2,89,11,051
Datinakhali	198		98,69,635
Shimulbank	105		52,33,897
Bagaiya	250		1,24,61,660

Single pit to twin pit latrine

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	Sqm	3.00	169.00	507

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	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.				
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 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	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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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
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, themal, 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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
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
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, labor 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, labor and transportation, VAT and IT)	Each	1	400	400
	Total =				**16368.85**

Village wise cost

Village	Number of single pit latrine	Total cost for one single pit to twin pit latrine	Total Cost
Induria	415	16,368.85	67,93,072.75
Charsharat	350		57,29,097.5
Fulchari	155		25,37,171.75
Tipna	300		49,10,655
Pathordubi	1260		2,06,24,751
Datinakhali	410		67,11,228.5
Shimulbank	195		31,91,925.75
Bagaiya	400		65,47,540

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 7 concentrates on the availability of surface water in the selected villages and financial and economic cost-benefit analysis of intervention in 8 villages is conducted in this section the details of which are given below.

District	Upazila	Union	Village	Number of Household (HH)
Barishal	Hijla	Memania	Induria	728
chittagong	mirchorai	echakhali	chorshorot	941
Gaibandha	Fulchari	Fulchari	Fulchari	377
sylhet	goyainghota	rostompur	bagaiya	921
sunamganj	santigan	shimulbak	shimulbak	462
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469
Khulna	Dumuria	Khurnia	Tipna	722
Satkhira	Shyamnagar	Labsa	Datinakhali	568

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: Three water access strategies 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) conservation of rainwater and single pit latrine as well as twin pit latrine was considered.

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 1098 lacs and the cost of sanitation is 1596 lacs. The total cost is 2963 lacs including price as well as physical contingency.

Table 6.1: Financial Investment Cost (BDT in Lac)

District	Upazila	Union	Village	Number of HH	Water supply	Sanitation	Financial Cost (BDT in Lac)
Barishal	Hijla	Memania	Induria	728	125	198	323
Chittagong	mirchorai	echakhali	chorshorot	941	125	167	292
Gaibandha	Fulchari	Fulchari	Fulchari	377	75	542	617
Sylhet	goyainghota	rostompur	bagaiya	921	200	91.5	291.5
Sunamganj	santigan	shimulbak	shimulbak	462	210	205	415
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	96	78.5	174.5
Khulna	Dumuria	Khurnia	Tipna	722	17	132.5	149.5
Satkhira	Shyamnagar	Labsa	Datinakhali	568	250	181	431
Sub-total					1098	1596	2693.5
Physical contingency							134.675
Price contingency							134.675
Total							**2963**

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 17 Lac and the economic O&M cost is 15 Lac.

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:

- 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.

- Healthcare cost savings due to seeking less healthcare: Significant and beneficial health impacts are associated with improvements in access to safe water and sanitation5. 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 (10%).
- 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 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 10% and average days lost due to water-borne disease will be 37 days.

Benefits		
Time saved benefit of water supply	**Time saved benefit of sanitation**	**Health benefit**
151	104	544

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.

[5] 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

Table 6.2: Financial Cash Flow (BDT in Lac)

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Benefit	Total Benefit	
1	808.05		808.05				0	-808.05
2	1077.4		1077.4				0	-1077.4
3	1077.4		1077.4				0	-1077.4
4		17	16.72	151	104	544	798.7674	782.04
5		17	16.72	151	104	544	798.7674	782.04
6		17	16.72	151	104	544	798.7674	782.04
7		17	16.72	151	104	544	798.7674	782.04
8		17	16.72	151	104	544	798.7674	782.04
9		17	16.72	151	104	544	798.7674	782.04
10		17	16.72	151	104	544	798.7674	782.04
11		17	16.72	151	104	544	798.7674	782.04
12		17	16.72	151	104	544	798.7674	782.04
13		17	16.72	151	104	544	798.7674	782.04
14		17	16.72	151	104	544	798.7674	782.04
15		17	16.72	151	104	544	798.7674	782.04
16		17	16.72	151	104	544	798.7674	782.04
17		17	16.72	151	104	544	798.7674	782.04
18		17	16.72	151	104	544	798.7674	782.04
19		17	16.72	151	104	544	798.7674	782.04
20		17	16.72	151	104	544	798.7674	782.04

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

- Project's implementation period is 3 years;
- Project's economic life is assumed to be 20 years;
- Discount rate is 12%; and physical and price contingency is assumed at 5%.
- 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;
- 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:

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.

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)[6] is given below:

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

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)	1,615.86	Positive value is acceptable
FBCR	1.66	Value >1 is acceptable
FIRR	21%	≥ 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 21% 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] Gittenger J.P. Economic Analysis of Agricultural Project, The WB, Washington, USA, 1982, p361

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:

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.

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.

Intangible Benefit

One of the intangible benefits 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.

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:

- Conversion Factor (CF) for various broad components are taken from FPCO Guidelines[7] to adjust local financial prices (eliminating market distortions) for traded and non-traded items;
- 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 6.3: 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	808.05	1077.4	808.05	2694	0.902	729	972	729	2430
Physical contingency			134.675	135	0.902			121	121
Price contingency			134.675	135	0	0	0	0	0
Total	**808.05**	**1077.4**	**1077.4**	**2963**		**729**	**972**	**850**	**2551**

Table 6.4: Economic Incremental Benefit (BDT in Lac)

Benefits		
Time saved benefit of water supply	**Time saved benefit of sanitation**	**Health benefit**
136	94	490

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.

Table 6.5: Economic Cash Flow (BDT in Lac)

Year	Cost			Benefit				Cash Flow
	Investment Cost	**Maintenance Cost**	**Total Cost**	**Time Saved Benefit water supply**	**Time Saved Benefit sanitation**	**Health Benefit**	**Total Benefit**	
1	729		728.8611				0	-728.8611
2	972		971.8148				0	-971.8148
3	850		850.338				0	-850.33795
4		15.1	15.1	136.3	93.9	490.3	720.5	705.4
5		15.1	15.1	136.3	93.9	490.3	720.5	705.4
6		15.1	15.1	136.3	93.9	490.3	720.5	705.4
7		15.1	15.1	136.3	93.9	490.3	720.5	705.4

7 FPCO Guidelines for Project Assessment, (May1992) MoWR (renamed), Dhaka

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Benefit	Total Benefit	
8		15.1	15.1	136.3	93.9	490.3	720.5	705.4
9		15.1	15.1	136.3	93.9	490.3	720.5	705.4
10		15.1	15.1	136.3	93.9	490.3	720.5	705.4
11		15.1	15.1	136.3	93.9	490.3	720.5	705.4
12		15.1	15.1	136.3	93.9	490.3	720.5	705.4
13		15.1	15.1	136.3	93.9	490.3	720.5	705.4
14		15.1	15.1	136.3	93.9	490.3	720.5	705.4
15		15.1	15.1	136.3	93.9	490.3	720.5	705.4
16		15.1	15.1	136.3	93.9	490.3	720.5	705.4
17		15.1	15.1	136.3	93.9	490.3	720.5	705.4
18		15.1	15.1	136.3	93.9	490.3	720.5	705.4
19		15.1	15.1	136.3	93.9	490.3	720.5	705.4
20		15.1	15.1	136.3	93.9	490.3	720.5	705.4

Assumption

- Project's implementation period is 3 years;
- It is assumed that the project's economic life is 20 years;
- Discount rate is 12% as well as price and physical contingency are assumed at 5%.
- 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;
- Standard conversion factor is 0.902

The 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:

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.

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)[8] is given below:

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

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)	1,544	Positive value is acceptable
EBCR	1.73	Value >1 is acceptable
EIRR	22%	≥ 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 22% 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.

6.4 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	1.51	1.51	2.01	1.38
FNPV (BDT In Lac)	1248	1373	2242	1005
FIRR	19%	19%	25%	17%

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

Table 6.7: Results of Economic Sensitivity Analysis

	Benefits decreased by 10%	Total cost increased by 10%	Best Case	Worst Case
EBCR	1.58	1.58	2.10	1.43
ENPV (BDT in Lac)	1212	1333	2101	1001
EIRR	20%	20%	26%	18%

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, $PM_{2.5}$, PM_{10} 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	• 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	PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
	• Generation of liquid and solid wastes, debris. • Occupational health and safety	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 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

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
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
During Construction Phase of the Sub-projects			
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

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
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
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	• 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.	Contractor, PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
	aquatic wildlife (such as snakes, frogs etc.) • Discharge of liquid and septage from the labor camp.	• 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).	
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. • Solid wastes from the labor camp.	• 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. • Adequate supply of garbage/waste bins in the construction camps and project site and proper disposal of wastes.	Contractor, PMU, DPHE
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

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
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 • 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.	• 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. • 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;	Contractor, PMU, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
		• 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

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
Pump House construction and Electrical works	• Air and noise pollution affecting nearby settlements • Water pollution from temporary labor shed toilets	• Ensure adequate number of portable toilets	Contractor, PMU, DPHE
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.	WATSAN Committee, DPHE

Design and Planning Phase of the Sub-projects			
Activity/Issues	**Anticipated Environmental Impacts**	**Proposed Mitigation and Enhancement Measures**	**Responsible Authority**
		• 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.	
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.

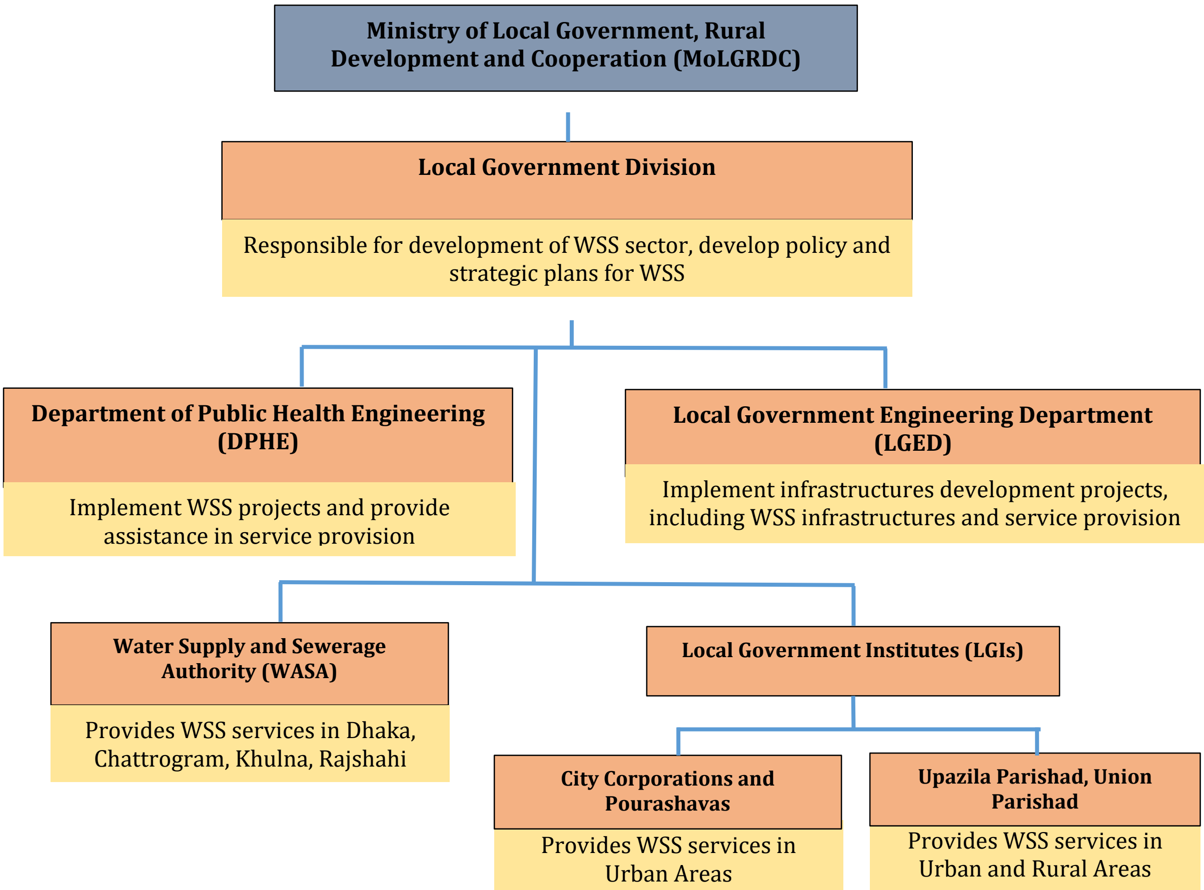


Figure 8.1: Institutional Framework of water supply and sanitation in Bangladesh

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.

- **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.
- **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.

a) 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.

b) 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).

a) 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).

b) 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 8.2**

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.

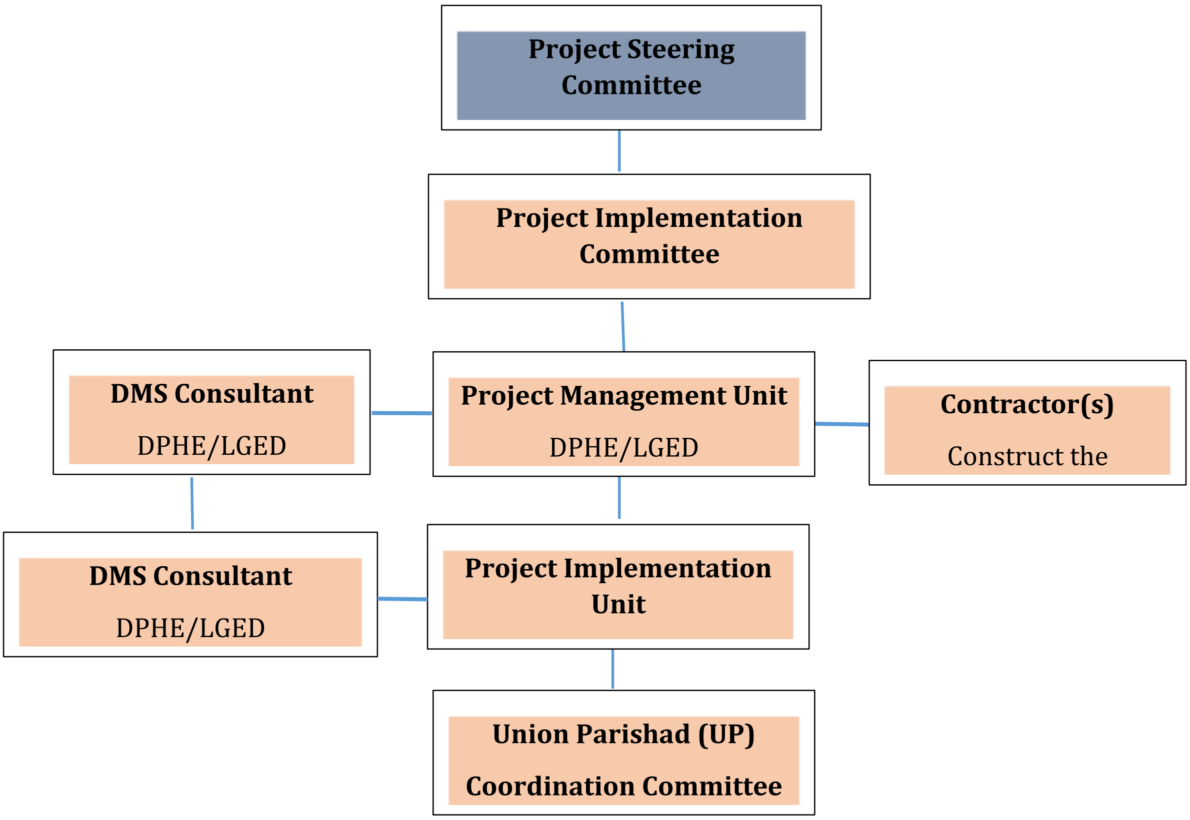


Figure 8.2: Organizational arrangement for project implementation of My Village My Town.

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 8.1**

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

In this study, the water supply, availability, and sanitation condition have been analyzed in the selected disaster prone areas, i.e., Induria (Barishal), Charsharat (Chattogram), Tipna (Khulna), Pathordubi (Kurigram), Datinakhali (Satkhira), Fulchari (Gaibandha), Shimulbank (Sunamganj), and Bagaiya (Sylhet). To analyze the conditions, a survey has been done by a group of team conducted by CEGIS. Some water samples have been collected during the survey. The problem has been assessed based on people's opinions and the laboratory results of water sample testing. Based on the problems, some technologies have been selected to solve the issues. Some designs have been formulated for the implementation of technologies. Water is a basic human requirement.Disaster-prone areas, 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 helps to meet their water demand and mitigate the poor conditions of sanitation.

Some recommendations are-

- Provision of water supply during the dry season in areas where ponds and rivers are the main sources of water and they dry up;
- During the dry season, as the water table drops, groundwater is difficult to tap or unavailable. In such a situation, water can be supplied through pipes to the villages. Alternatively, groundwater recharge could be provided;
- Adequate measures should be taken to remove salinity;
- Implementation of an iron removal treatment plant and a water purification treatment plant where iron, odor, and sewage problems have been found;
- Negative impacts on the environment should be mitigated;
- Reduce the cost as much as possible for the implementation of the project;
- Toilets need to be implemented at a safe distance from a water source;
- A local team needs to be formed to ensure the proper distribution of water and
- A meeting can be held to address the local people about the importance of hygiene every month.

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:

Development of draft questionnaires

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 questionnaire was used. The app on the mobile for KoboToolbox is named "KoboCollect."

Field testing and finalization of Questionnaires

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 questionnaire parameters 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.

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 plain land.

There are **8 villages** in this survey. All the households were surveyed on plainland, and data was processed comprehensively.

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. 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.

