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

'My Village-MY Town' Technical Assistance Project

Study - 4

Feasibility Study on Water Supply Option in Hill Districts

under

Feasibility and Review Study on Rural Water and Sanitation

December 2022

CEGIS
Center for Environmental and Geographic Information Services

Study-04

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Abbreviations and Acronyms

AIRP	Arsenic Iron Removal Plant
As	Arsenic
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BGS	British Geological Survey
BSTI	Bangladesh Standard Testing Institute
BTM	Bangladesh Transverse Mercator
BUET	Bangladesh University of Engineering and Technology
CBOs	community-based organizations
CF	Conversion Factor
CHELSA	Climatologies at high resolution for the earth's land surface areas
CHF	Conventional Households Filter
CMIP	Coupled Model Inter-comparison Project
DO	Dissolved Oxygen
DOE	Department of the Environment
DPHE	Department of Public Health and Engineering
EBCR	Economic Benefit Cost Ratio
EC	Electric Conductivity
ECR	Environment Conservation Rules
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
FBCR	Financial Benefit Cost Ratio
Fe	Iron
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GCM	Global Circulation Models
GOB	Government Of Bangladesh
GW	Ground Water
HH	Household Head
HRU	Hydrological Response Units
HTW	Hand Tubewells
IRU	Iron Removal Unit
LGED	Local Government Engineering Department
LTAR	Long Term Septage Acceptance Rate
NGOs	non-governmental organizations
PET	Potential Evapotranspiration
PP2041	Perspective Plan 2041

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

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 the 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 on Rural Water and Sanitation was designated as "Study-4," which covers one village of hill area.

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. Social structure of the village is captured from the primary survey. It is found that the village includes 215 households consisting of 1081 population, of which 554 (51.2 %) are males and 527 (48.8%) are females. The average sex ratio is 105.0, which refers to 105 males per 100 females. The average HH size of this village is 5.03 which is higher than the national average of 4.2. The average income of the people was 10,000 BDT.

From the survey data, it has been found that the major water supply sources are ring well (40.46%), tubewell, springs, surface water (river/pond), and pipe supply from riverbed/river bank hand-dug well.

Water quality from collected samples indicates that the water condition is good but not sufficient to drink without further treatment. Unfortunately, individuals are compelled to drink surface water because other sources of water are unavailable and the treatment process is difficult. Iron, turbidity, odor and bad taste are the main reasons for the bad quality of water.

According to survey data, sanitation condition is not at the satisfactory condition. In the Chotoharina village, 15.81% of people is out of toilet facility. Amongst the available toilet, 38.12% of toilets are in clean condition; whereas 43.65% toilets are dirty but people can use them. In addition to these, 17.68% toilets are unusable because of dirty condition. Pit latrines are the most common toilet type. Vip latrines are also there but in a minimum range.

In the village Chotoharina, hygiene condition is not satisfactory at all. Half of the total population have a habit of washing their hand. 41.45% population wash their hand sometimes and 7.695 completely ignore hand washing. Different local NGOs, are involved in the public awareness activities conducted in the study area.

Hydro geologically, the area is complex and is characterized by a series of folded Tertiary formations. As per analysis, village Chotoharina lies in Zone-M which refers unfavorable for extensive ground water development.

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.

Hill districts people face difficulties collecting water as there is no surface water supply (canals), the aquifer is too deep to collect water or establish wells and the local tributaries contain contaminations which often cause diseases.The current demand for general water use per person-day has been assessed based on data from the village. 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. Ring well and rainwater harvesting plant are suggested for the village.

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 the village included in this study.

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.

1. Introduction

1.1 Background

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

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

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

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

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

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

Among 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

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

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

1.2 The setting of the study area

A total of 40 sample villages are selected from 15 different districts to conduct this study of water supply, sanitation, and hygiene. Out of 40 villages, 15 pilot villages were selected for the feasibility study as **(Figure 1.1)** pilot villages for the "My Village My Town" project. The villages were selected based on nine criteria. These are Arsenic contamination, Barind area, Coastal area, Cyclone-prone area, Beel/Char area, Haor, Hilly area, Flood-prone area, and Plain land. Figure 1.1 the selection criteria of the selected village respectively. The "Rural Water, Supply and Sanitation," a component of the "My Village My Town" project studied the villages through a full census. The project devide the 15 village into 8 catagories and 8 different study was conducted. Out of these 8 studies, hill area is the number 4 .Location of detail feasibility and census are illustrated in **Figure 1.2**.

Feasibility and review study on Rural Water and Sanitation
Under
The project "Technical Assistance Project for My Village-My Town"

Selection of Study Area

Study Area				Coastal										
				South-West	South-Central	South-East	Cyclone Prone	Barind	Beel/Char	Haor	Hill District	Plain Land	Flood Prone	As Contamination
Dictrict	**Upazila**	**Union**	**Village**											
Cumilla	Monoharganj	Bipulshar	**Shekchail ***											■
Khulna	Dumuria	Khurnia	**Tipna ***				■							■
			Gonali				■							■
Satkhira	Shyamnagar	Labsa	Jabakhali	■			■							■
			Kalbari	■			■							■
			Banbibitala	■			■							■
			Chunar	■			■							■
			Datinakhali *	■			■							■
Sunamganj	Dakkhin Sunamganj (Shantiganj)	Shimulbank	Lalukhali							■				■
			Shimulbank *							■				■
Naogaon	Niamatpur	Hazinagar	**Khordachompa ***					■				■		
			Patail					■				■		
Chattogram	Mirsarai	Ichakhali	**Charsharat ***			■								
Rajshahi	Bagmara	Sonadanga	**Sonadanga ***									■		
Gaibandha	Fulchari	Gazaria	Ziadanga									■	■	
		Fulchari	**Fulchari ***						■				■	
			Parul						■				■	
			Baje Fulchchari						■				■	
Barisal	Hijla	Memania	**Induria ***		■		■							
			Baduri		■		■							
Sylhet	Gowainghat	Rustimpur	**Bagaiya ***							■				
Rangamati	Borkol	Bhushonchora	Dakkhin Arebanya								■			
			Hugichcharapara								■			
			Chota Harina (mouza) *								■			
			Pittichara								■			
			Mirpara								■			
			Bhalukya Charypara								■			
Gopalganj	Muksodpur	Jolirpar	**Beelchanda ***									■		
			Baniarchar									■		
			Jolirpar									■		
Kurigram	Bhurungamari	Pathordubi	**Pathordubi ***									■	■	
			Maidam									■	■	
		Baladia	Sarkarpara									■	■	
			Uttar Baladia									■	■	
Narshingdi	Monohardi	Chalakchar	**Hafizpur ***									■		
			Chengain									■		
			Chalakchar									■		
Netrokona	Barhatta	Shahata	**Dakkhin Demura ***									■		
			Shahata									■		
			Kadam Deuli									■		
Total District = 15	**Total Upazila = 15**	**Total Union = 17**	**Total Village = 40**	**5**	**2**	**1**	**9**	**2**	**3**	**3**	**6**	**17**	**8**	**10**

* Selected pilot villages for My Village My Town Project

South-West	South-Central	South-East	Cyclone Prone	Barind	Beel/Char	Haor	Hill District	Plain Land	Flood Prone	As Contamination
Coastal										

Figure 1.1: Selection of study area

Description of Study Location in Hill Districts

In the Rural Water Supply and Sanitation component of the "My Village-My Town" project, ChotaHarina village is selected based on hill area criteria. This village is located in Bhushonchora Union of Borkol Upazila of Rangamati District. This village is one of the 15 pilot villages of the "My Village-My Town" project. According to BBS, the total area of the village is about 1830 hectares. The identical location of this village is Choto Harina Bazar which is located in the east of Karnafully River and geographical co-ordinate is 22°52'29.79"N and 92°23'36.52"E.

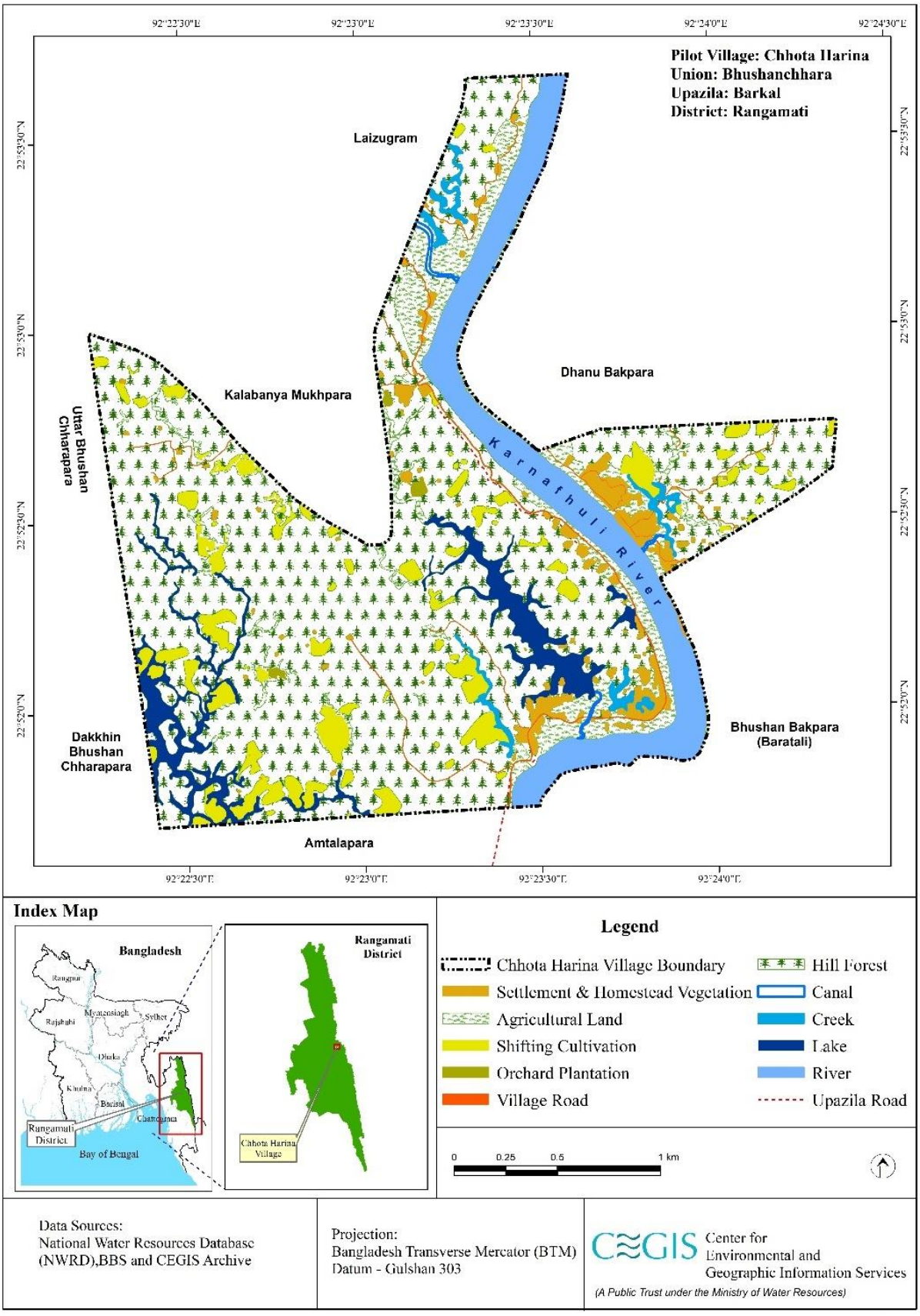

Figure 1.2: Choto Harina Village Location

1.3 The objectives of the Study

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

Study-04: Feasibility study for water supply options including surface water availability and sanitation in rural areas, hill districts, arsenic-contaminated areas, disaster-prone and other difficult areas. This will include:

- To assess the water supply and sanitation conditions of the selected villages of the country
- Calculate the water required to meet the demand as per the commitment and goal of the government and international agencies in the water and sanitation sector.
- Identify the suitable options to meet the demand overcoming water quality challenges and other geographical issues.
- Quantify the resource required to meet the 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 ground water sources.
- Develop a Small-scale piped water supply scheme technical Guideline for supporting existing DPHE intervention
- Recommend and suggest Implementation modalities to the water supply and sanitation improvement project

1.4 Overall approach

This 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 1.3**. The methodology in different subsequent sections has described in **Appendix I.**

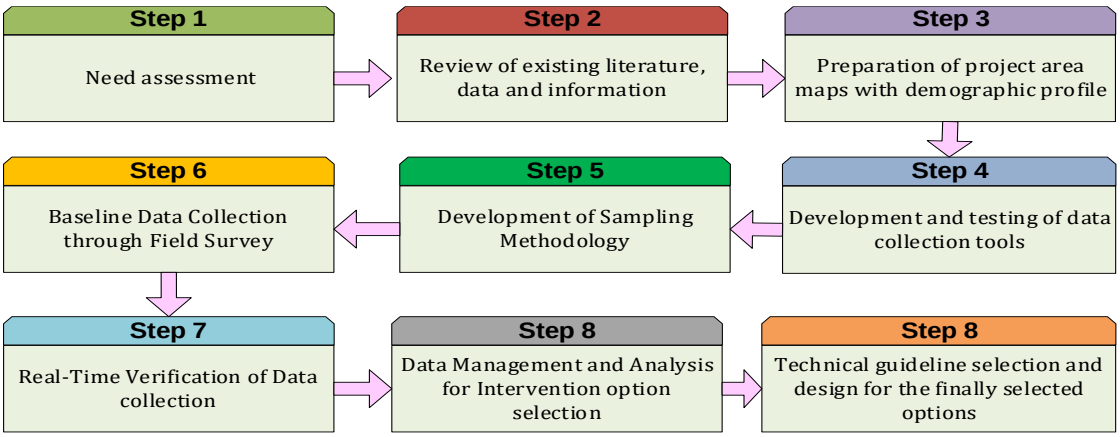

Figure 1.3: Flow diagram of the methodology for the study

2. Existing WASH Status

2.1 WASH Analysis of Hill Area

ChotoHarina village lacks a modernized communications network. For instance, water transport is the only means to get there because there is no direct road link from the district headquarter. Consequently, there is no electricity connection with national grid system. The only hope for power is solar power plant and generator as well. Besides, villages in hill district is mainly peopled by the mostly poor and unfortunate group with deficient accessibility to basic drinking water options and sanitation services. Major portion of the population are remaining illiterate. People have to suffer from scarcity of drinking water mainly in pre-monsoon period, thus they have to lead unhygienic life, which accelerates the degradation of sanitation condition also. Thus these situations have resulted in the current state of water supply, sanitation, and hygiene being in the below-average zone of the standard. Current situation is assessed by thoroughly household survey. After developing the questionnaire, a mobile tool named "KoboToolbox" was used to develop the digital version to analysis existing condition of WASH in the rural areas. The baseline is using 4 prepared survey questionnaires. These include household inquiries, water supply system, sanitation, awareness and cleanliness.

2.1.1 Water Supply

From the survey data, it has been found that the major water supply sources are ring well, tubewell, springs, surface water (river/pond), and pipe supply from riverbed/river bank hand-dug well. The water supply coverage has done the number of population per water source. Water supply coverage data has been presented in the following **Figure 2.1.**

It has been found that the water supply coverage from ring well, surface water (river/pond) and springs are the most used sources and their percentages by coverage are 40.47%, 16.74%, and 21.4% respectively. Even if, most of the sources like ring wells, springs, and tube wells are abundant in water at the monsoon, but reverse scenario appears in the dry and pre-monsoon season. During the pre-monsoon as well as late post monsoon period a large portion of the total population have to be dependent on untreated surface water from pond or Karnafully River. In addition to this, people used to collect water from riverbed/river bank hand-dug well by running solar power plant dependent small motor; whereas it supplies 5.58% of percent of the total supply. Although there are two springs where water is available throughout the whole year, but are not feasible to collect water for drinking or domestic purposes due to being remotest corner of the village.