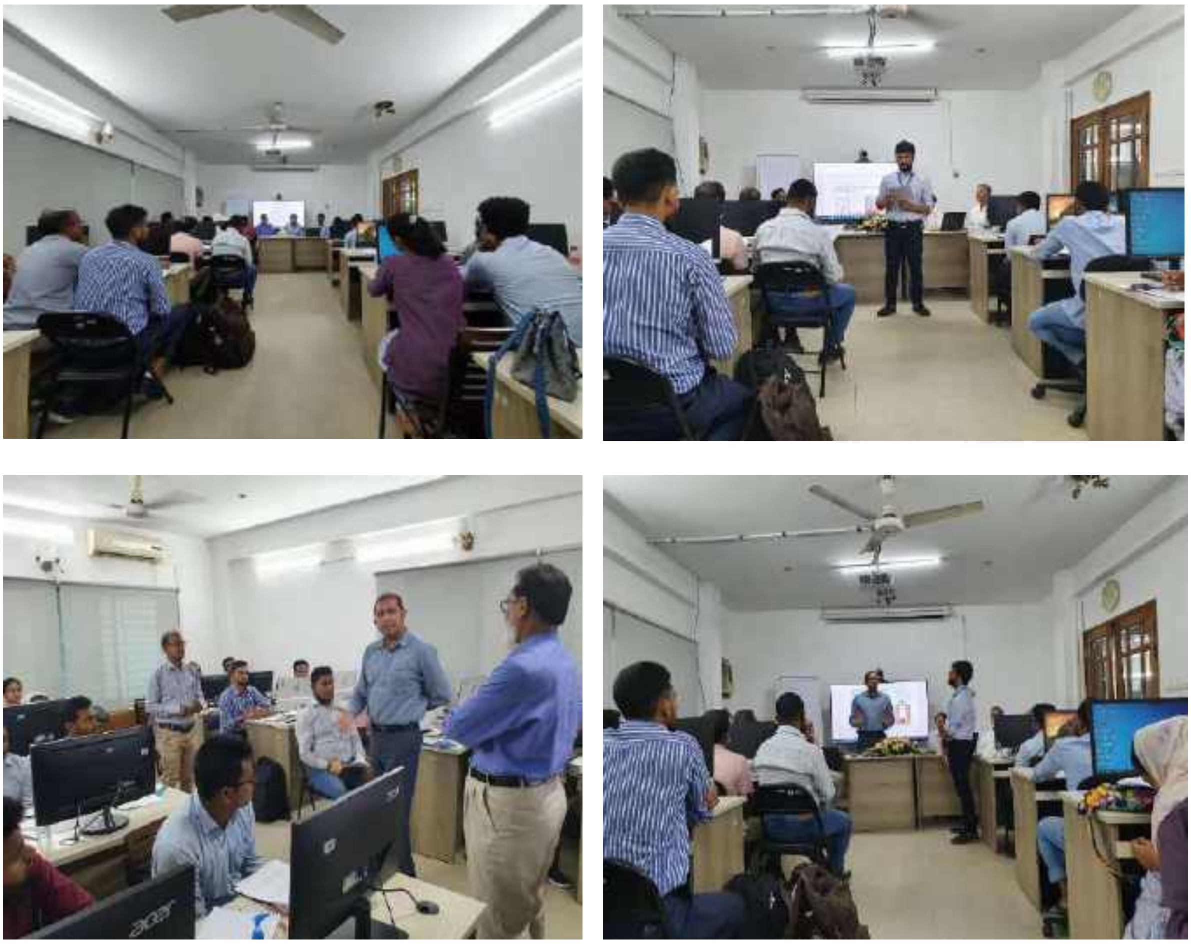


Figure I.3: Field Staff Training

Mobilization of the field team

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

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

Verified and approved information appropriately processed for further analysis. 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.

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. The collected data was accordingly converted to an Excel file and analyzed. Finally, the findings were visualized through synchronized use of the Excel file.

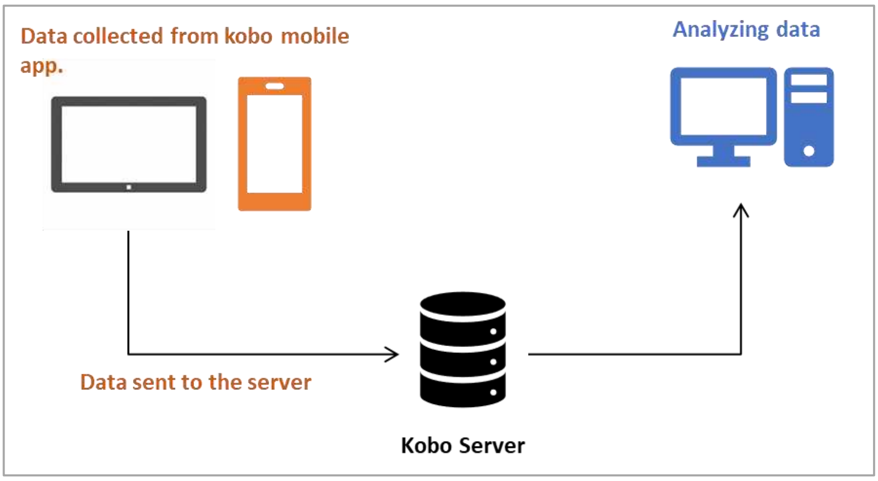


Figure I.5: Data Collection and Management

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.

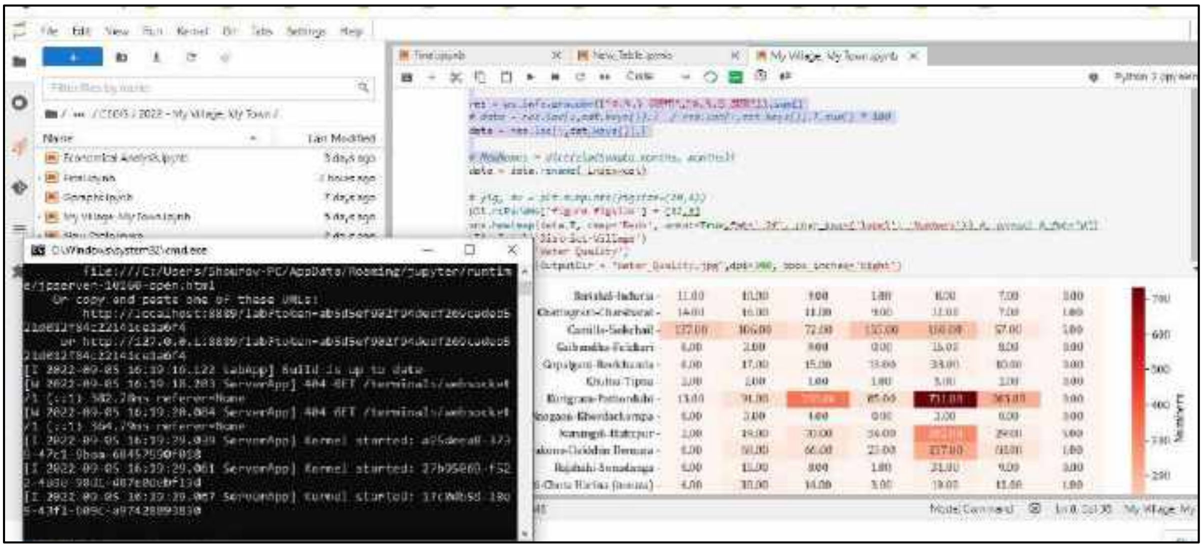


Figure I.6: Data Analysis

I.9 Limitations and Constraints

The project followed proper guidelines and monitoring by the DPHE officials and consultants. Despite 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. However, those limitations couldn't resist credible study findings.

Appendix II: Economical and Financial Analysis

Table: Investment cost (BDT in Lac)

District	Upazila	Union	Village	Number of Household (HH)	water supply	sanitation	Financial Cost (BDT in Lac)
Barishal	Hijla	Memania	Induria	728	125	198	323
chittagong	Mirchorai	Echakhali	Chorshorot	941	125	167	292
Gaibandha	Fulchari	Fulchari	Fulchari	377	75	542	617
Sylhet	Goyainghota	Rostompur	Bagaiya	921	200	91.5	291.5
Sunamganj	Santigan	Shimulbak	Shimulbak	462	210	205	415
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	96	78.5	174.5
Khulna	Dumuria	Khurnia	Tipna	722	17	132.5	149.5
Satkhira	Shyamnagar	Labsa	Datinakhali	568	250	181	431
Sub-total					**1098**	**1595.5**	**2693.5**
Physical contingency							134.675
Price contingency							134.675
Total							**2963**

Table: O&M cost (BDT in Lac)

District	Upazila	Union	Village	Number of Household (HH)	Number of Residents (Apprx)	Average water source maintenance cost per year	Avg. cost (BDT) for operating and maintaining Community Toilet	Total Maintenance Cost	Total Maintenance Cost
						BDT	**BDT**	**BDT**	**BDT in Lac**
Barishal	Hijla	Memania	Induria	728	2912	97.28	150	180020	2
Gaibandha	Fulchari	Fulchari	Fulchari	377	1508	244.14	0	92041	1
sylhet	goyainghota	rostompur	bagaiya	921	3684	77.7	0	71562	1
sunamganj	santigan	shimulbak	shimulbak	462	1848	201.42	0	93056	1
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	9876	298.7	0	737490	7
Khulna	Dumuria	Khurnia	Tipna	722	2888	180.2	0	130104	1
chittagong	mirchorai	echakhali	chorshorot	941	3764	228.93	90.62	300697	3
Satkhira	Shyamnagar	Labsa	Datinakhali	568	2272	118.49	0	67302	1
Total									17

Table: 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 Saved Benefit of Intervention (Water Access)	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 Intervention
						Hour	Tk/hour	BDT	Hour	Tk/hour	BDT	BDT in lac
Barishal	Hijla	Memania	Induria	728	2912	0.12	62.50	1937542	0.05833333	62.5	968770.833	10
Gaibandha	Fulchari	Fulchari	Fulchari	377	1508	0.17	62.50	1433385	0.08333333	62.5	716692.708	7
sylhet	goyainghota	rostompur	bagaiya	921	3684	0.13	62.50	2801375	0.06666667	62.5	1400687.5	14
sunamganj	santigan	shimulbak	shimulbak	462	1848	0.15	62.50	1580906	0.075	62.5	790453.125	8
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	9876	0.25	62.50	14081016	0.125	62.5	7040507.81	70
chittagong	mirchorai	echakhali	chorshorot	941	3764	0.17	62.50	3577760	0.08333333	62.5	1788880.21	18
Khulna	Dumuria	Khurnia	Tipna	722	2888	0.20	62.50	3294125	0.1	62.5	1647062.5	16
Satkhira	Shyamnagar	Labsa	Datinakhali	568	2272	0.12	62.50	1511708	0.05833333	62.5	755854.167	8
Total												151

Table: 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 Intervenion
						Hour	Tk/hour	BDT	Hour	Tk/hour	BDT	BDT in lac
Barishal	Hijla	Memania	Induria	728	2912	0.167	62.50	2767917	0.08333333	62.5	1383958.33	14
Gaibandha	Fulchari	Fulchari	Fulchari	377	1508	0.100	62.50	860031	0.05	62.5	430015.625	4
sylhet	goyainghota	rostompur	bagaiya	921	3684	0.083	62.50	1750859	0.04166667	62.5	875429.688	9
sunamganj	santigan	shimulbak	shimulbak	462	1848	0.183	62.50	1932219	0.09166667	62.5	966109.375	10
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	9876	0.133	62.50	7509875	0.06666667	62.5	3754937.5	38
chittagong	mirchorai	echakhali	chorshorot	941	3764	0.117	62.50	2504432	0.05833333	62.5	1252216.15	13
Khulna	Dumuria	Khurnia	Tipna	722	2888	0.133	62.50	2196083	0.06666667	62.5	1098041.67	11
Satkhira	Shyamnagar	Labsa	Datinakhali	568	2272	0.100	62.50	1295750	0.05	62.5	647875	6
Total												**104**

Table: 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)**
Barishal	Hijla	Memania	Induria	728	2912	6000	20%	44	73	500	66
Gaibandha	Fulchari	Fulchari	Fulchari	377	1508	6000	20%	23	73	500	34
sylhet	goyainghota	rostompur	bagaiya	921	3684	6000	20%	55	73	500	84
sunamganj	santigan	shimulbak	shimulbak	462	1848	6000	20%	28	73	500	42
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	9876	6000	20%	148	73	500	225
chittagong	mirchorai	echakhali	chorshorot	941	3764	6000	20%	56	73	500	86
Khulna	Dumuria	Khurnia	Tipna	722	2888	6000	20%	43	73	500	66
Satkhira	Shyamnagar	Labsa	Datinakhali	568	2272	6000	20%	34	73	500	52
Total								**431**			**656**

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)**
Barishal	Hijla	Memania	Induria	728	2912	3000	10%	22	37	500	33
Gaibandha	Fulchari	Fulchari	Fulchari	377	1508	3000	10%	11	37	500	17
sylhet	goyainghota	rostompur	bagaiya	921	3684	3000	10%	28	37	500	42
sunamganj	santigan	shimulbak	shimulbak	462	1848	3000	10%	14	37	500	21
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	9876	3000	10%	74	37	500	113
chittagong	mirchorai	echakhali	chorshorot	941	3764	3000	10%	28	37	500	43
Khulna	Dumuria	Khurnia	Tipna	722	2888	3000	10%	22	37	500	33
Satkhira	Shyamnagar	Labsa	Datinakhali	568	2272	3000	10%	17	37	500	26
Total								**216**			**328**

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)**
Barishal	Hijla	Memania	Induria	728	2912	3000	10%	22	36.50	500	33
Gaibandha	Fulchari	Fulchari	Fulchari	377	1508	3000	10%	11	36.50	500	17
sylhet	goyainghota	rostompur	bagaiya	921	3684	3000	10%	28	36.50	500	42
sunamganj	santigan	shimulbak	shimulbak	462	1848	3000	10%	14	36.50	500	21
Kurigram	Bhurungamari	Pathordubi	Pathordubi	2469	9876	3000	10%	74	36.50	500	113
chittagong	mirchorai	echakhali	chorshorot	941	3764	3000	10%	28	36.50	500	43
Khulna	Dumuria	Khurnia	Tipna	722	2888	3000	10%	22	36.50	500	33
Satkhira	Shyamnagar	Labsa	Datinakhali	568	2272	3000	10%	17	36.50	500	26
Total								**216**			**328**

Table: Financial 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 Benefit	Total Benefit	
1	808.05		808.05				0	-808.05
2	1077.4		1077.4				0	-1077.4
3	1077.4		1077.4				0	-1077.4
4		17	16.72	151	104	544	798.7674	782.04
5		17	16.72	151	104	544	798.7674	782.04
6		17	16.72	151	104	544	798.7674	782.04
7		17	16.72	151	104	544	798.7674	782.04
8		17	16.72	151	104	544	798.7674	782.04
9		17	16.72	151	104	544	798.7674	782.04
10		17	16.72	151	104	544	798.7674	782.04
11		17	16.72	151	104	544	798.7674	782.04
12		17	16.72	151	104	544	798.7674	782.04
13		17	16.72	151	104	544	798.7674	782.04
14		17	16.72	151	104	544	798.7674	782.04
15		17	16.72	151	104	544	798.7674	782.04
16		17	16.72	151	104	544	798.7674	782.04
17		17	16.72	151	104	544	798.7674	782.04
18		17	16.72	151	104	544	798.7674	782.04
19		17	16.72	151	104	544	798.7674	782.04
20		17	16.72	151	104	544	798.7674	782.04
Total			**2,431.99**				**4,047.84**	**1,615.86**

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Benefit	Total Benefit	
Financial Net Present Value (FNPV)								**1,615.86**
Financial Benefit Cost Ratio (FBCR)								**1.664419**
Financial Internal Rate of Return (FIRR)								**21%**

Table: 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	808	-808	0	889	-889	0	735	-735	0	889	-889
2	0	1077	-1077	0	1185	-1185	0	979	-979	0	1185	-1185
3	0	1077	-1077	0	1185	-1185	0	979	-979	0	1185	-1185
4	726	17	709	799	18	780	879	15	863	726	18	708
5	726	17	709	799	18	780	879	15	863	726	18	708
6	726	17	709	799	18	780	879	15	863	726	18	708
7	726	17	709	799	18	780	879	15	863	726	18	708
8	726	17	709	799	18	780	879	15	863	726	18	708
9	726	17	709	799	18	780	879	15	863	726	18	708
10	726	17	709	799	18	780	879	15	863	726	18	708
11	726	17	709	799	18	780	879	15	863	726	18	708
12	726	17	709	799	18	780	879	15	863	726	18	708
13	726	17	709	799	18	780	879	15	863	726	18	708

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
14	726	17	709	799	18	780	879	15	863	726	18	708
15	726	17	709	799	18	780	879	15	863	726	18	708
16	726	17	709	799	18	780	879	15	863	726	18	708
17	726	17	709	799	18	780	879	15	863	726	18	708
18	726	17	709	799	18	780	879	15	863	726	18	708
19	726	17	709	799	18	780	879	15	863	726	18	708
20	726	17	709	799	18	780	879	15	863	726	18	708
	3680	**2432**	**1248**	**4048**	**2675**	**1373**	**4453**	**2211**	**2242**	**3680**	**2675**	**1005**
	FBCR		**1.51**	FBCR		**1.51**	FBCR		**2.01**	FBCR		**1.38**
	FNPV		**1248**	FNPV		**1373**	FNPV		**2242**	FNPV		**1005**
	FIRR		**19%**	FIRR		**19%**	FIRR		**25%**	FIRR		**17%**

Table: 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 Benefit	Total Benefit	
1	729		728.8611				0	-728.8611
2	972		971.8148				0	-971.8148
3	850		850.338				0	-850.33795
4		15.1	15.1	136.3	93.9	490.3	720.5	705.4
5		15.1	15.1	136.3	93.9	490.3	720.5	705.4
6		15.1	15.1	136.3	93.9	490.3	720.5	705.4

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Benefit	Total Benefit	
7		15.1	15.1	136.3	93.9	490.3	720.5	705.4
8		15.1	15.1	136.3	93.9	490.3	720.5	705.4
9		15.1	15.1	136.3	93.9	490.3	720.5	705.4
10		15.1	15.1	136.3	93.9	490.3	720.5	705.4
11		15.1	15.1	136.3	93.9	490.3	720.5	705.4
12		15.1	15.1	136.3	93.9	490.3	720.5	705.4
13		15.1	15.1	136.3	93.9	490.3	720.5	705.4
14		15.1	15.1	136.3	93.9	490.3	720.5	705.4
15		15.1	15.1	136.3	93.9	490.3	720.5	705.4
16		15.1	15.1	136.3	93.9	490.3	720.5	705.4
17		15.1	15.1	136.3	93.9	490.3	720.5	705.4
18		15.1	15.1	136.3	93.9	490.3	720.5	705.4
19		15.1	15.1	136.3	93.9	490.3	720.5	705.4
20		15.1	15.1	136.3	93.9	490.3	720.5	705.4
Total			**2,107**				**3,651**	**1,544**
Economic Net Present Value (ENPV)								**1,544**
Economic Benefit Cost Ratio (EBCR)								**1.7327154**
Economic Internal Rate of Return (EIRR)								**22%**

Table: 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	729	-729	0	802	-802	0	663	-663	0	802	-802
2	0	972	-972	0	1069	-1069	0	883	-883	0	1069	-1069
3	0	850	-850	0	935	-935	0	773	-773	0	935	-935
4	655	15	640	720	17	704	793	14	779	655	17	638
5	655	15	640	720	17	704	793	14	779	655	17	638
6	655	15	640	720	17	704	793	14	779	655	17	638
7	655	15	640	720	17	704	793	14	779	655	17	638
8	655	15	640	720	17	704	793	14	779	655	17	638
9	655	15	640	720	17	704	793	14	779	655	17	638
10	655	15	640	720	17	704	793	14	779	655	17	638
11	655	15	640	720	17	704	793	14	779	655	17	638
12	655	15	640	720	17	704	793	14	779	655	17	638
13	655	15	640	720	17	704	793	14	779	655	17	638
14	655	15	640	720	17	704	793	14	779	655	17	638
15	655	15	640	720	17	704	793	14	779	655	17	638
16	655	15	640	720	17	704	793	14	779	655	17	638
17	655	15	640	720	17	704	793	14	779	655	17	638
18	655	15	640	720	17	704	793	14	779	655	17	638
19	655	15	640	720	17	704	793	14	779	655	17	638
20	655	15	640	720	17	704	793	14	779	655	17	638

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**
	3319	**2107**	**1212**	**3651**	**2318**	**1333**	**4016**	**1916**	**2101**	**3319**	**2318**	**1001**
	EBCR		**1.58**	EBCR		**1.58**	EBCR		**2.10**	EBCR		**1.43**
	ENPV		**1212**	ENPV		**1333**	ENPV		**2101**	ENPV		**1001**
	EIRR		**20%**	EIRR		**20%**	EIRR		**26%**	EIRR		**18%**

Appendix III: Water Supply and Sanitation Demand

Water Supply Demand

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

Current demand

Current demand for overall water uses per person-day has been assessed based on data available[9] of disaster-prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[10] rate.