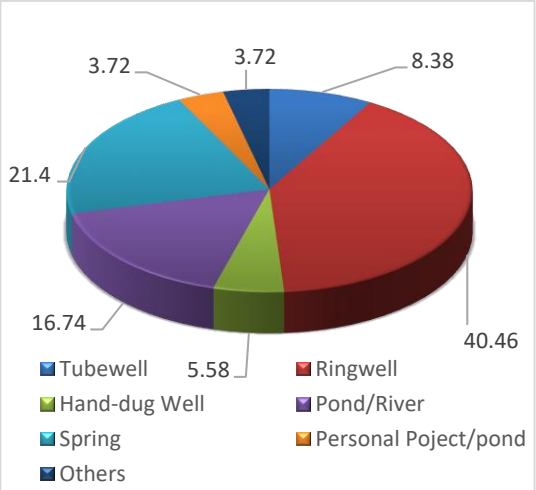

Figure 2.1: Percentages of Water Supply from Different Sources

Table 2.1: Percentages of Daily Consumption of Water

Daily Water User (L)	%
0-5 L	1.87
5-8 L	5.61
8-10 L	31.31
10-15 L	22.9
>15 L	38.32

From the survey data, it has been found that, 38.92% of house numbers consumes more than 15 liters daily followed by 8-10L (31.31%), 10-15L (22.9%) 5-8L (5.61%) and, 0-5L (1.87%).

There are different reasons responsible for seasonal water scarcity. For instance, drying up of water from rivers, canals, canals and other sources, insufficient rainfall, drop in the water level, tube well sinking in floods are responsible to create water crisis. In other words, main reason of the unavailability of water is the drying up of waterbodies which also accelerates drop in the water level in the considered village.

2.1.2 Quality of Drinking Water

Peoples of the village Chotoharina collect drinking water mainly from ring well, tubewell and spring as per water availability. But during the post monsoon season people used collect drinking water using pipe line from riverbed/river bank hand-dug well. During pre-monsoon and dry season, people become dependent on surface water from canals or Karnafully River. Water Quality from both hand dug well and river is presented in the **Table 2.2.**

Table 2.2: Summery of Existing Surface Water Quality

Surface Water Quality Parameters	Surface Water Quality Status		ECR'97 and Draft ECR'2017
	Karnafully River	Sample Hand dug Well	
Electric Conductivity (EC)	161	192.4	-
Total Dissolved Solid (TDS)	80.5	96.2	1000 µS/mg
Dissolved Oxygen (DO)	6.7	5.62	6
Salinity	0	0	0 ppt
pH	6.6	6.36	6.5-8.5
Iron	0.2561	0.2192	0.3-1
Arsenic	0	0	0.3-1

Water quality from collected samples indicates that the water condition is good but not sufficient to drink without further treatment. Unfortunately, individuals are compelled to drink surface water because other sources of water are unavailable and the treatment process is difficult. From the survey data, it is summarized that 53.8% of total source water is in good condition; whereas 22.79% of water is in acceptable condition as per local people opinion. But 23.26% of total source water is in at unsatisfactory condition. Iron, turbidity, odor and bad taste are the main reasons for the bad quality of water. Reasons behind being the bad quality of water is illustrated in the **Figure 2.2**.

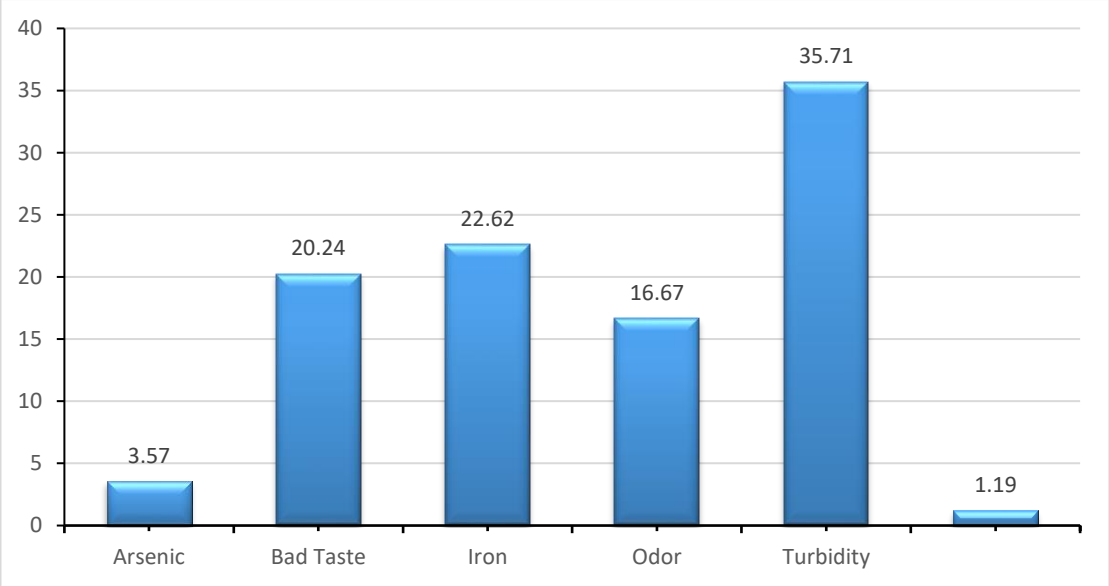

Figure 2.2: Percentages of the Causes of Poor Water Quality

2.1.3 Sanitation Condition

According to survey data, sanitation condition is not at the satisfactory condition. In the Chotoharina village, 15.81% of people is out of toilet facility. Amongst the available toilet, 38.12% of toilets are in clean condition; whereas 43.65% toilets are dirty but people can use them. In addition to these, 17.68% toilets are unusable because of dirty condition. There are also some number of abandoned toilets in there.

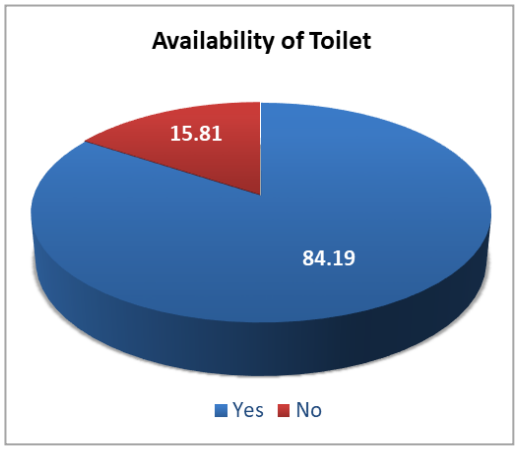

Figure 2.3: Percentage of People Using toilet

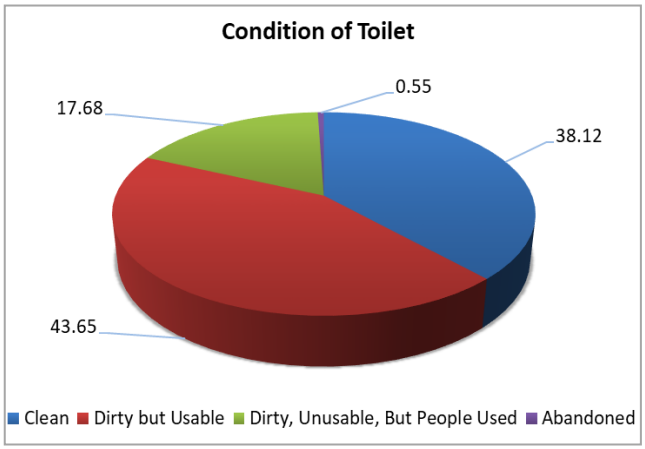

Figure 2.4: Physical Condion of Existing Toilet

Latrine types that are commonly seen in Chotoharina include flash latrine, open latrine, pit latrine, septic tank latrine, and VIP latrine. **Figure 2.5** shows the percentage of latrine's type in the considered village. 85.058% are keen at enhancing existing sanitation where both building of new latrine or improvement of existing latrine are included. In the village, people who have toilets, most of the toilets are in the house boundary. Again, some of the toilet is in outside of the house boundary but in their own place. Details of toilet locations are tabulated in the **Table 2.3.**

Table 2.3: Location of Toilet

Location of Toilet	%
Attached toilet	14.92
Toile in the outside of the house boundary, but other place	6.63
Toile in the outside of the house boundary, but own place	34.25
Toilet in the house boundary	44.2

Main improvements are demanded by local people to enhance the physical condition of existing toilets are:

- Floor/wall improvement
- Improvement flash tank,
- Improvement water supply,
- Improvement water tank,
- Pan improvement.

Community toilet practice is very poor in this selected village. There is only 1.4% of community toilets are ex

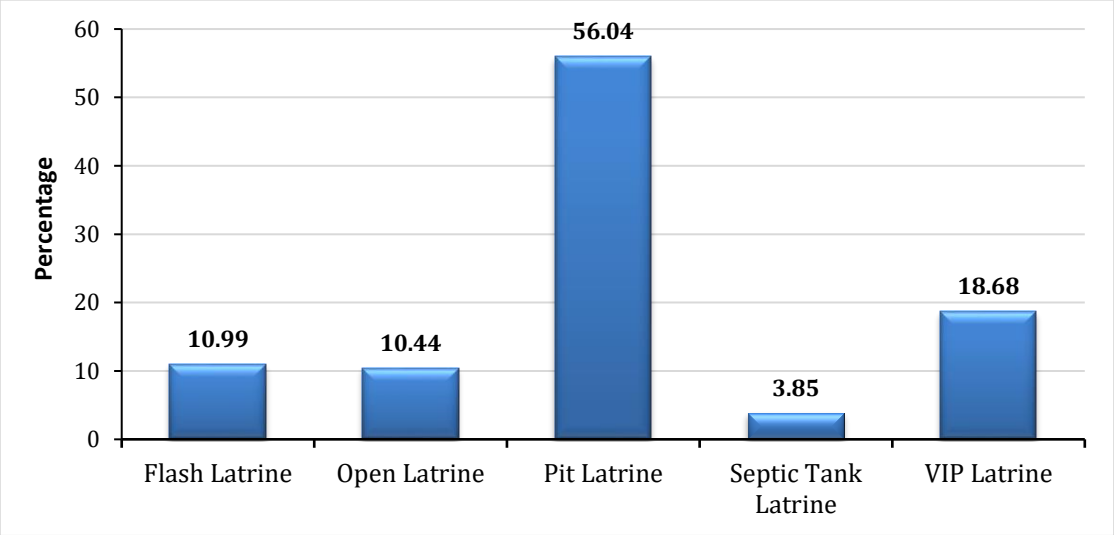

Figure 2.5: Types of Toilets by percentages

2.1.4 Hygiene Condition

In the village Chotoharina, hygiene condition is not satisfactory at all. Half of the total population have a habit of washing their hand. 41.45% population wash their hand sometimes and 7.695 completely ignore hand washing. 80.47% of people who wash their hand practice using soap while doing so. Summary of people who wash their hands after using the toilets by location is shown in **Table 2.4**. Besides, people have poor practice of washing their hands at other times e.g. after working outside, before cooking or eating, before feeding the children which is illustrated in **Figure 2.7.**

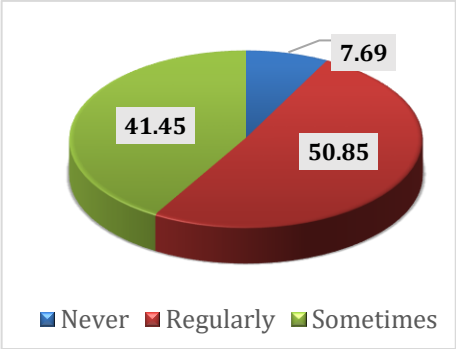

Figure 2.6: Percentage of Washing Hand

Table 2.4: Percentage of washing hands after using toilet

Location of Washing Hands after Using Toilet	Percentage
Anywhere else outside the toilet	71.62
In cubicle of toilet	17.12
Inside of room	1.35
No hand wash	0.45
Outside of toilet cubicle but inside of toilet block	9.46

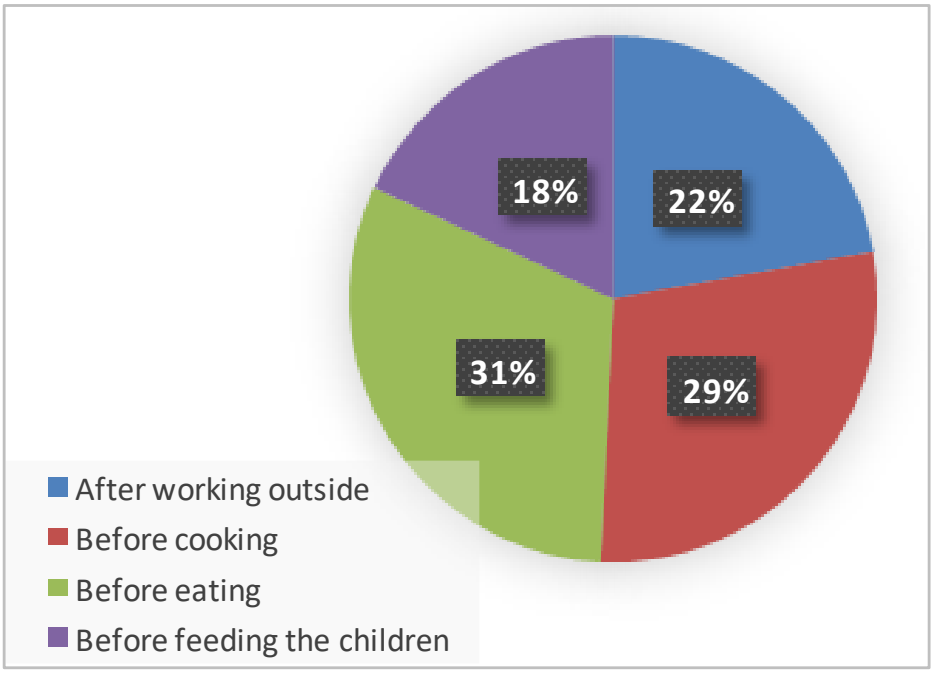

Figure 2.7: Percentage of Washing Hand at Other Time

2.1.5 Assessment of DPHE Intervention

Over the past year, DPHE has expanded its initiatives to provide clean water and sanitary conditions for people everywhere in the country. Moreover, they have developed numerous interventions even

in the most remote areas of the country, such as the upazilla Barkol in the district Rangamati. The existing DPHE water supply interventions in the village is tabulated in the following **Table 2.5.**

Table 2.5: Existing DPHE Intervention in the villages.

Technologies / Upazila	STW-6		STW-TDev		DTW-TDev		RW6		GFS		Total WP	Total Functional
	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional	#WP	Functional		
Barkal, Rangamati	1	1	14	12	9	8	52	50			76	71

Specifically, DPHE has taken initiatives in the village chotoharina. 40% of total drinking water demand is fulfilled by number of ring wells constructed by DPHE.

2.2 Socio-Economic Context and Community Perception

Bangladesh lies in the north-eastern 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 than 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

Social structure of the village is captured from the primary survey. It is found that the village includes 215 households consisting of 1081 population, of which 554 (51.2 %) are males and 527 (48.8%) are females. The average sex ratio is 105.0, which refers to 105 males per 100 females. The average HH size of this village is 5.03 which is higher than the national average of 4.2. Moreover, the age composition (**Table 2.6**) shows that the rate of the adult population for both males and females is the highest.