Table: Current Demand for Overall Water Use before project implementation (Liter) in Induria

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Barishal	Induria	807	4.2	3389	237258	7117740	854	843	832

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: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	832	Estimated based on 70 litre/ person
2021	843	
2022	854	
2023	865	Business as usual Projection
2024	876	
2025	887	
2026	898	Forecasted through end of the project
2027	909	
2028	920	

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

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

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2029	931	
2030	942	
2031	953	
2032	964	
2033	975	
2034	986	
2035	997	
2036	1008	
2037	1019	
2038	1030	
2039	1041	
2040	1052	
2041	1063	
2042	1074	
2043	1085	
2044	1096	
2045	1107	

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 830 Lac to 1110 Lac litres for the period.

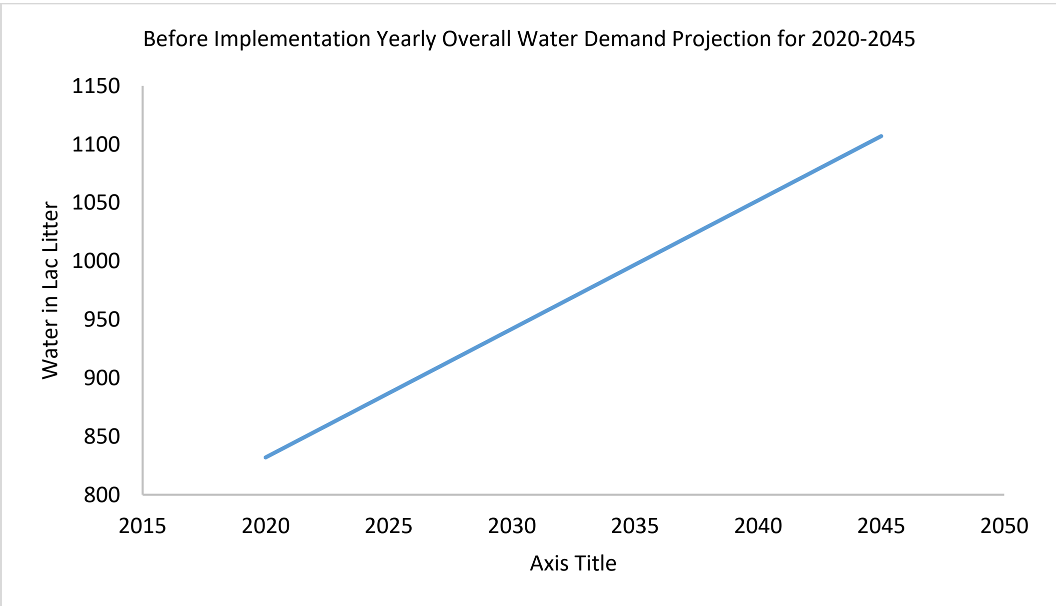


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Assumptions
2020	832	Estimated based on 70 litres per person per day.
2021	843	
2022	854	
2023	865	Business as usual Projection
2024	876	
2025	1153	
2026	1167	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	1182	
2028	1196	
2029	1210	
2030	1225	
2031	1239	
2032	1253	
2033	1268	
2034	1282	
2035	1296	
2036	1310	
2037	1325	
2038	1339	
2039	1353	
2040	1368	
2041	1382	
2042	1396	
2043	1411	
2044	1425	
2045	1439	

Based on projected data, after implementation, a chart has been prepared, and presented below:

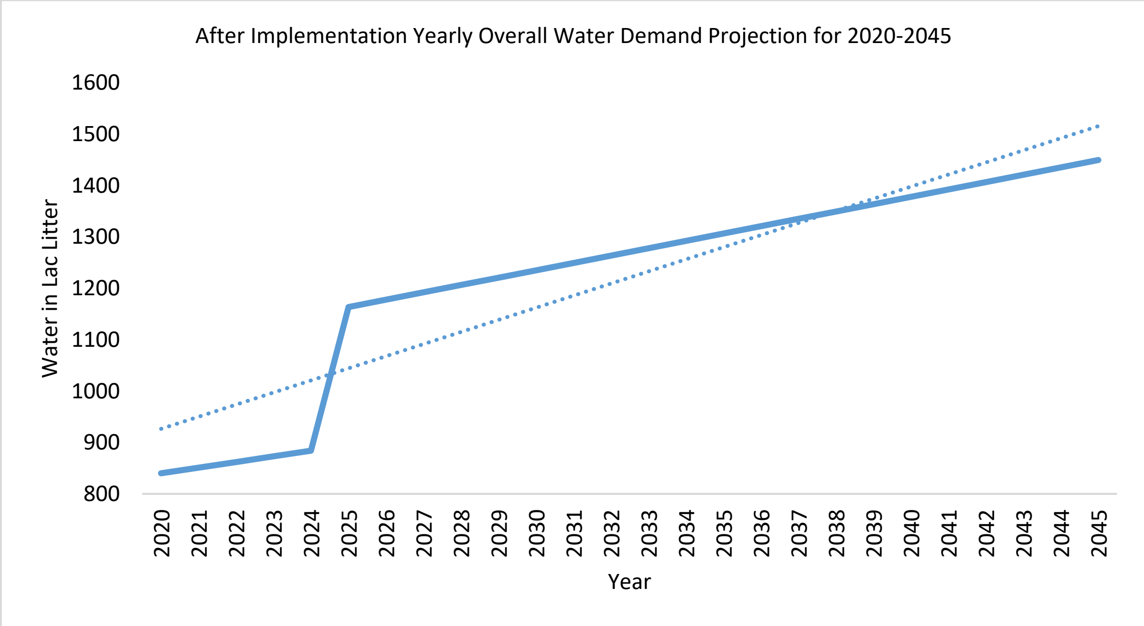


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 Period

After implementation of the project, it is estimated that the overall water use varies between 830 Lac to 1445 Lac litres over the period. The trend is upward.

Current demand

Current demand for overall water use per person-day has been assessed based on data available[11] of disaster prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[12] rate.

Table: Current Demand for Overall Water Use before project implementation (Liter) in Charsharat

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Chattogram	Charsharat	676	4.2	2839	198744	5962320	715	706	697

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,

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

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

business as usual projection for a period, and forecasted for a period of 20-year. These are shown in the following Table.

Table: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	697	Estimated based on 70 litre/ person
2021	706	
2022	715	
2023	724	Business as usual Projection
2024	733	
2025	742	
2026	751	Forecasted through end of the project
2027	760	
2028	769	
2029	778	
2030	787	
2031	796	
2032	805	
2033	814	
2034	823	
2035	832	
2036	841	
2037	850	
2038	859	
2039	868	
2040	877	
2041	886	
2042	895	
2043	904	
2044	913	
2045	922	

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 695 Lac to 930Lac litres for the period.

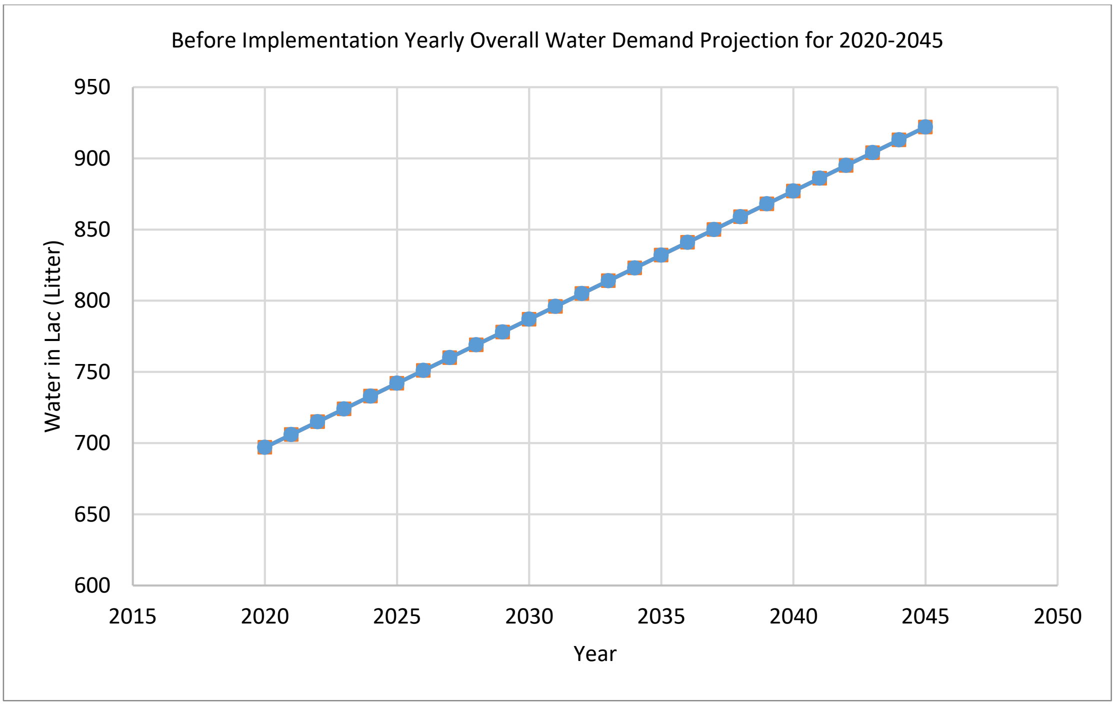


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	697	Estimated based on 70 litre/ person
2021	706	
2022	715	
2023	724	Business as usual Projection
2024	733	
2025	965	
2026	976	Forecasted through end of the project
2027	988	
2028	1000	
2029	1011	
2030	1023	
2031	1035	
2032	1047	
2033	1058	
2034	1070	
2035	1082	

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2036	1093	
2037	1105	
2038	1117	
2039	1128	
2040	1140	
2041	1152	
2042	1164	
2043	1175	
2044	1187	
2045	1199	

Based on projected data, after implementation, a chart has been prepared, and presented below:

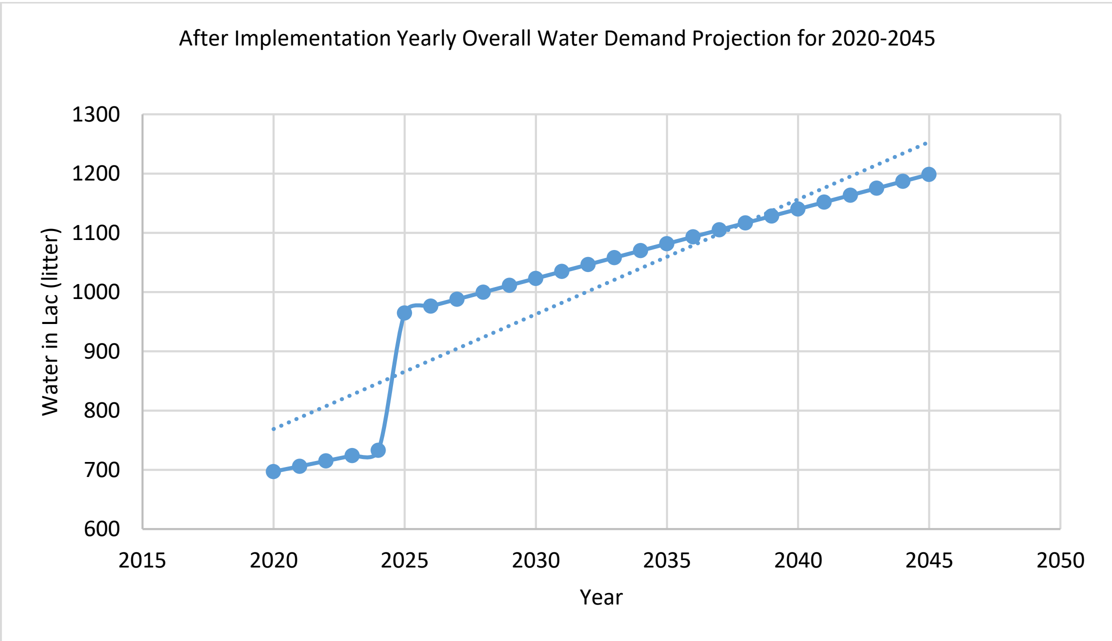


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 695 Lac to 1200 Lac litres over the period. The trend is upward.

Current demand

Current demand for overall water use per person-day has been assessed based on data available[13] of disaster prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[14] rate.

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

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

Table: Current Demand for Overall Water Use before project implementation (Liter) in Fulchari

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Gaibandha	Fulchari	306	4.2	1285	89964	2698920	324	320	316

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: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	316	Estimated based on 70 litre/ person
2021	320	
2022	324	
2023	328	Business as usual Projection
2024	332	
2025	336	
2026	340	Forecasted through end of the project
2027	344	
2028	348	
2029	352	
2030	356	
2031	360	
2032	364	
2033	368	
2034	372	
2035	376	
2036	380	
2037	384	
2038	388	
2039	392	
2040	396	
2041	400	
2042	404	

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2043	408	
2044	412	
2045	416	

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 315 Lac to 420 Lac litres for the period.

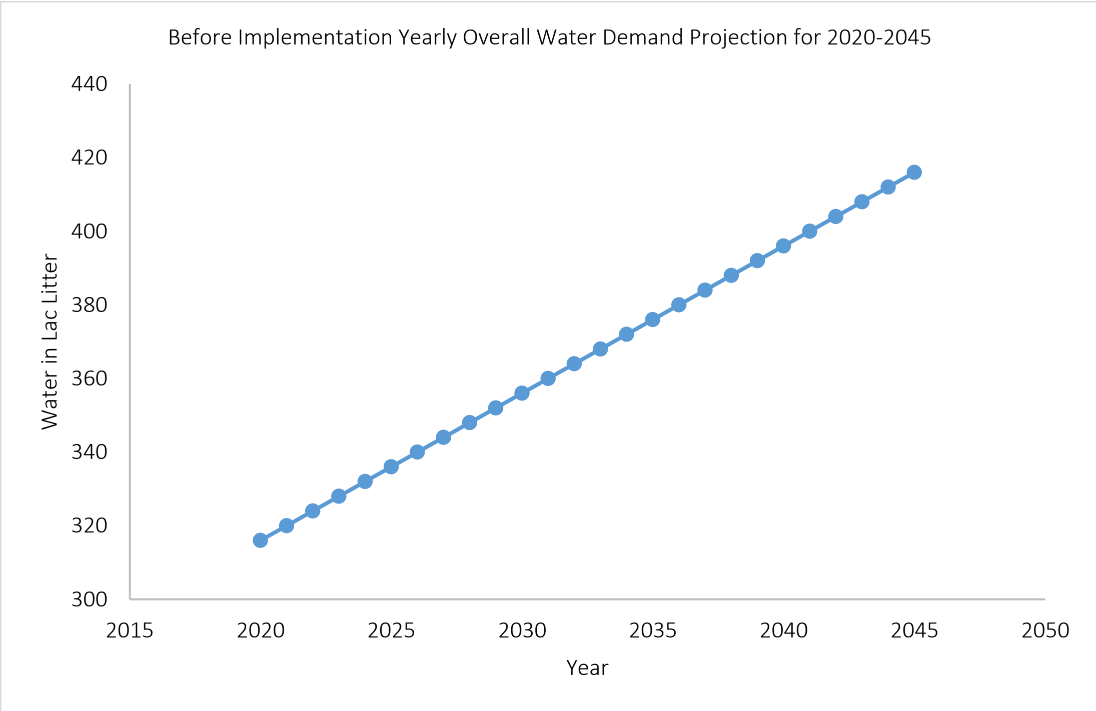


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	316	Estimated based on 70 litre/ person
2021	320	
2022	324	
2023	328	Business as usual Projection
2024	332	
2025	437	
2026	442	Forecasted through end of the project

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2027	447	
2028	452	
2029	458	
2030	463	
2031	468	
2032	473	
2033	478	
2034	484	
2035	489	
2036	494	
2037	499	
2038	504	
2039	510	
2040	515	
2041	520	
2042	525	
2043	530	
2044	536	
2045	541	

Based on projected data, after implementation, a chart has been prepared, and presented below:

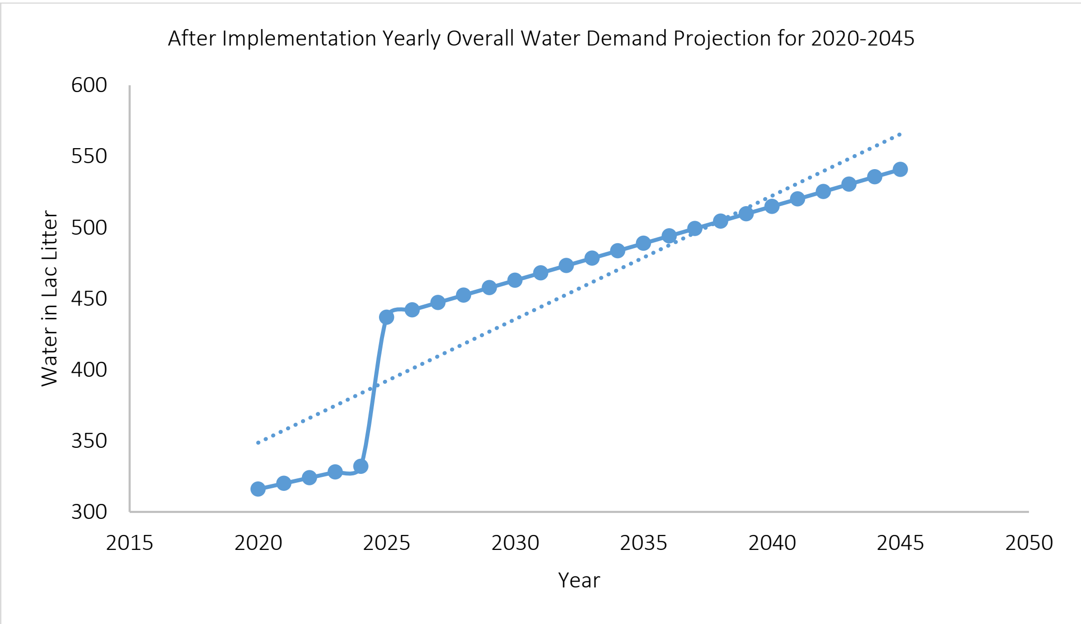


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 315 Lac to 545 Lac litres over the period. The trend is upward.