Table 2.6: Age Structure of Population in the Village

Adult (> 18 yrs)		Children Under 5 years		Children(5-18 years)	
Female(%)	Male(%)	Boy (%)	Girl (%)	Boy (%)	Girl (%)
30.6	31.5	5.2	4.8	14.5	13.3

Majority of the housing type is kutcha followed by Jhupri (11.63%), pucca (5.1%), and semi-pucca (3.3%). Most of the houses are owned by HHs (80%). In this study, the status of school-going children aged >5 years is also analyzed which revealed that the ratio of school-going boys is a little bit higher than the girls in Chotoharina. It is also observed that majority of the HH heads are married and most of them are monogamous. A few of 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 the **Table 2.7**.

Table 2.7: Marital status of the HH heads

Married (one wife)	Married (more than one wife)	Widow	Unmarried	Widower	Separated	Divorcee
89.3	6.1	2.3	1.4	0.5	0.5	

In the village, the majority of the HH heads are male (96.28%) and no third gender is shown. Among the total population of the village, 4.7% of people are physically disabled.

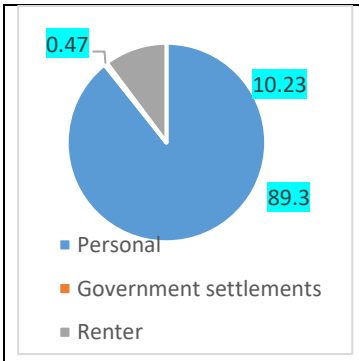

Figure 2.8: Percentage of Household type

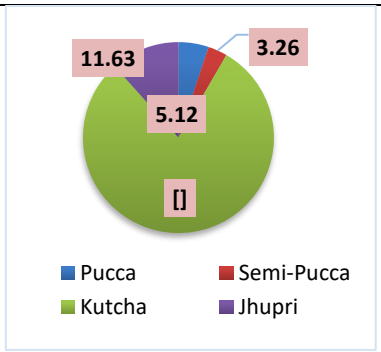

Figure 2.9: Percentage of Housing Condition

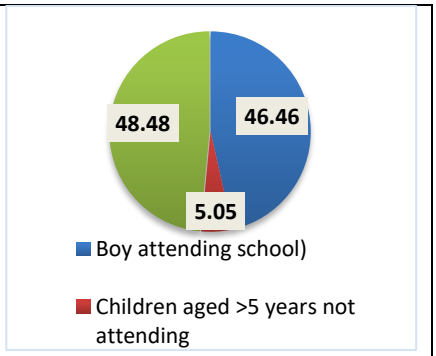

Figure 2.10: Percentage of Children's School Attendance

2.2.2 Beneficiary Community Desccription

The total household number is 215 in Chota Harina.. It is found that the village consisting of 1081 population,. The average HH size of this village is 5.03 which is higher than the national average of 4.2. Moreover, the age composition (**Table 2.8**) shows that the rate of the adult population for both males and females is the highest.

Table 2.8: Age Structure of Population in the Pilot Villages

Adult (> 18 yrs)		Children Under 5 years		Children(5-18 years)	
Female(%)	Male(%)	Boy (%)	Girl (%)	Boy (%)	Girl (%)
30.6	31.5	5.2	4.8	14.5	13.3

In this village, the status of school-going children aged >5 years is also analyzed which revealed that the ratio of school-going boys is a little bit higher than the girls in Chotoharina. It is also observed that majority of the HH heads are married and most of them are monogamous. A few of 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 the **Table2.9**.

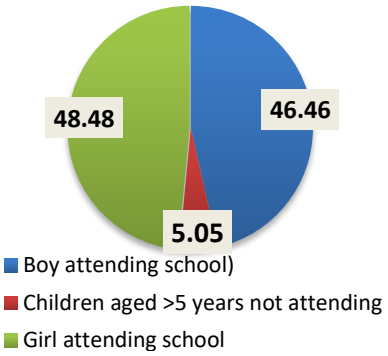

Figure 2.11: Percentage of attending school

Table 2.9: Marital status of the HH heads

Married (One wife)	Married (More than one wife)	Widow	Unmarried	Widower	Separated	Divorcee
89.3	6.1	2.3	1.4	0.5	0.5	

In the village, the majority of the HH heads are male (96.28%) and no third gender is shown. Among the total population of the village, 4.7 % of people are physically disabled.

2.2.3 Economic Activities

The average monthly income of the HHs in the pilot village Chotoharina is more than BDT 10,000. After analyzing the monthly income-expenditure data it is observed that the majority of the HHs are in the breakeven situation, as the average difference between the amount of income and expenditure is BDT3, 532. Main sources of income are agriculture and daily labor; their monthly income is low and they are forced to involve in secondary occupations to manage their livelihoods. But for those who are involved in government and private jobs, and business their income is higher than other occupational groups. Majority (more than 96%) of the HH head is employed. They are involved in different occupations to earn their livelihoods. Small scale business is the main occupation for the majority of them. Moreover, a remarkable number of HH heads is containing day laborship and agriculture as their main means of livelihoods. The following **Table 2.10** present the occupations of HH heads in the pilot villages.

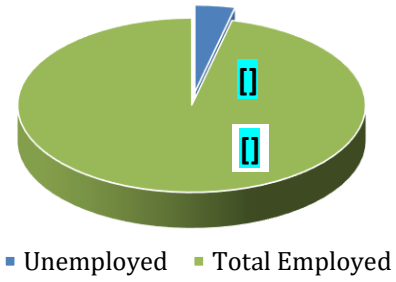

Figure 2.12: Percentage of Employment Status

Table 2.10: Main Occupation of the HH Head

Occupation Type	Percentage by HH
Government job (service)	0.93
Non-government job (service)	1.86
Business	36.74
Agricultural	16.28
Laborer	26.05

Occupation Type	Percentage by HH
Housewife	1.86
Rickshaw/auto rickshaw/van driving	0.93
Expatriates	0
Fisherman	4.19
Housemaid	0.47
Self-employed	6.05
Village Doctor	0
Others	0.93

On the the other hand, the HH heads' involvement in secondary occupations are found; significantly they are involved in agriculture followed by day laboring and business **(Table 2.11).**

Table 2.11: Secondary Occupation of the HH Head

Occupation Type	Percentage by HH
Non-government job (service)	2.8
Business	8.3
Agricultural	50.0
Laborer	27.8
Transport Driver	2.8

3. Water Resources Assesment in the Villages

3.1 Water availability analysis

Ground Water

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

Chota Harina (mouza), Rangamati

Seven years of data from 1993 to 2000 are considered for Chota Harina (mouza). Long term data of groundwater level is not found for this area. Also, the data contain some missing values. The data is analyzed and graphically represented in **Figure 3.1**. The figure shows an upward trend in the groundwater level. During this period the water level move upward by 1.08 m.

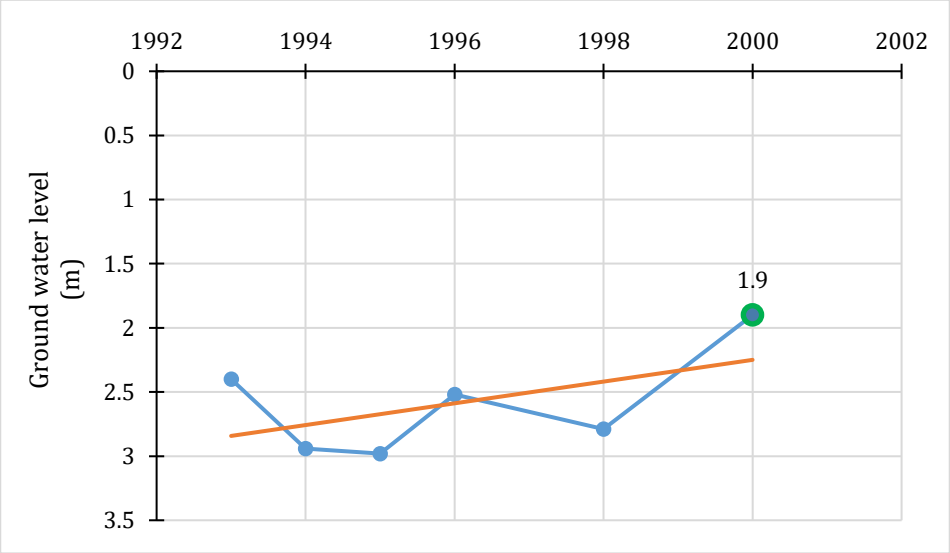

Figure 3.1: Annual groundwater trend (1993-2000) in Chota Harina (mouza)

Adequate surface water (pond, Canal) is not available in hill districts.

3.2 Hydrogeological Assessment

Based on the physiography, geology and suitability of the region for groundwater development Bangladesh was hydro geologically classified as i) Younger Alluvium, Complex Geology area, Older Alluvium area and Coastal Area (BGS, 1979). Hydro geologically, the area is complex and is characterized by a series of folded Tertiary formations. The groundwater survey has led to the identification of 15 zones for groundwater developments (UNDP, 1982). Each zone has been classified and rated as to its development potential in relation to the other zones (**Figure 3.2**). As per analysis, village Chotoharina lies in Zone-M which refers unfavorable for extensive ground water development. The aquifers have low transmissivities and intensive development would therefore incur large drawdown. This is substantiated by the existence of successful irrigation wells in tea plantation within the area. However, wells can be developed successfully on an individual basis.

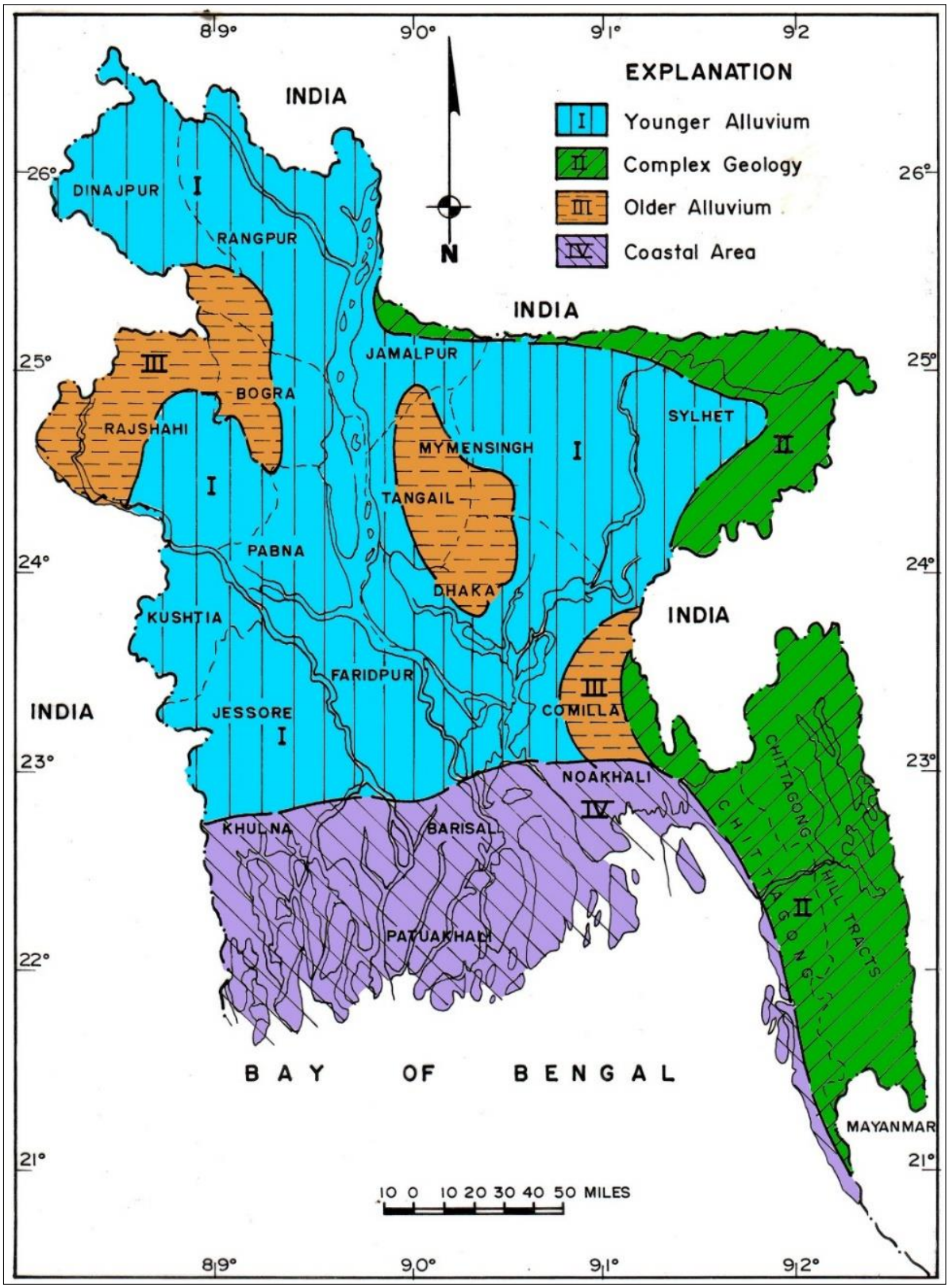

Figure 3.2: Hydrogeological Classification of Bangladesh (BGS 1979)

The basis of the classification involved:

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

Owing to the complex hydrogeology of the area, detailed investigations, including test drilling, will be required to evaluate each potential development site. Drilling test bore hole and construction of piezometer of maximum 50m is suggested. Tubewells of about 50m depth can be constructed to abstract water for the inhabitants of the villages. The area is almost free from the risk of high salinity in groundwater[1] (**Figure 3.3**) and risk of the occurrence of arsenic in shallow groundwater **(Figure 3.4).**

[1] Surface Maps Were Created Using Multi–Gaussian Kriging from The Time Series Data of Observed Groundwater Levels from The Bangladesh Water Development Board (Bwdb). (Source: Qureshi Et Al. 2014).