Current demand

Current demand for overall water use per person-day has been assessed based on data available[15] of disaster prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[16] rate.

Table: Current Demand for Overall Water Use before project implementation (Liter) in Fulchari

District	Village	Number of household (hh)	hh size (4.2)	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

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: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	804	Estimated based on 70 litre/ person
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	

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

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

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2036	972	
2037	983	
2038	993	
2039	1004	
2040	1014	
2041	1025	
2042	1035	
2043	1046	
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 1170 Lac litres for the period.

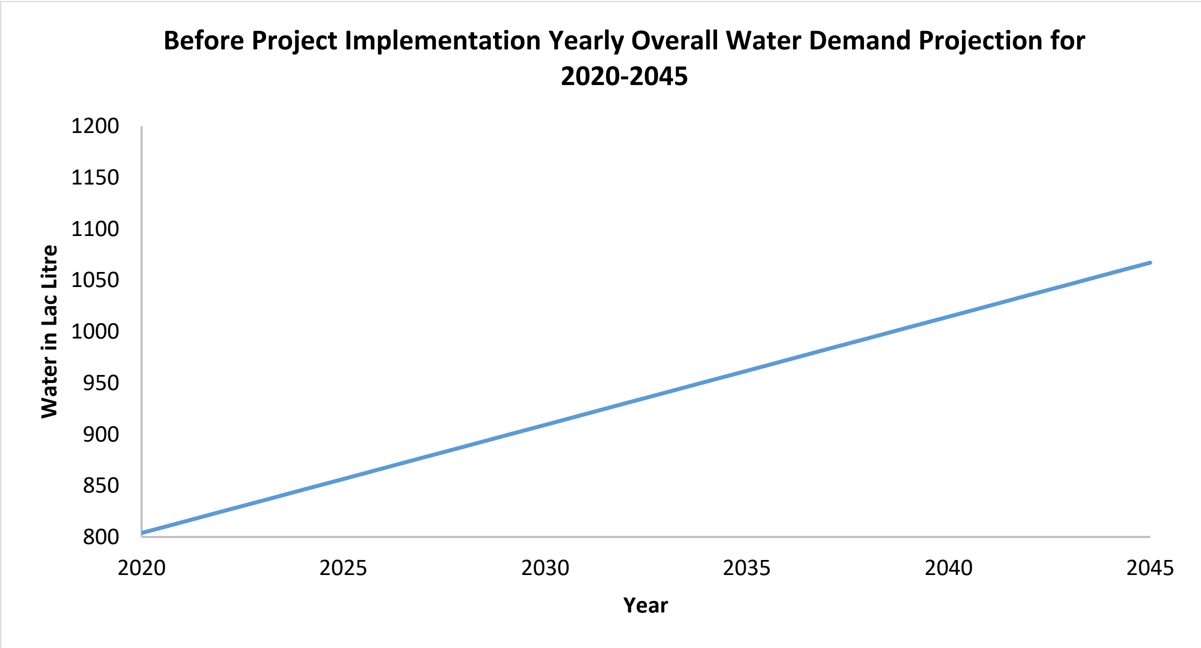


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	804	Estimated based on 70 litre/ person
2021	814	
2022	825	
2023	835	Business as usual Projection
2024	846	
2025	856	
2026	1127	Forecasted through end of the project
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:

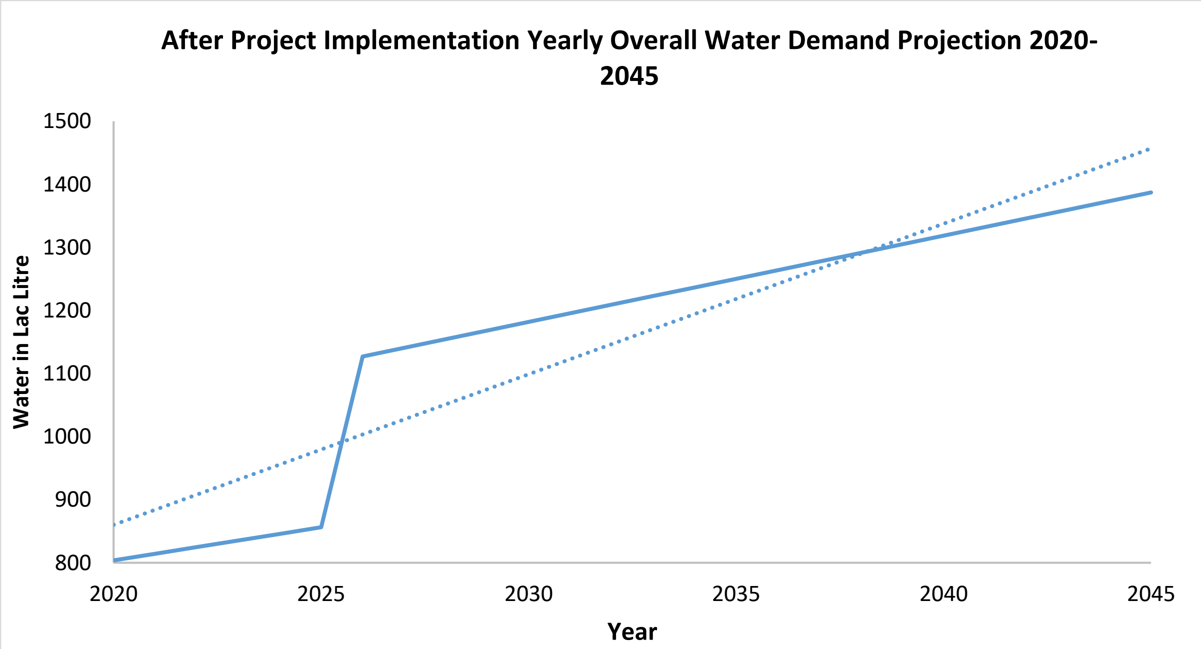


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 800 Lac to 1390 Lac litres over the period. The trend is upward.

Current demand

Current demand for overall water use per person-day has been assessed based on data available[17] of disaster prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[18] rate.

Table: Current Demand for Overall Water Use before project implementation (Liter) in Fulchari

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Kurigram	Pathordubi	2500	4.2	10500	735000	22050000	2646	2612	2579

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.

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

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

Table: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	2579	Estimated based on 70 litre/ person
2021	2612	
2022	2646	
2023	2679	Business as usual Projection
2024	2713	
2025	2747	
2026	2780	Forecasted through end of the project
2027	2814	
2028	2847	
2029	2881	
2030	2915	
2031	2948	
2032	2982	
2033	3015	
2034	3049	
2035	3083	
2036	3116	
2037	3150	
2038	3183	
2039	3217	
2040	3251	
2041	3284	
2042	3318	
2043	3351	
2044	3385	
2045	3419	

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 2575 Lac to 3425 Lac litres for the period.

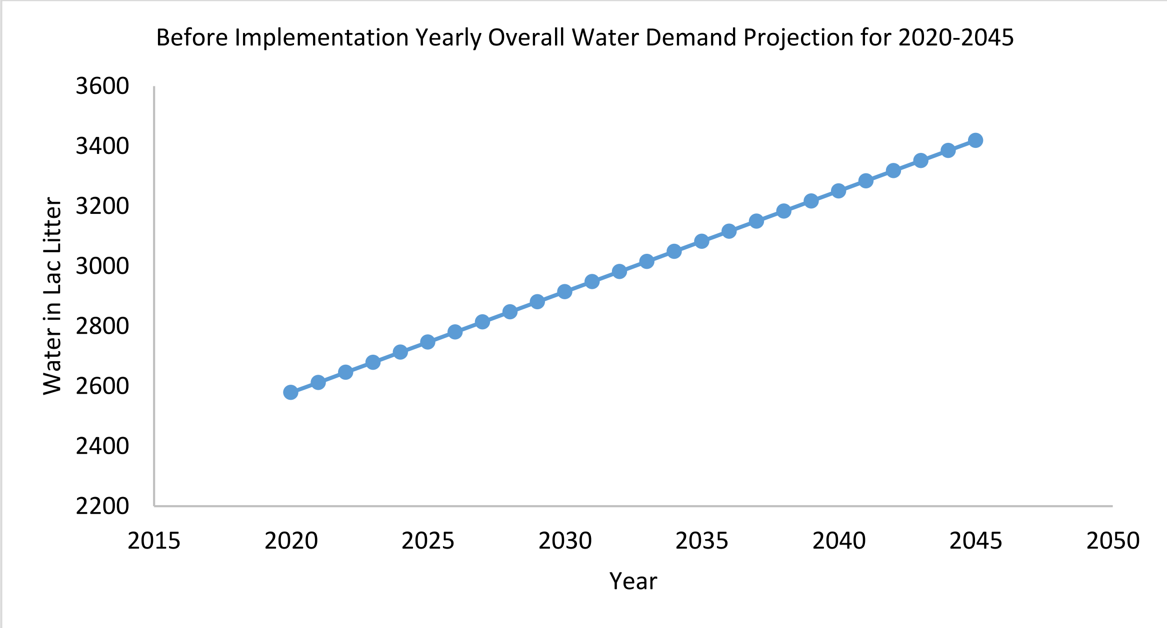


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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.

Based on projected data, after implementation, a chart has been prepared, and presented below:

Table: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	2579	Estimated based on 70 litre/ person
2021	2612	
2022	2646	
2023	2679	Business as usual Projection
2024	2713	
2025	3570	
2026	3614	Forecasted through end of the project
2027	3657	
2028	3701	
2029	3744	
2030	3788	
2031	3832	
2032	3875	
2033	3919	
2034	3962	

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2035	4006	
2036	4049	
2037	4093	
2038	4136	
2039	4180	
2040	4223	
2041	4267	
2042	4311	
2043	4354	
2044	4398	
2045	4441	

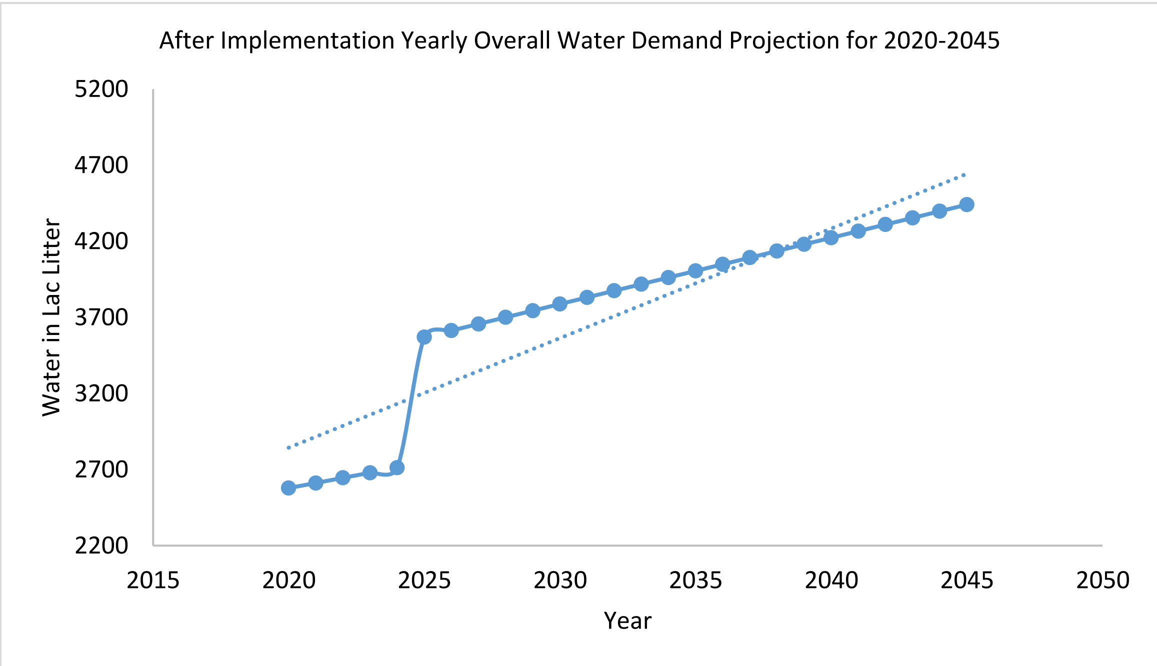


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 2580 Lac to 4445 Lac litres over the period. The trend is upward.

Current demand

Current demand for overall water use per person-day has been assessed based on data available[19] of disaster prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[20] rate.

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

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

Table: Current Demand for Overall Water Use before project implementation (Liter) in Datinakhali

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Satkhira	Datinakhali	568	4.0	2255	157847	4735416	568	561	554

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: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	554	Estimated based on 70 litre/ person
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	

Year	Avg. yearly Drinking water demand (Litre)	Remarks
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 550 Lac to 740 Lac litres for the period.

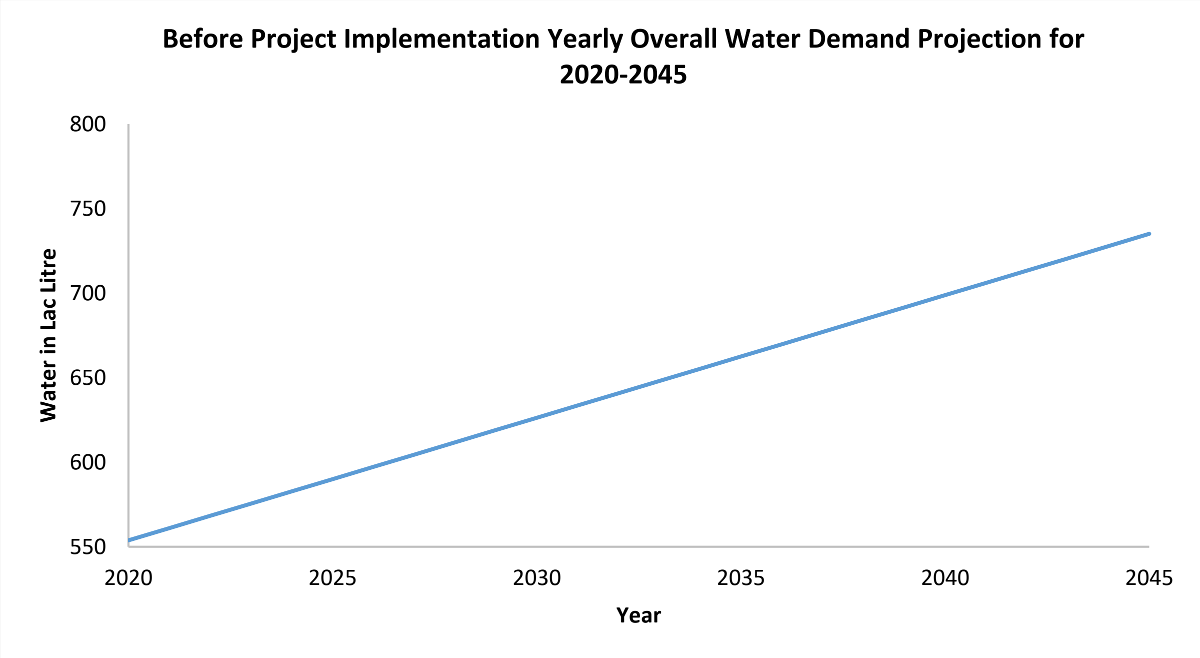


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	554	Estimated based on 70 litre/ person
2021	561	
2022	568	
2023	575	Business as usual Projection
2024	583	
2025	590	
2026	776	Forecasted through end of the project

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2027	786	
2028	795	
2029	805	
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:

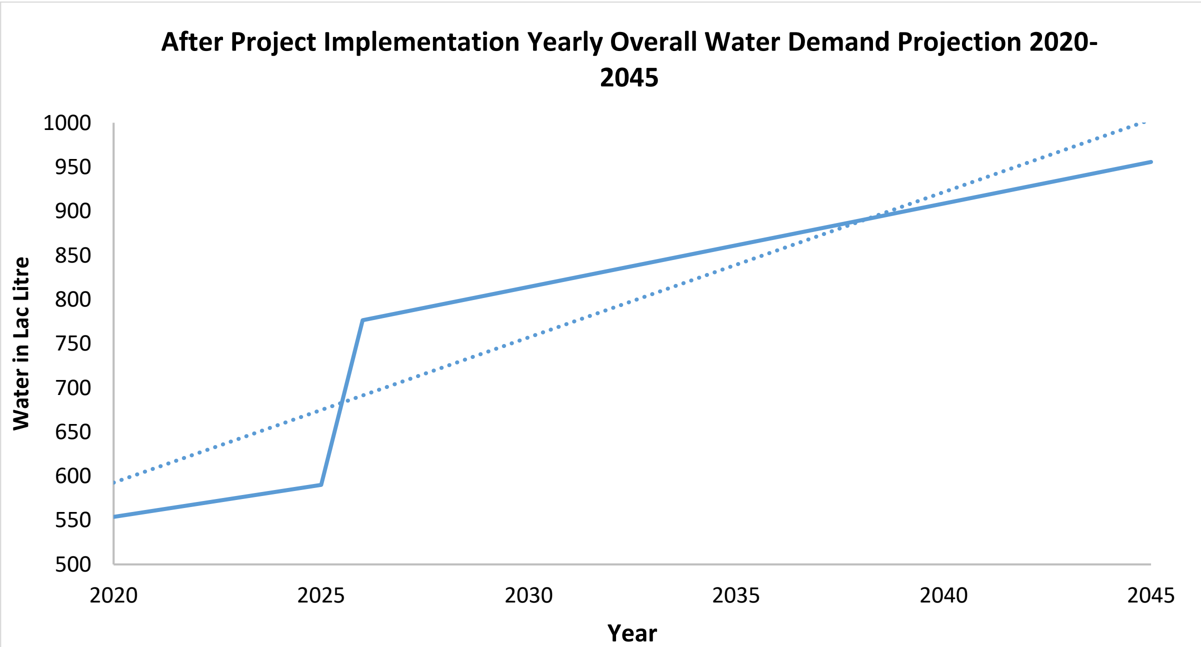


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 550 Lac to 960 Lac litres over the period. The trend is upward.

Current demand

Current demand for overall water use per person-day has been assessed based on data available[21] of disaster prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[22] rate.

Table: Current Demand for Overall Water Use before project implementation (Liter) in Fulchari

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Sunamganj	Shimulbank	462	5.7	2629	184015	5520438	662	654	646

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: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	646	Estimated based on 70 litre/ person
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	

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

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

Year	Avg. yearly Drinking water demand (Litre)	Remarks
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 640 Lac to 870 Lac litres for the period.