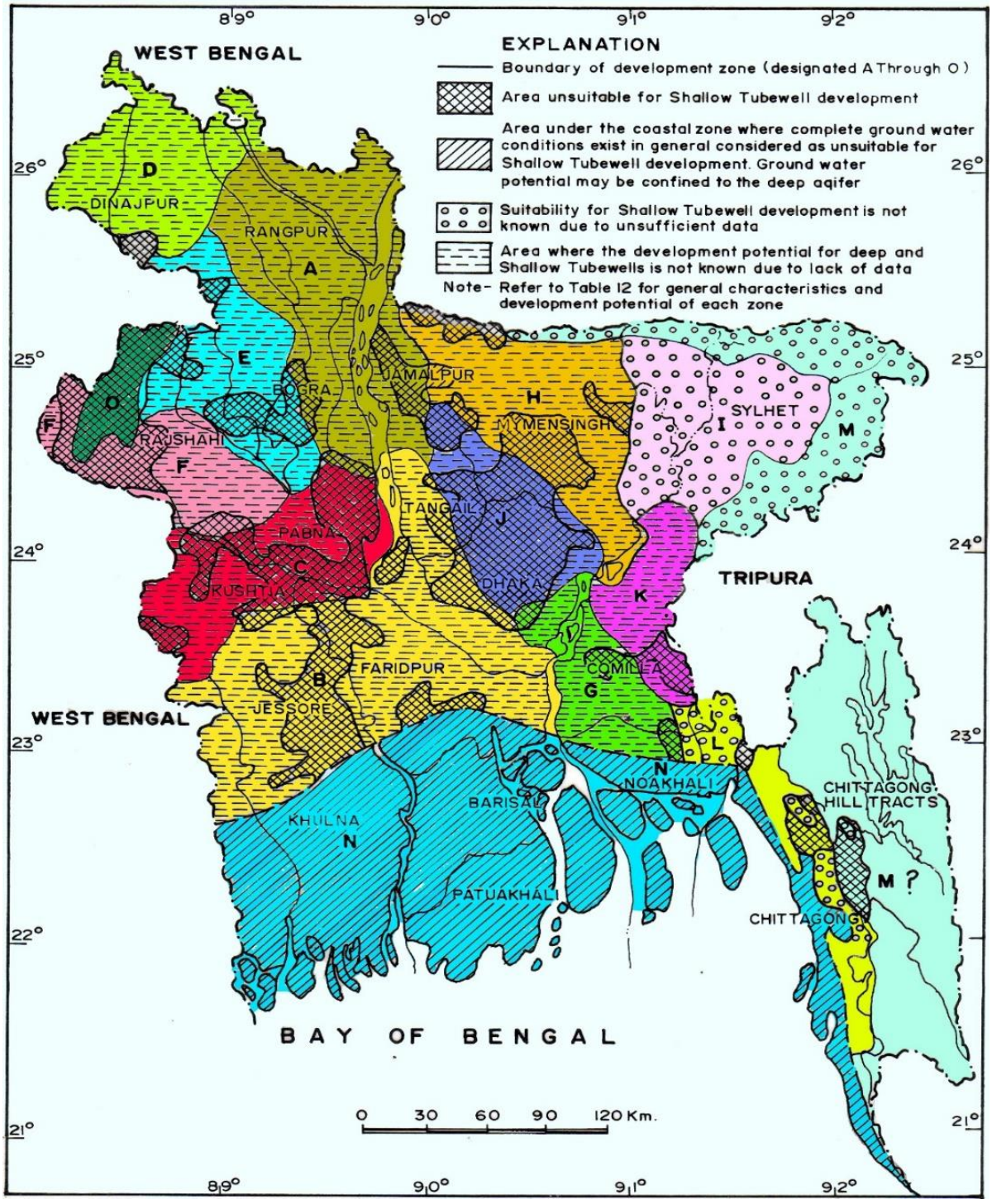

Figure 3.3: Major Groundwater Development Zone of Bangladesh (UNDP 1982)

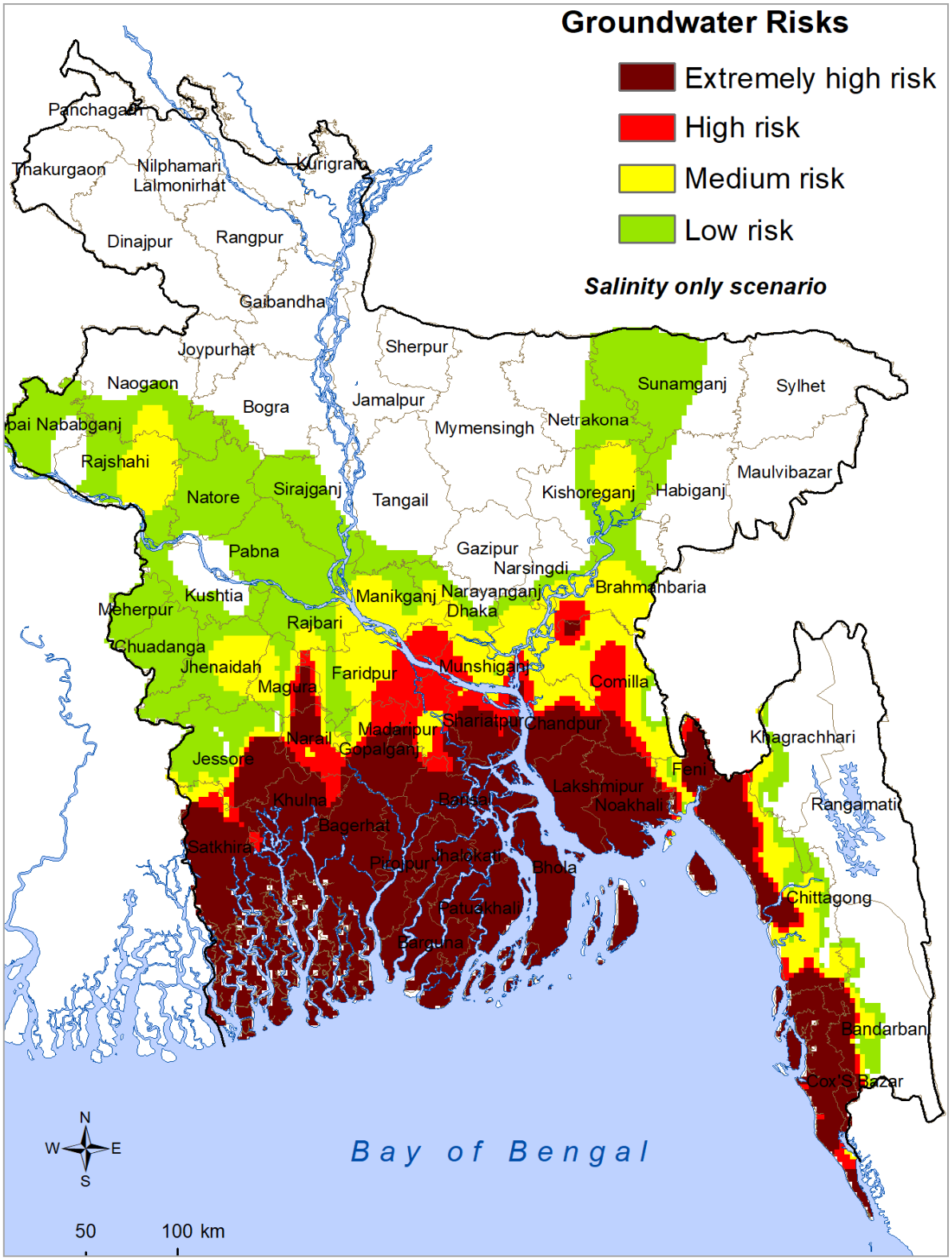

Figure 3.4: Groundwater Risk Maps at the National Scale in Bangladesh Featuring Risks Imposed by Groundwater Salinity (EC: Electrical Conductivity) Alone