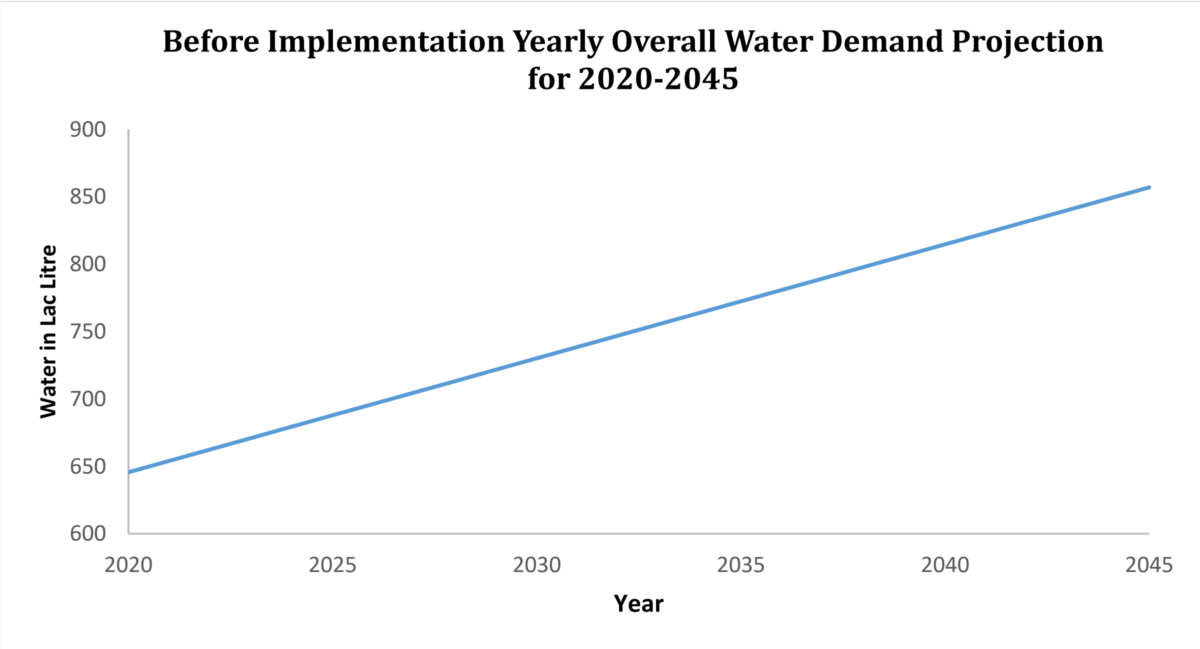


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	646	Estimated based on 70 litre/ person
2021	654	
2022	662	
2023	671	Business as usual Projection
2024	679	
2025	688	
2026	905	Forecasted through end of the project
2027	916	
2028	927	
2029	938	
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:

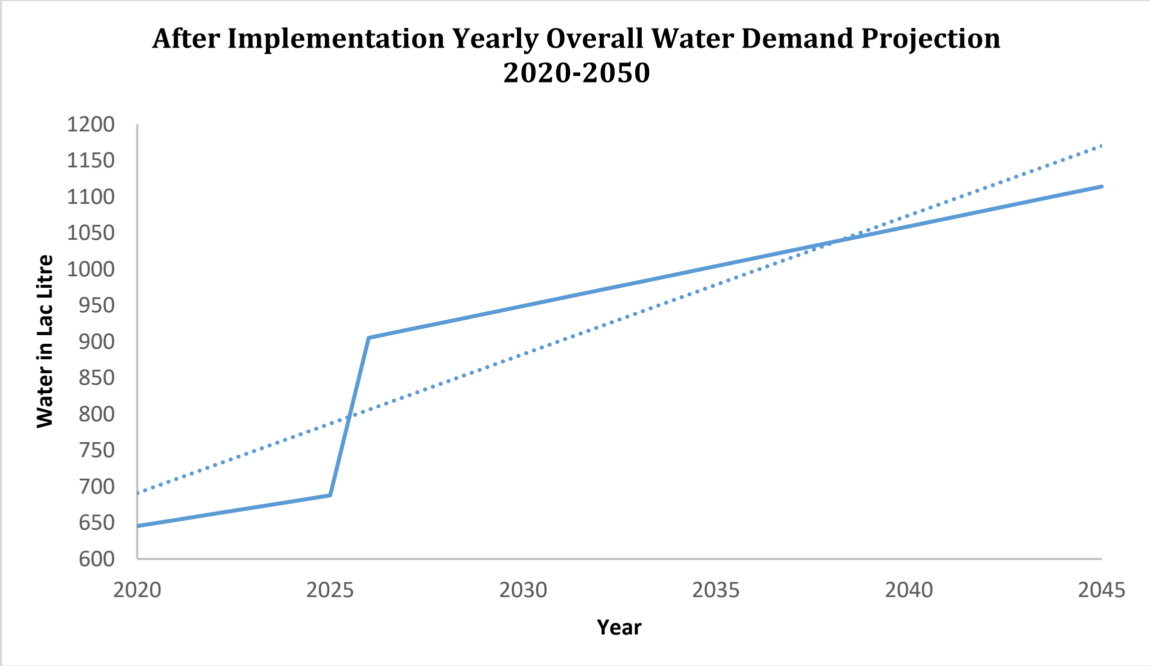


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 640 Lac to 1120 Lac litres over the period. The trend is upward.

Current demand

Current demand for overall water uses per person-day has been assessed based on data available[23] of disaster prone pilot villages. Previous two years (2021 and 2020) data are related with the population growth[24] rate.

Table: Current Demand for Overall Water Use before project implementation (Liter) in Fulchari

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Overall water demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre /person)	Monthly	Year 2022	Year 2021	Year 2020
Sylhet	Bagaiya	836	4.2	3511	245784	7373520	885	873	862

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.

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

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

Table: Before Project Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	862	Estimated based on 70 litre/ person
2021	873	
2022	885	
2023	896	Business as usual Projection
2024	908	
2025	920	
2026	931	Forecasted through end of the project
2027	943	
2028	954	
2029	966	
2030	978	
2031	989	
2032	1001	
2033	1012	
2034	1024	
2035	1036	
2036	1047	
2037	1059	
2038	1070	
2039	1082	
2040	1094	
2041	1105	
2042	1117	
2043	1128	
2044	1140	
2045	1152	

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 860 Lac to 1155 Lac litres for the period.

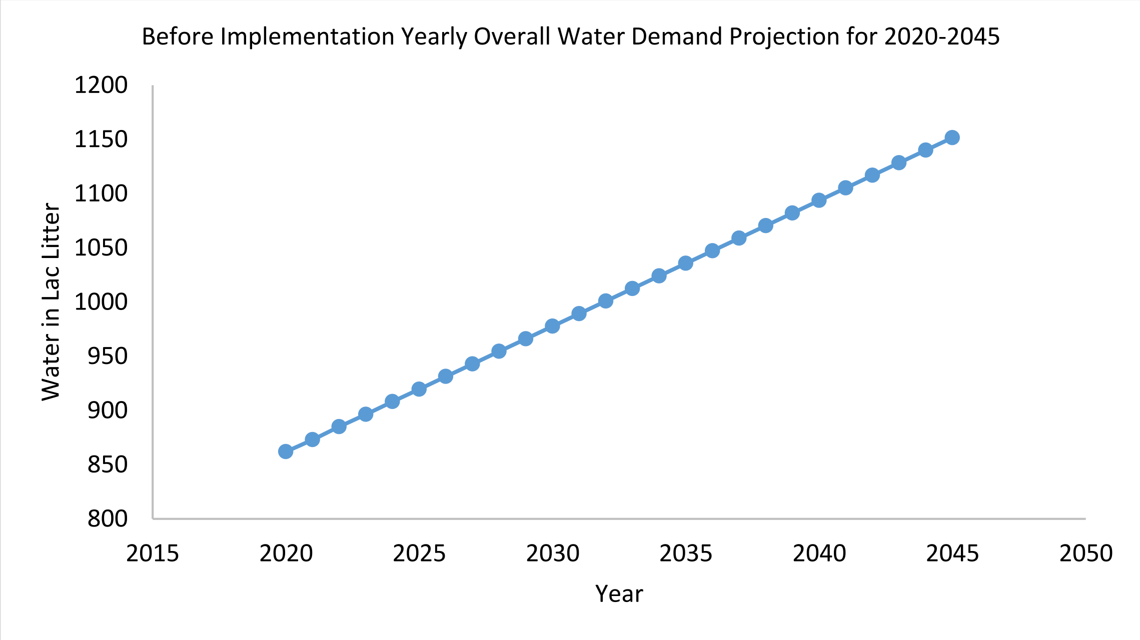


Figure: Before Project Implementation Yearly Overall Water Demand Projection for 2020-2045

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: After Implementation Overall Water Demand and Projection

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2020	862	Estimated based on 70 litre/ person
2021	873	
2022	885	
2023	896	Business as usual Projection
2024	908	
2025	1195	
2026	1210	Forecasted through end of the project
2027	1225	
2028	1240	
2029	1255	
2030	1270	
2031	1285	
2032	1300	
2033	1315	
2034	1330	

Year	Avg. yearly Drinking water demand (Litre)	Remarks
2035	1345	
2036	1360	
2037	1375	
2038	1389	
2039	1404	
2040	1419	
2041	1434	
2042	1449	
2043	1464	
2044	1479	
2045	1494	

Based on projected data, after implementation, a chart has been prepared, and presented below:

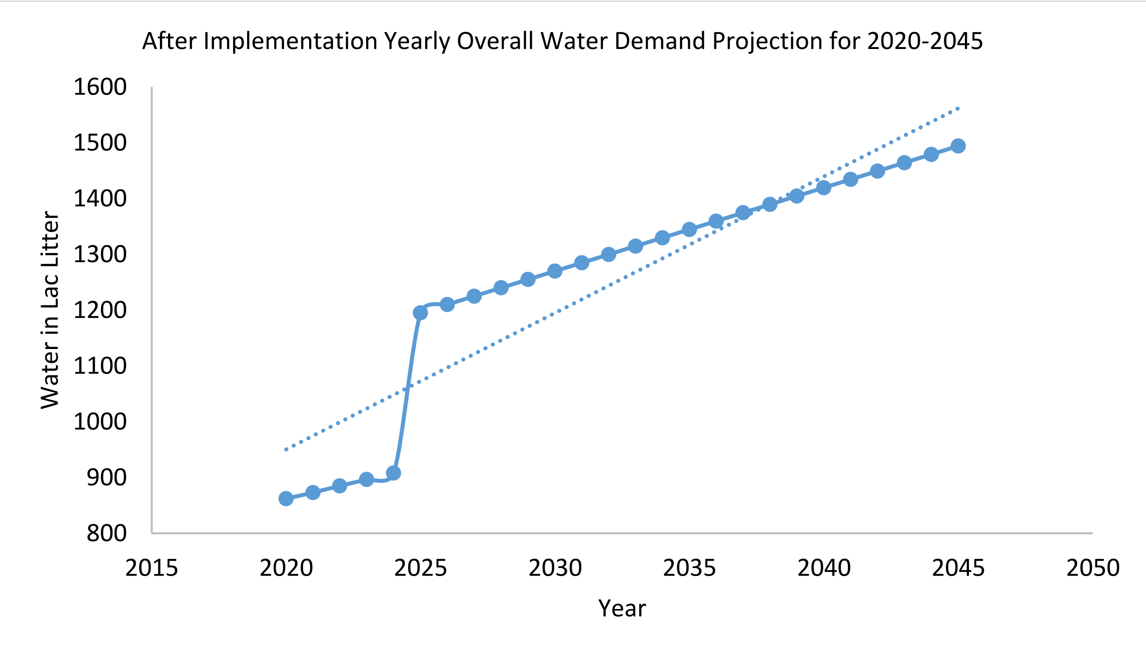


Figure: After Project Implementation Yearly Overall Water Demand for 2020-2045 period

After implementation of the project, it is estimated that the overall water use varies between 860 Lac to 1500 Lac litres over the period. The trend is upward.

Sanitation Demand

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[25] 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 2020-21 have taken for calculation of the previous data. Based on the assumption,

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

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: Sanitation Demand before Project Implementation

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village		
						Year 2022	Year 2021	Year 2020
Barishal	Induria	728	4.7	3421.6	415	415	435.75	457.5375

Source: BBS, Statistical Pocket book Household size 4.2 (2018)

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 25-year. These are shown in the following Table.

Table: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	3842	Estimated based on awareness of better future sanitation situation
2021	3659	
2022	3485	DPHE data on conversion of single pit latrine.
2023	3305	Business as usual Projection
2024	3129	
2025	2950	
2026	2773	
2027	2595	
2028	2417	
2029	2239	
2030	2062	
2031	1884	
2032	1706	
2033	1529	
2034	1351	
2035	1173	
2036	995	
2037	818	
2038	640	
2039	462	
2040	284	

Year	Single Pit Latrine	Remarks
2041	107	
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.

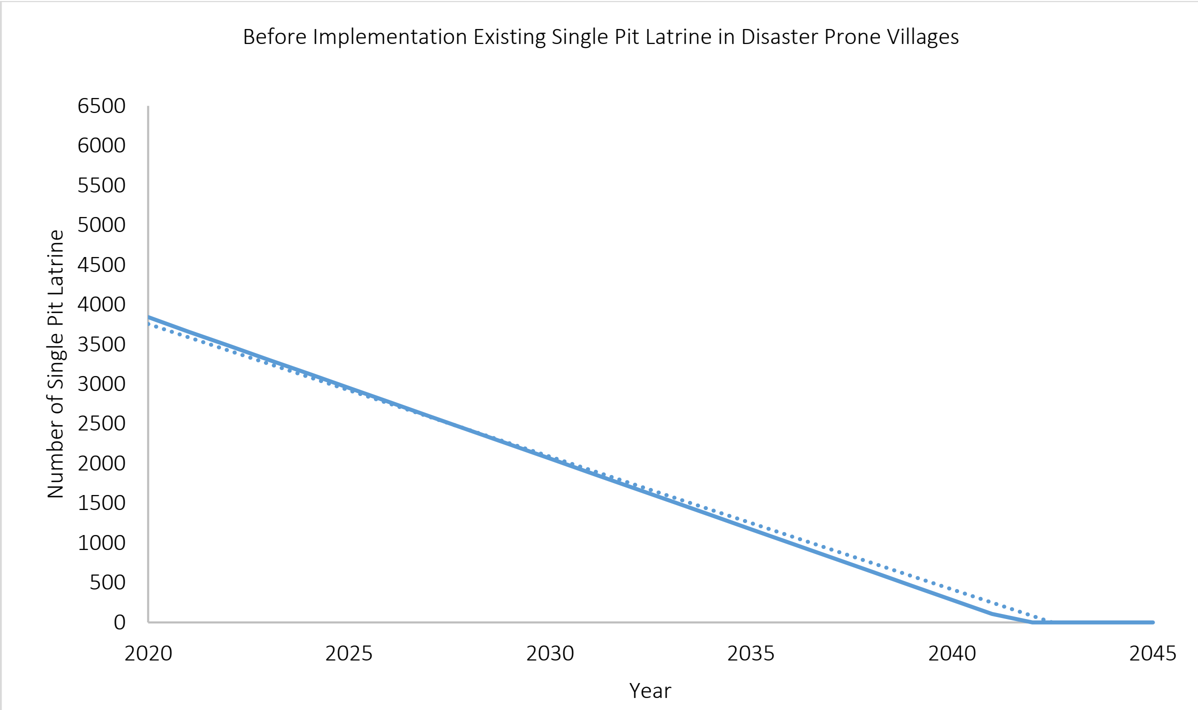


Figure: Before Implementation Existing Single Pit Latrine in Disaster Prone Villages

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: 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	3842	1752	1752	Estimated based on population grows and awareness of better sanitation condition
2021	3659	1775	1775	
2022	3485	1798	1798	DPHE data

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2023	3305	1821	1821	Business as usual Projection
2024	3129	1844	1844	
2025	2950	1867	1867	
2026	2773	2456	1890	Forecasted through end of the project with increase in 30% twin pit latrine.
2027	2595	2486	1913	
2028	2417	2516	1935	
2029	2239	2546	1958	
2030	2062	2576	1981	
2031	1884	2605	2004	
2032	1706	2635	2027	
2033	1529	2665	2050	
2034	1351	2695	2073	
2035	1173	2724	2096	
2036	995	2754	2119	
2037	818	2784	2142	
2038	640	2814	2164	
2039	462	2844	2187	
2040	284	2873	2210	
2041	107	2903	2233	
2042	0	2933	2256	
2043	0	2963	2279	
2044	0	2992	2302	
2045	0	3022	2325	

After implementation of the project, it is estimated that the investment in construction new twin pit latrine varies between 1752 number in 2022 to 2325 over the period. The trend is presented in the following Chart:

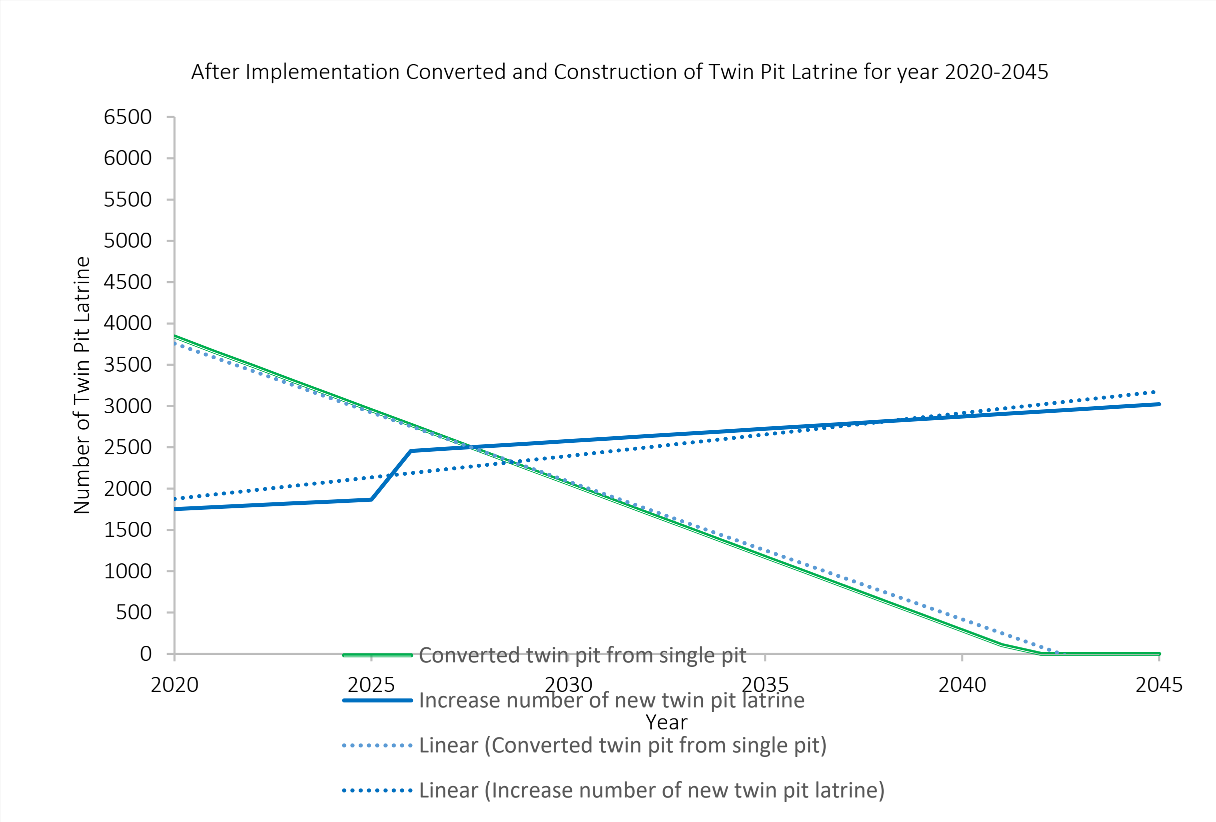


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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[26].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[27] 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 2020-21 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.

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

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

Table: Sanitation Demand before project

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village	Year 2021	Year 2020
						Year 2022		
Gaibandha	Fulchari	377	4.2	1583.4	155	155	163	171

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	171	Estimated based on awarness of better future sanitation situation
2021	163	
2022	155	DPHE data on convesion of single pit latrine.
2023	147	Business as usual Projection
2024	139	
2025	131	
2026	123	
2027	115	
2028	108	
2029	100	
2030	92	
2031	84	
2032	76	
2033	68	
2034	60	
2035	52	
2036	44	
2037	36	
2038	28	
2039	21	
2040	13	
2041	5	
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.

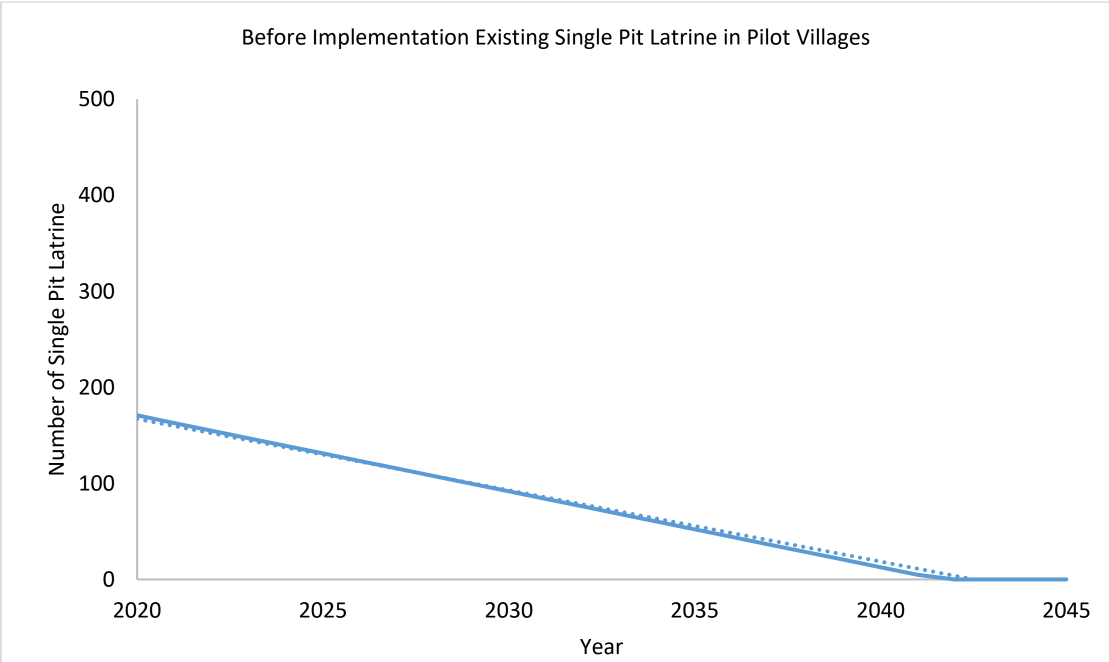


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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	171	93	93	Estimated based on population grows and awarness of better sanitation condition
2021	163	94	94	
2022	155	95	95	DPHE data
2023	147	96	96	Business as usual Projection
2024	139	97	97	
2025	131	99	99	
2026	123	130	100	Forecasted through end of the project with increase in 30% twin pit latrine.
2027	115	131	101	
2028	108	133	102	
2029	100	135	103	

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2030	92	136	105	
2031	84	138	106	
2032	76	139	107	
2033	68	141	108	
2034	60	142	110	
2035	52	144	111	
2036	44	146	112	
2037	36	147	113	
2038	28	149	114	
2039	21	150	116	
2040	13	152	117	
2041	5	153	118	
2042	0	155	119	
2043	0	157	120	
2044	0	158	122	
2045	0	160	123	

After implementation of the project, it is estimated that the investment in construction new twine pit latrine varies between 93 number in 2020 to 160 over the period. The trend is presented in the following Chart:

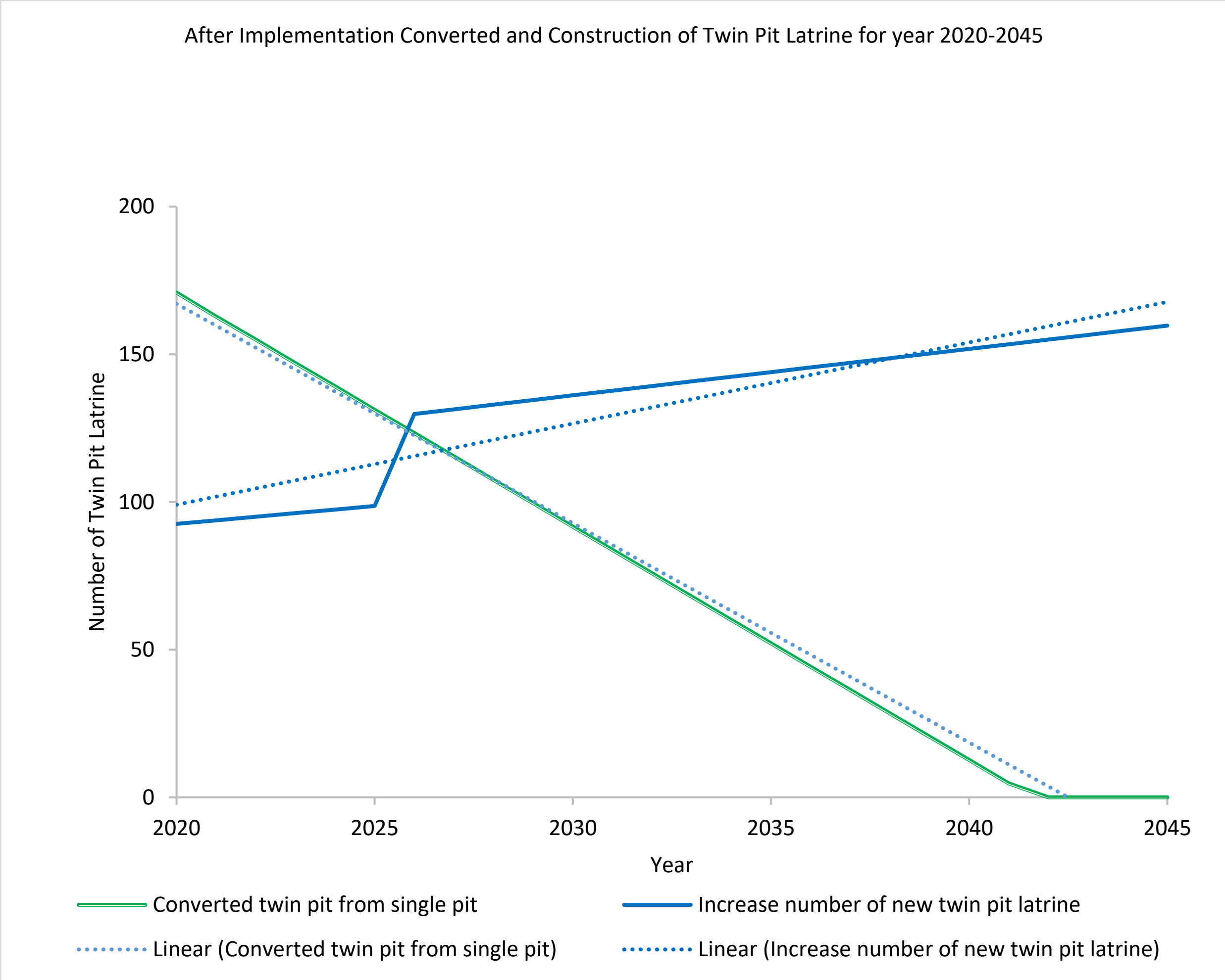


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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[28].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[29] 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 2020-21 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

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

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

type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village	Year 2021	Year 2020
						Year 2022		
Barishal	Induria	728	4.7	3421.6	415	415	436	458

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	458	Estimated based on awarness of better future sanitation situation
2021	436	
2022	415	DPHE data on convesion of single pit latrine.
2023	394	Business as usual Projection
2024	373	
2025	351	
2026	330	
2027	309	
2028	288	
2029	267	
2030	246	
2031	224	
2032	203	
2033	182	
2034	161	
2035	140	
2036	119	
2037	97	
2038	76	
2039	55	
2040	34	
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.

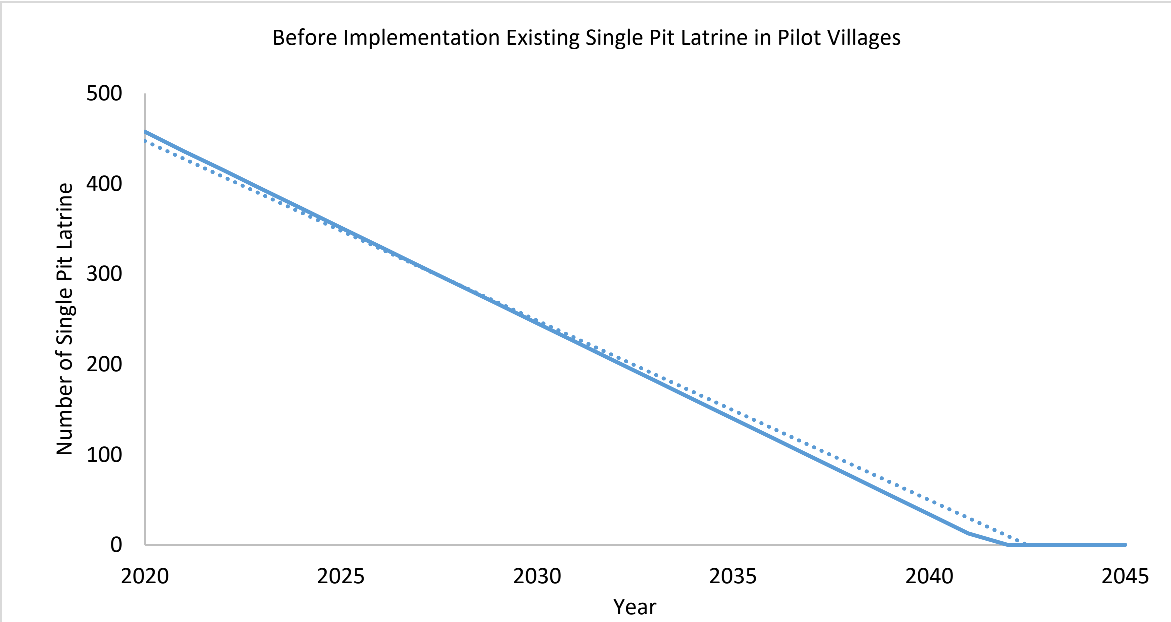


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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	458	224	224	Estimated based on population grows and awarness of better sanitation condition
2021	436	227	227	
2022	415	230	230	DPHE data
2023	394	233	233	Business as usual Projection
2024	373	236	236	

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2025	351	239	239	
2026	330	314	242	Forecasted through end of the project with increase in 30% twin pit latrine.
2027	309	318	245	
2028	288	322	248	
2029	267	326	251	
2030	246	329	253	
2031	224	333	256	
2032	203	337	259	
2033	182	341	262	
2034	161	345	265	
2035	140	349	268	
2036	119	352	271	
2037	97	356	274	
2038	76	360	277	
2039	55	364	280	
2040	34	368	283	
2041	13	371	286	
2042	0	375	289	
2043	0	379	292	
2044	0	383	294	
2045	0	387	297	

After implementation of the project, it is estimated that the investment in construction new twine pit latrine varies between 224 number in 2020 to 387 over the period. The trend is presented in the following Chart:

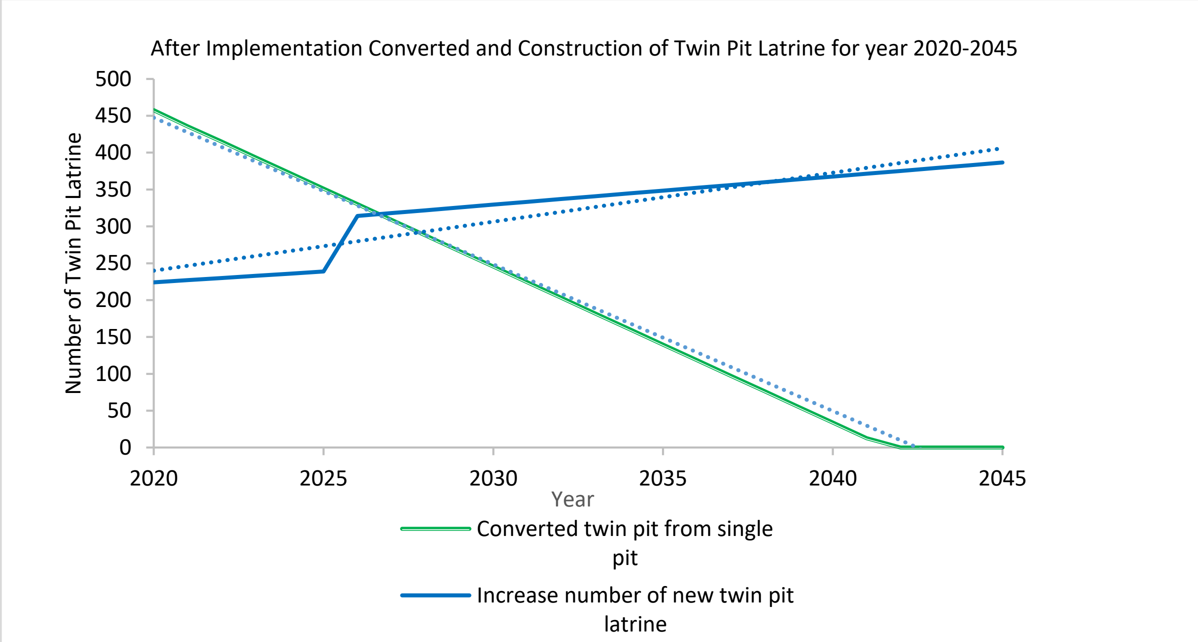


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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[30].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[31] 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 2020-21 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.

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

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

Table: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village	Year 2021	Year 2020
						Year 2022		
Khulna	Tipna	772	4.2	3242.4	300	300	315	331

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	331	Estimated based on awarness of better future sanitation situation
2021	315	
2022	300	DPHE data on convesion 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	

Year	Single Pit Latrine	Remarks
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.

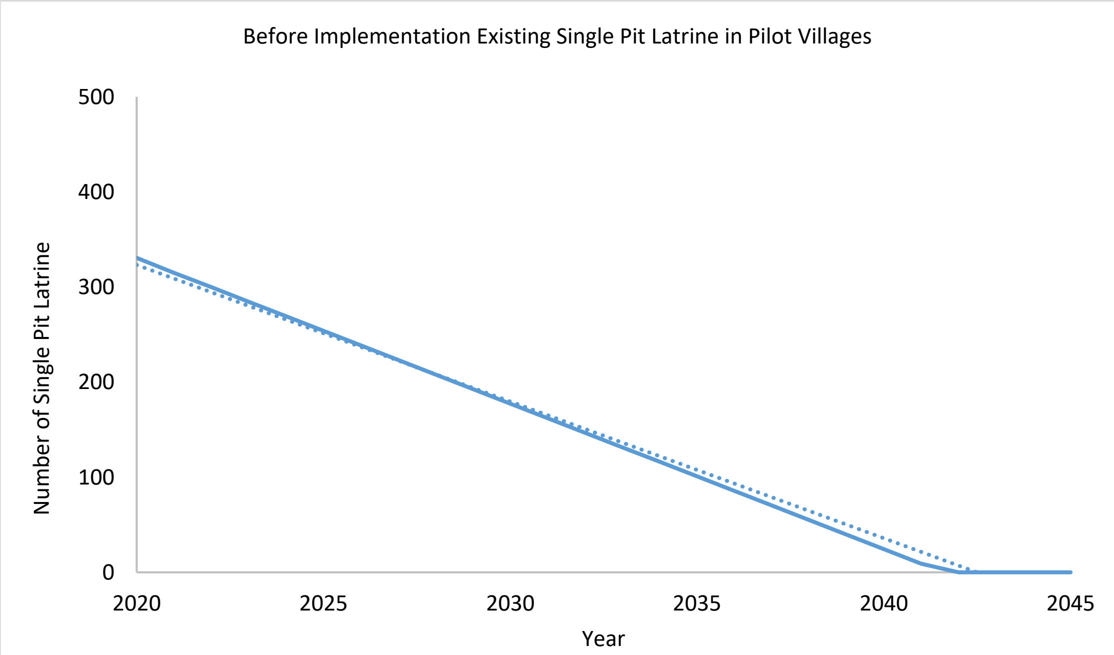


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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 awarness 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	

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2027	223	201	154	Forecasted through end of the project with increase in 30% twin pit latrine.
2028	208	203	156	
2029	193	205	158	
2030	177	208	160	
2031	162	210	162	
2032	147	213	163	
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 twine pit latrine varies between 141 number in 2020 to 244 over the period. The trend is presented in the following Chart:

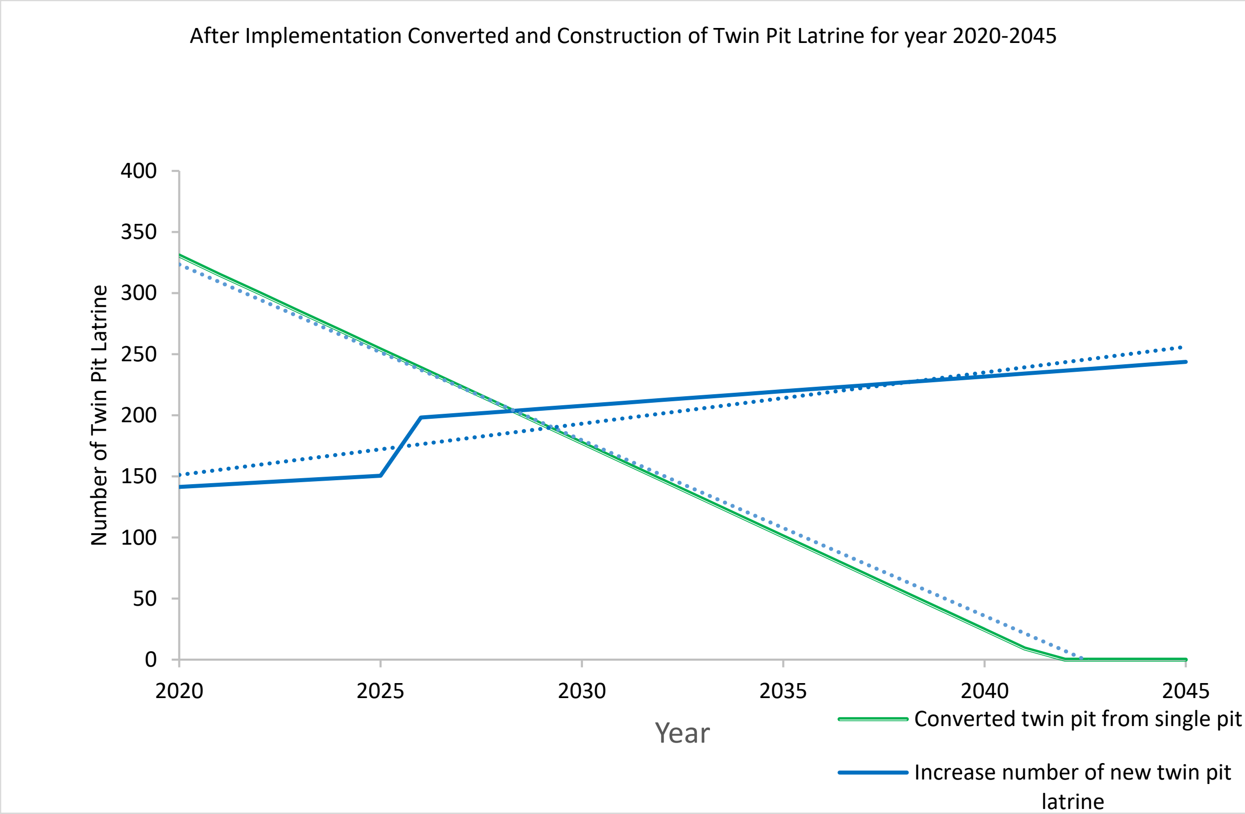


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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 .

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[32] 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 2020-21 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.

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

Table: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village		
						Year 2022	Year 2021	Year 2020
Kurigram	Pathordubi	2469	4.1	10122	1260	1260	1323	1389

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	1389	Estimated based on awarness of better future sanitation situation
2021	1323	
2022	1260	DPHE data on convesion of single pit latrine.
2023	1195	Business as usual Projection
2024	1131	
2025	1067	
2026	1003	
2027	938	
2028	874	
2029	810	
2030	745	
2031	681	
2032	617	
2033	553	
2034	488	
2035	424	
2036	360	
2037	296	
2038	231	
2039	167	
2040	103	
2041	39	
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.

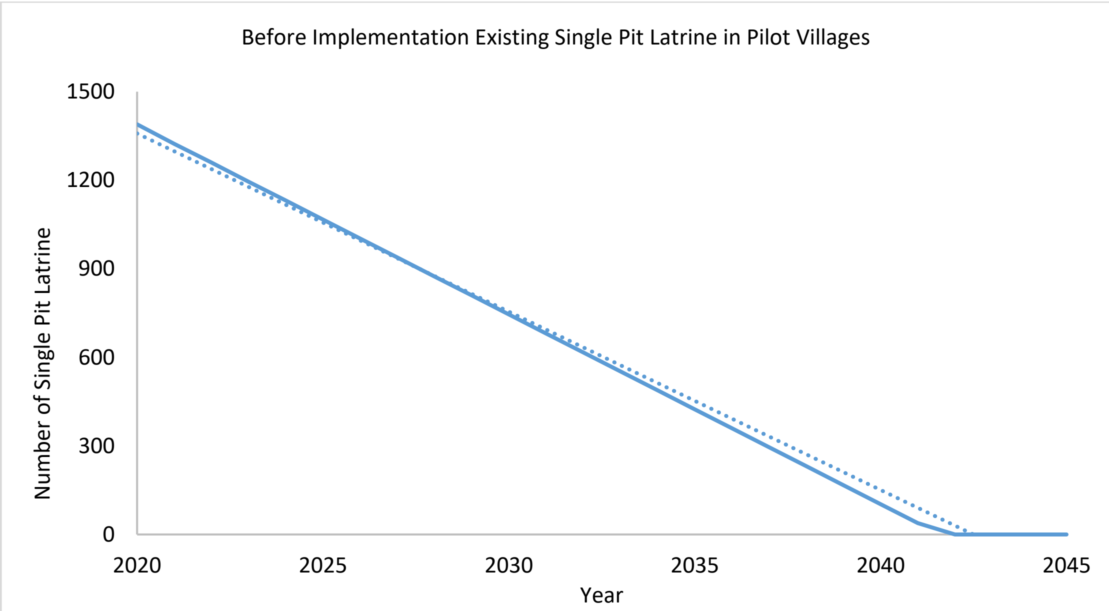


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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	1389	565	565	Estimated based on population grows and awareness of better sanitation condition
2021	1323	573	573	
2022	1260	580	580	DPHE data
2023	1195	587	587	Business as usual Projection
2024	1131	595	595	
2025	1067	602	602	
2026	1003	792	610	Forecasted through end of the project with increase in 30% twin pit latrine.
2027	938	802	617	
2028	874	812	624	
2029	810	821	632	
2030	745	831	639	
2031	681	840	646	

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2032	617	850	654	
2033	553	860	661	
2034	488	869	669	
2035	424	879	676	
2036	360	888	683	
2037	296	898	691	
2038	231	908	698	
2039	167	917	706	
2040	103	927	713	
2041	39	937	720	
2042	0	946	728	
2043	0	956	735	
2044	0	965	743	
2045	0	975	750	

After implementation of the project, it is estimated that the investment in construction new twine pit latrine varies between 565 number in 2020 to 975 over the period. The trend is presented in the following Chart:

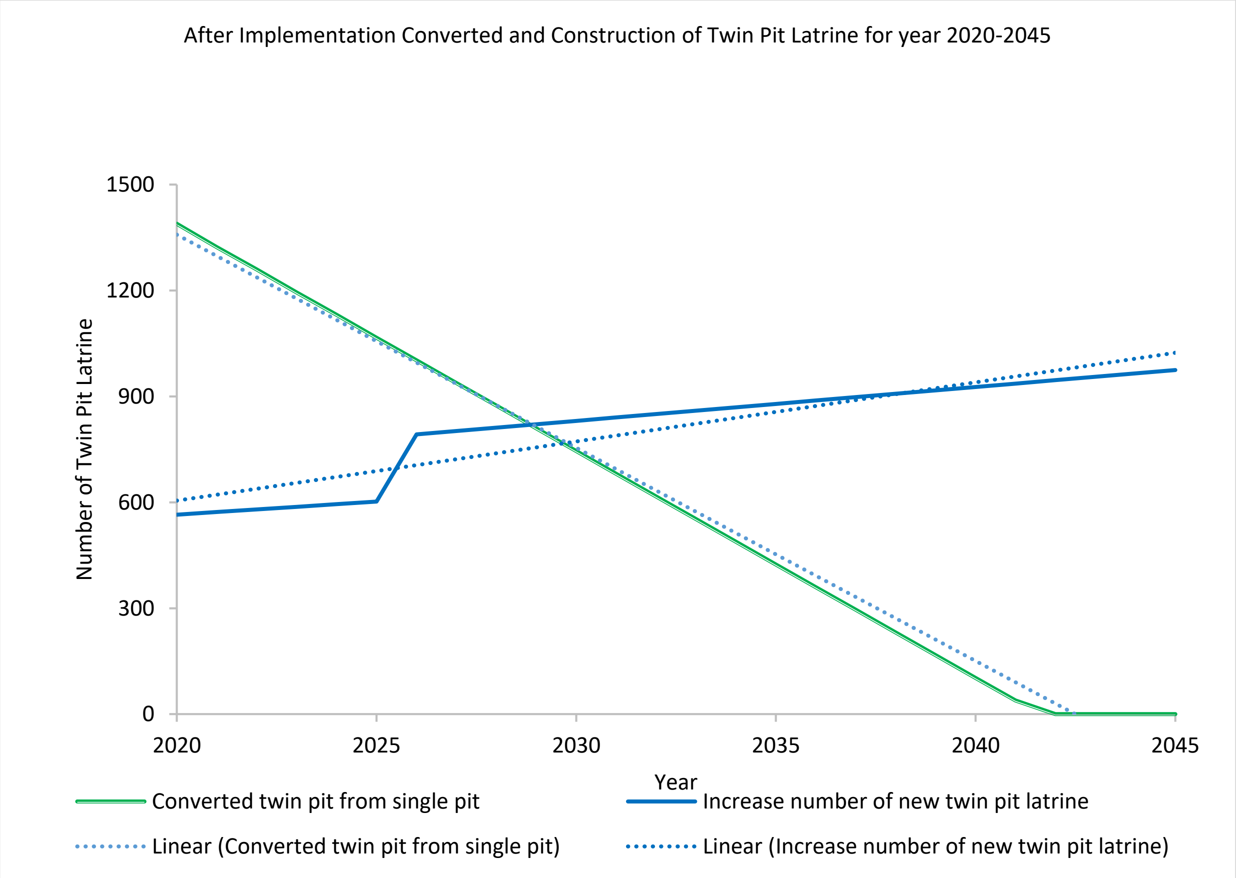


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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[33].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[34] 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 2020-21 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: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village		
						Year 2022	Year 2021	Year 2020
Satkhira	Datinakhali	568	4	2272	410	410	430.5	452.025

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	452	Estimated based on awarness of better future sanitation situation
2021	431	
2022	410	DPHE data on convesion of single pit latrine.
2023	389	Business as usual Projection
2024	368	
2025	347	

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

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

Year	Single Pit Latrine	Remarks
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	
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.

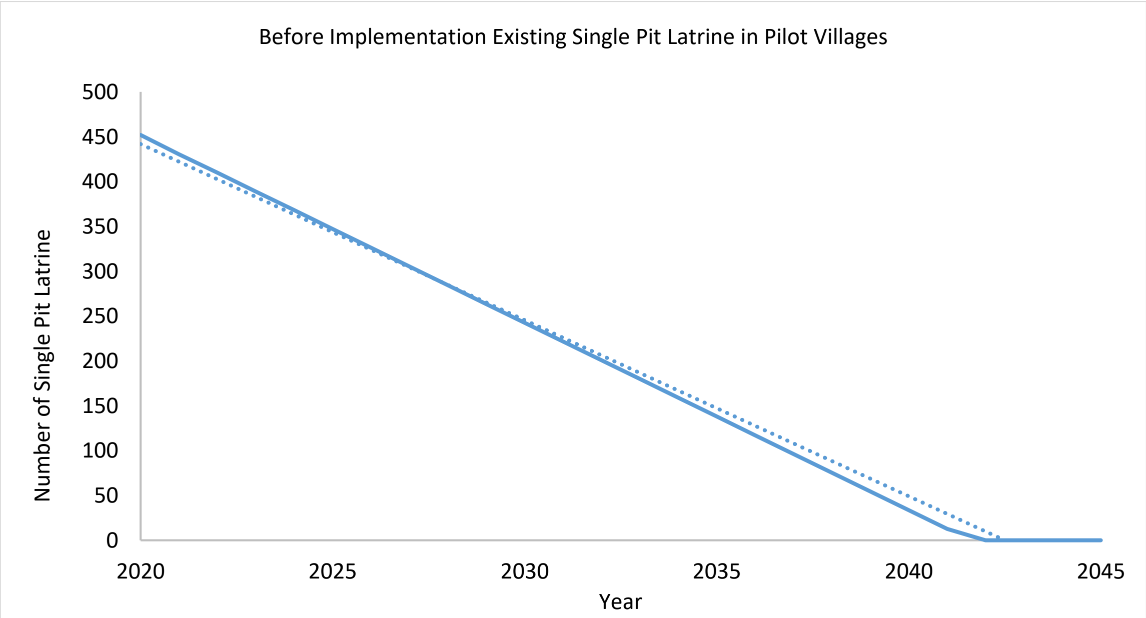


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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
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 twine pit latrine varies between 193 number in 2020 to 333 over the period. The trend is presented in the following Chart:

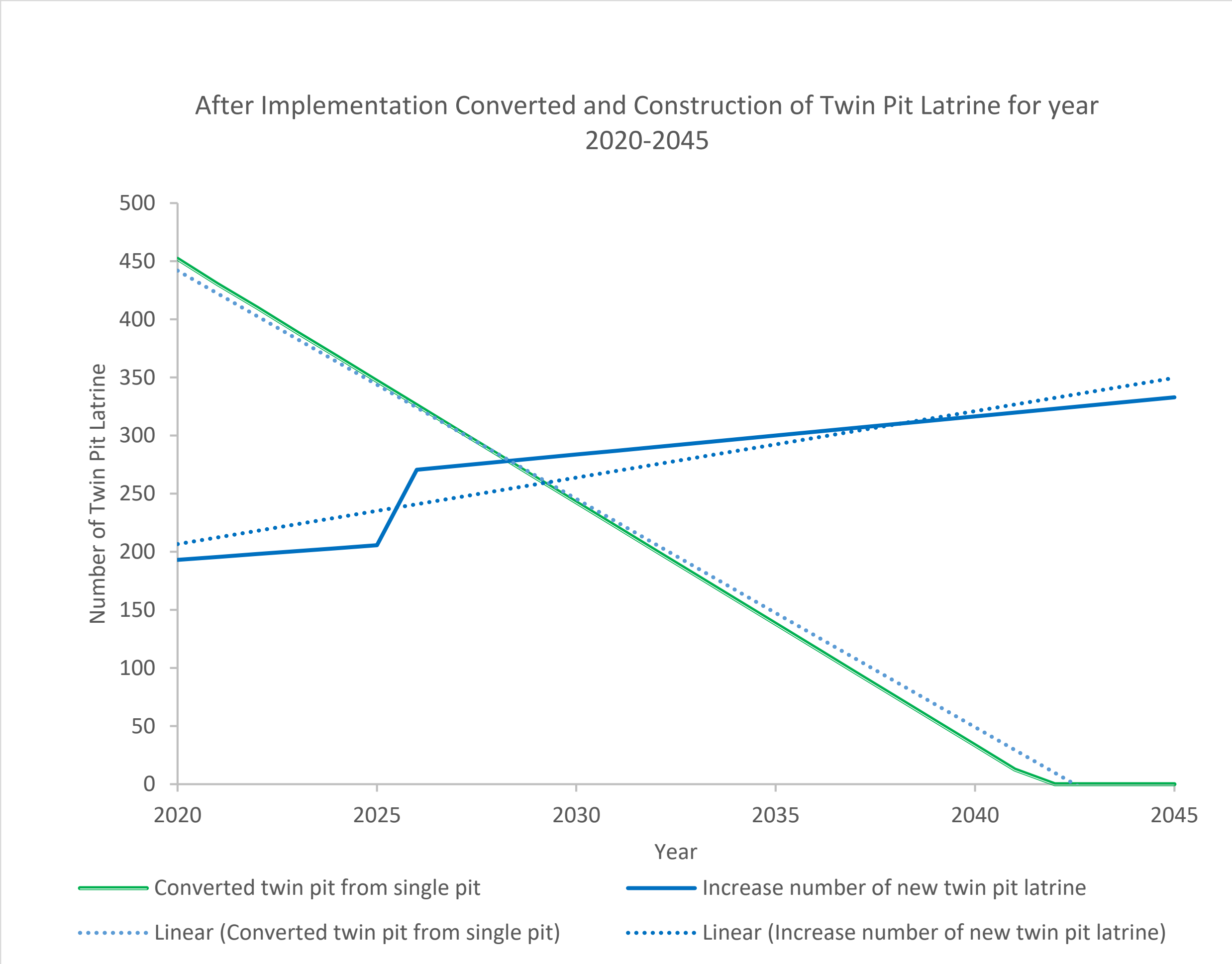


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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[35].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[36] 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 2020-21 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

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

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

type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village		
						Year 2022	Year 2021	Year 2020
Chattogram	Charsharat	941	4.9	4611	350	350	368	386

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	386	Estimated based on awarness of better future sanitation situation
2021	368	
2022	350	DPHE data on convesion of single pit latrine.
2023	332	Business as usual Projection
2024	314	
2025	296	
2026	278	
2027	261	
2028	243	
2029	225	
2030	207	
2031	189	
2032	171	
2033	154	
2034	136	
2035	118	
2036	100	
2037	82	
2038	64	
2039	46	
2040	29	
2041	11	
2042	0	

Year	Single Pit Latrine	Remarks
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.

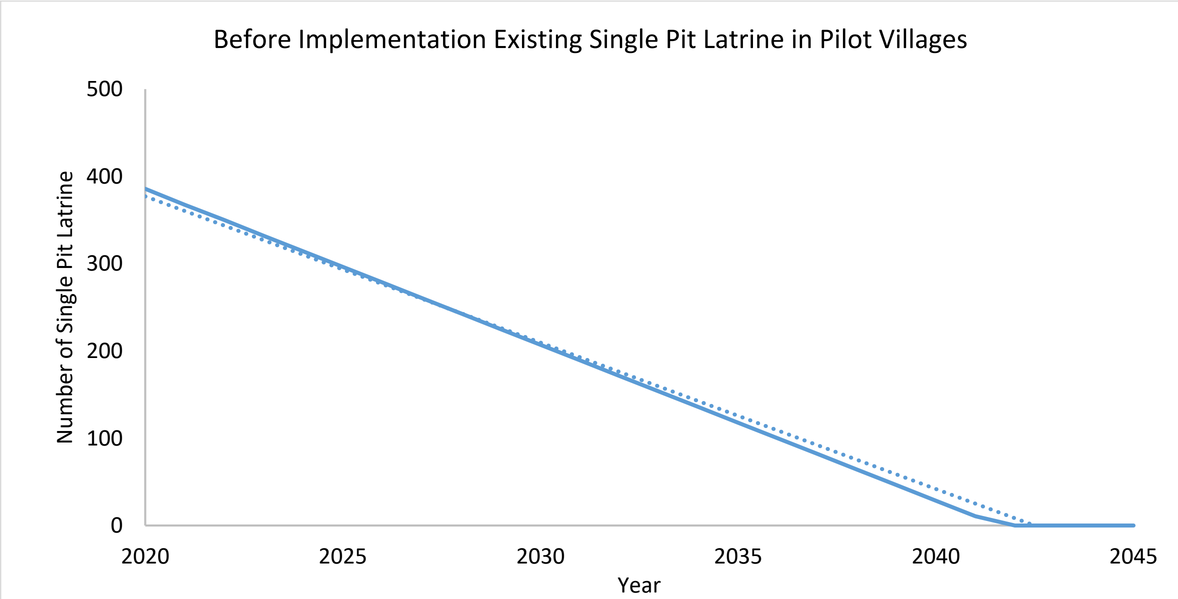


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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	386	190	190	Estimated based on population grows and awarness of better sanitation condition
2021	368	192	192	
2022	350	195	195	DPHE data
2023	332	197	197	Business as usual Projection
2024	314	200	200	
2025	296	202	202	
2026	278	266	205	
2027	261	270	207	

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine	Assumptions
2028	243	273	210	Forecasted through end of the project with increase in 30% twin pit latrine.
2029	225	276	212	
2030	207	279	215	
2031	189	283	217	
2032	171	286	220	
2033	154	289	222	
2034	136	292	225	
2035	118	295	227	
2036	100	299	230	
2037	82	302	232	
2038	64	305	235	
2039	46	308	237	
2040	29	312	240	
2041	11	315	242	
2042	0	318	245	
2043	0	321	247	
2044	0	325	250	
2045	0	328	252	

After implementation of the project, it is estimated that the investment in construction new twine pit latrine varies between 190number in 2020 to 328 over the period. The trend is presented in the following Chart:

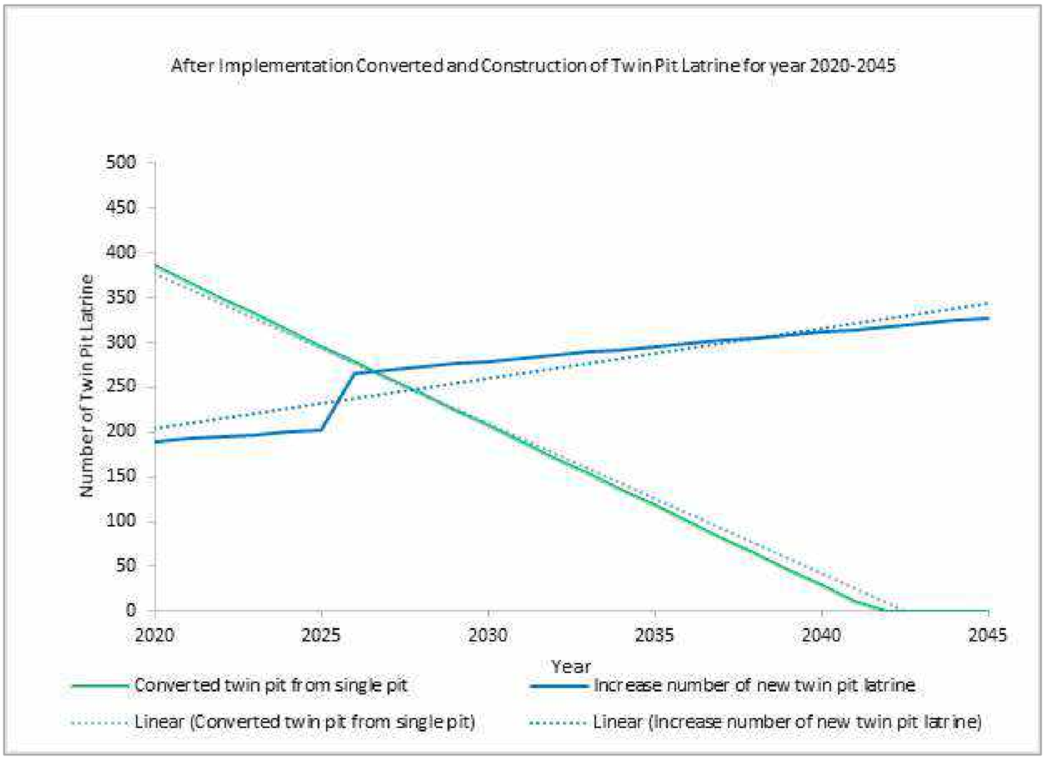


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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[37].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[38] 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 2020-21 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: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village		
						Year 2022	Year 2021	Year 2020
Sunamganj	Shimulbank	462	5.7	2633.4	195	195	204.75	214.9875

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection.

Year	Single Pit Latrine	Remarks
2020	215	Estimated based on awarness of better future sanitation situation
2021	205	
2022	195	DPHE data on convesion of single pit latrine.
2023	185	Business as usual Projection
2024	175	
2025	165	
2026	155	
2027	145	

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

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

Year	Single Pit Latrine	Remarks
2028	135	
2029	125	
2030	115	
2031	105	
2032	95	
2033	86	
2034	76	
2035	66	
2036	56	
2037	46	
2038	36	
2039	26	
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.

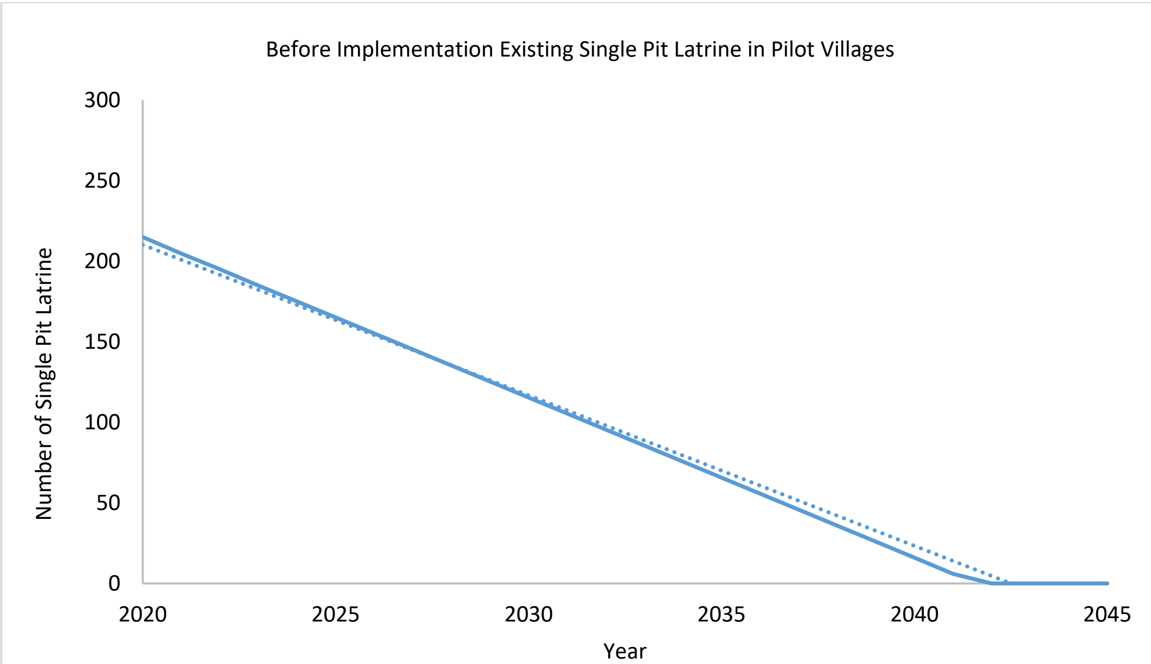


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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
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 twine pit latrine varies between 102 number in 2020 to 176 over the period. The trend is presented in the following Chart:

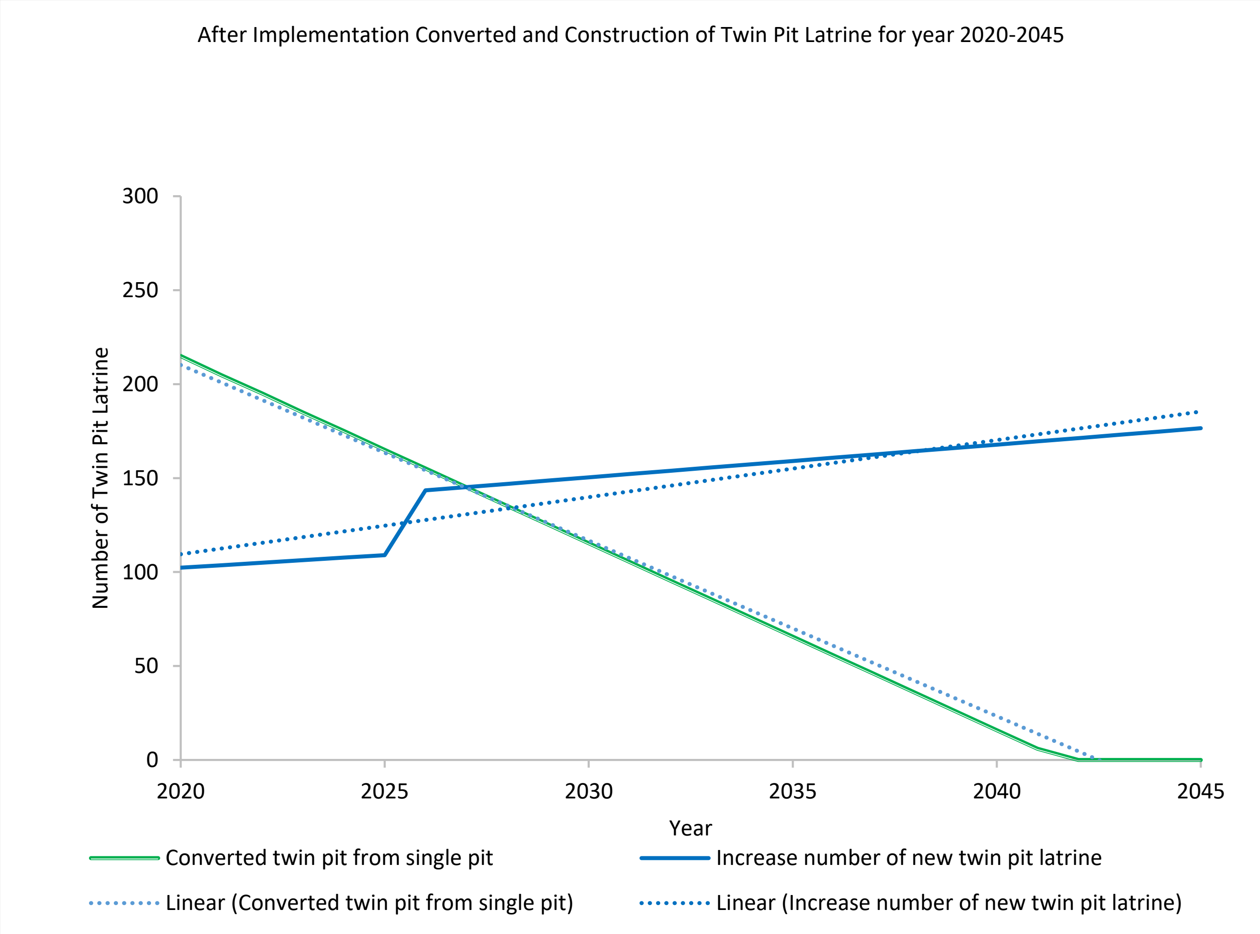


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.

Current demand

Current demand analysis for investment covers conversion 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[39].

For demand projection, previous two years (2021 and 2020) data have been estimated and are related with the population growth[40] 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 2020-21 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

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

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

type and number in the pilot villages and adjacent areas have been calculated. Details are given in the following Table.

Table: Current Sanitation by Pilot Village and Adjacent Area

District	Village	Number of household (hh)	hh size (4.2)	Number of Persons	Single Pit Latrine	Single Pit Latrine by Village		
						Year 2022	Year 2021	Year 2020
Sylhet	Bagaiya	921	5.9	5433.9	400	400	420	441

Source: BBS, Statistical PocketbookHousehold size 4.2 (2018)

Note: Average water demand is estiimated 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: Before Project Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine	Remarks
2020	441	Estimated based on awarness of better future sanitation situation
2021	420	
2022	400	DPHE data on convesion of single pit latrine.
2023	379	Business as usual Projection
2024	359	
2025	339	
2026	318	
2027	298	
2028	277	
2029	257	
2030	237	
2031	216	
2032	196	
2033	175	
2034	155	
2035	135	
2036	114	
2037	94	
2038	73	
2039	53	
2040	33	
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.

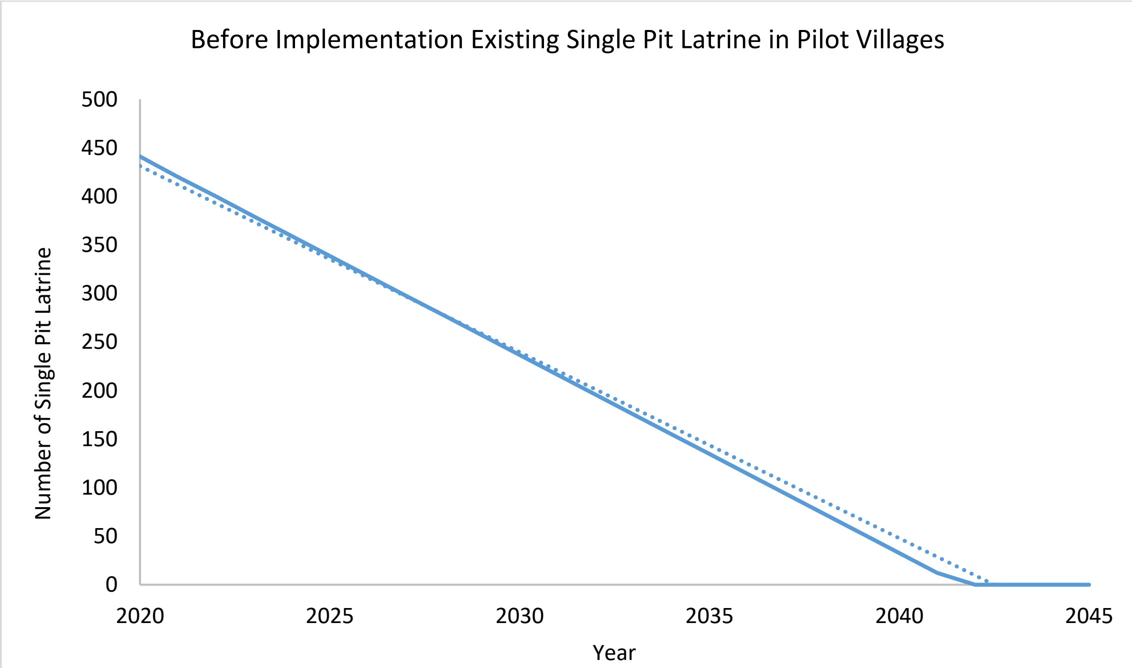


Figure: Before Implementation Existing Single Pit Latrine in Pilot Villages

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: 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	441	244	244
2021	420	247	247
2022	400	250	250
2023	379	253	253
2024	359	256	256
2025	339	260	260
2026	318	342	263
2027	298	346	266
2028	277	350	269
2029	257	354	272
2030	237	358	275
2031	216	362	279

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine
2032	196	366	282
2033	175	371	285
2034	155	375	288
2035	135	379	291
2036	114	383	295
2037	94	387	298
2038	73	391	301
2039	53	395	304
2040	33	400	307
2041	12	404	311
2042	0	408	314
2043	0	412	317
2044	0	416	320
2045	0	420	323

After implementation of the project, it is estimated that the investment in construction new twine pit latrine varies between 244 number in 2020 to 420 over the period. The trend is presented in the following Chart:

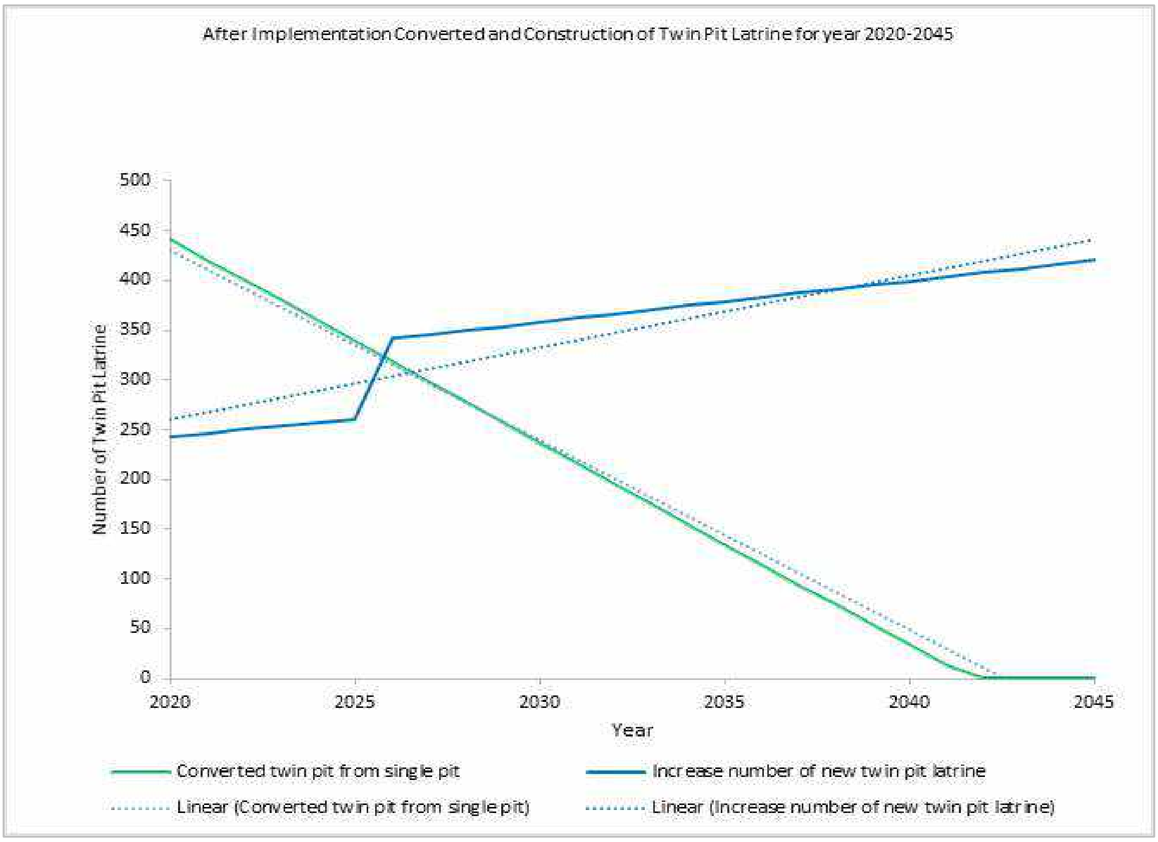


Figure: After Implementation Converted and Construction of Twin Pit Latrine for year 2020-2045

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 in the project.