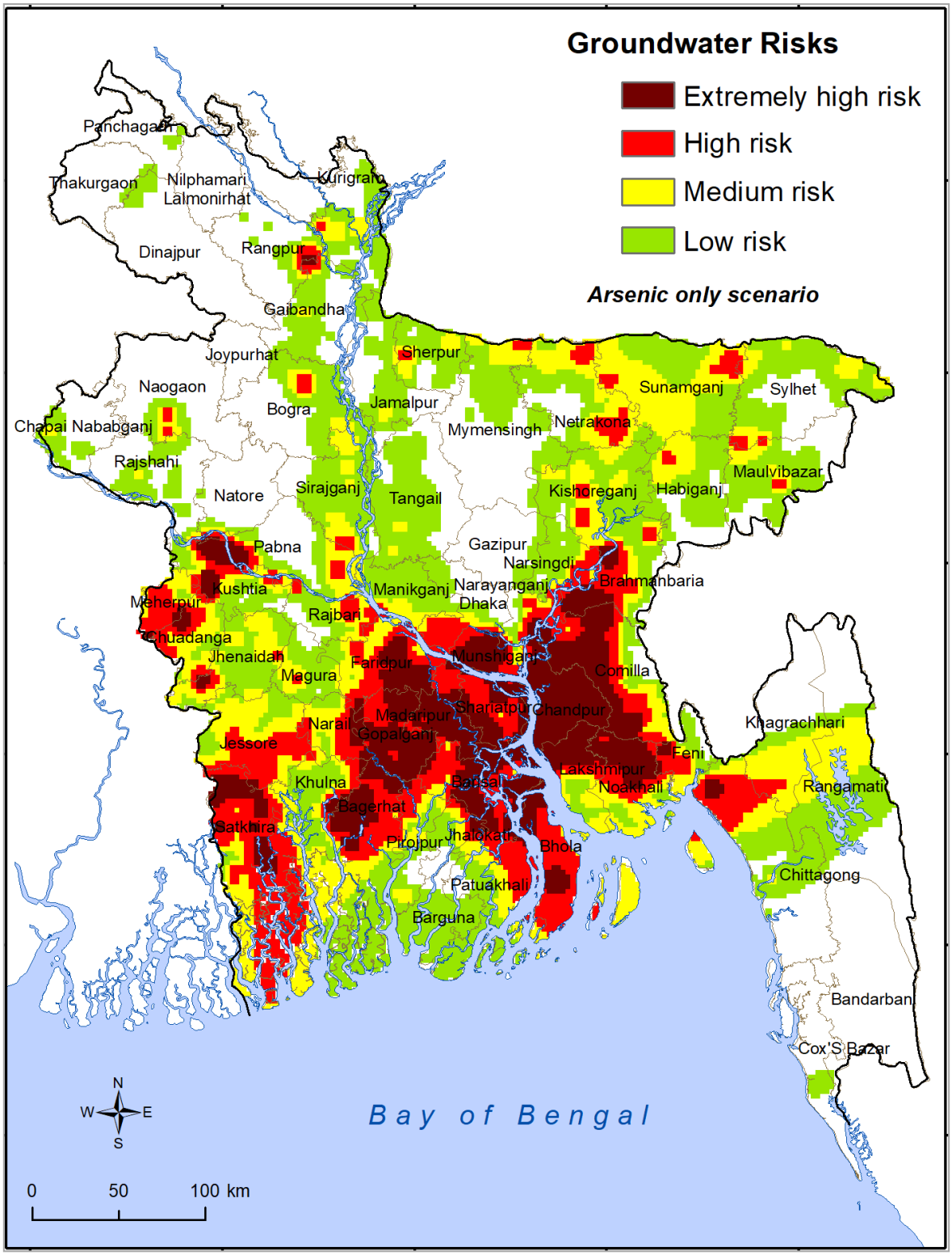

Figure 3.5: Groundwater Risk Maps at the National Scale in Bangladesh Featuring Risks Imposed by Groundwater Arsenic Alone

3.4 Climate Change Risk assessment

Assessment of future climate change is of great importance for the sustainable planning of water resources of Bangladesh. Global climate change impact 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 includea 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 prior to using RCMs in climate change impact assessment at 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 Inter comparison Project (ISIMIP) suggested trend-preserving bias correction method following Lange (2019).

The downscaling exercises and future climate change anomalies assessment through bias correction 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. FollowingIPCC 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 3.1: Change in Rainfall for Choto Harina Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Rainfall (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	-2.86	-6.95	0.16	-2.85	-5.89	-0.06	8.75	6.98	11.35	11.11	4.02	-0.65
SSP370	-4.86	-8.64	-9.58	-2.15	-10.65	-6.13	6.36	8.92	11.35	5.04	0.72	-7.42
SSP585	-3.43	1.53	0.30	-1.09	-4.33	0.66	8.44	8.62	14.39	9.60	-0.83	-1.45

Table 3.2: Change in Temperature for Choto Harina Village by 2050s Different Climate Change Scenario

Scenario	Monthly Change in Temperature (0C)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SSP126	1.34	1.64	1.36	1.34	1.46	1.46	1.10	1.06	1.22	1.32	1.34	1.52
SSP370	1.94	2.16	1.86	1.58	1.64	1.80	1.52	1.48	1.76	1.96	1.92	1.84
SSP585	2.38	2.22	2.06	1.94	2.02	2.14	1.76	1.80	2.08	2.28	2.44	2.42

3.5 Potential Water Sources Identification

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

Hill districts people face difficulties collecting water as there is no surface water supply (canals), the aquifer is too deep to collect water or establish wells and the local tributaries contain contaminations which often cause diseases.

Water availability from canal 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 canal 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 canal 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 canal 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 canal 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 3.6**

It has been found that, 44% of the canals falls under 1000 – 3000 m^3 volume class and which is the major class and the number of canal is approximately 3. The maximum number of canal is observed within the class of 0-100m^3. The total number of canal under all class is around 7.

Table 3.3: Number of canals under different water volume class

District	Upazila	Union	Village	Total Canal	Dry season water volume class (m3)						
					C1	C2	C3	C4	C5	C6	C7
					(No of canal)						
Rangamati	Borkol	Bhushonchora	Choto Harina	7	1	1	1	-	3	-	1
Total (%)				**100%**	**14%**	**14%**	**14%**		**44%**		**14%**

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

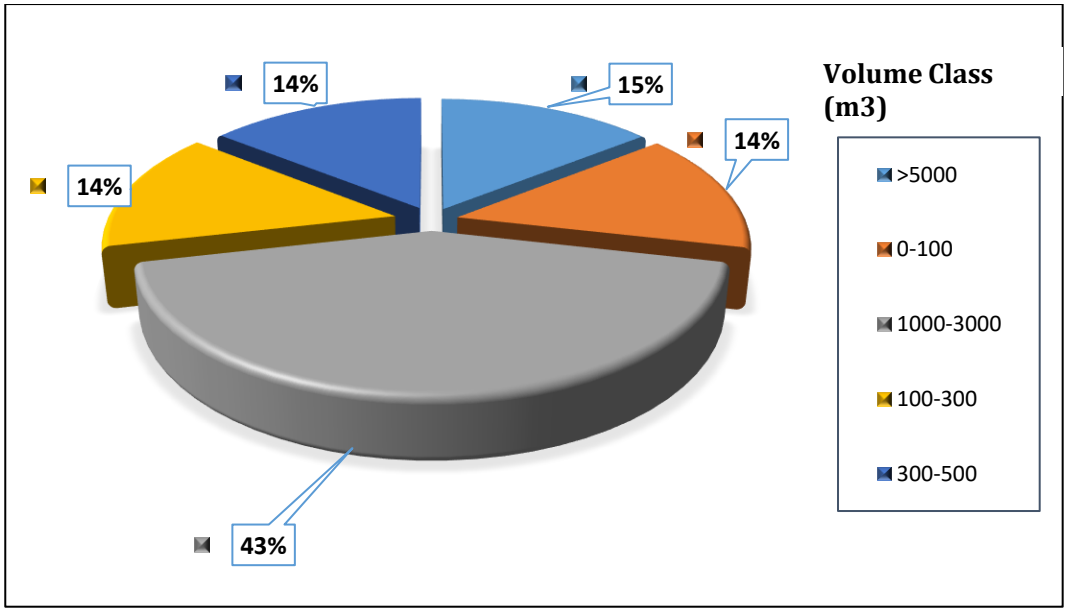

Figure 3.6: Dry season water volume of canals for Choto Harina village

Usages of the canals

Data on usage of the canal has been analyzed from the field data and presented in **Table 3.4**. It may be noted that complex matrices (with 6 combination) has been developed through mathematical combination of analysis because each large number of canals have multiple usages. From **Table 3.4** it has been observed that 71% of total canals have been used for only bath/wash and it has been observed that around 29% of the total surveyed canals have been used for cooking + bath/wash.

Table 3.4: Summary result of uses of the pond

District	Upazila	Union	Village	Surveyed Canal	X1	X2	X3	X4	X5	X6
Rangamati	Borkol	Bhushonchora	Choto Harina	7	0	0	5	2	0	0
Total (%)				**100%**	**0%**	**0%**	**71%**	**29%**	**0%**	**0%**

Usage of Pond			
X1	Only Fish	X4	Only cooking + Bath/Wash
X2	Only Irrigation	X5	Only Fish + Bath/Wash

Vegetation coverage of canal

In hill areas most of the canals are covered with vegetation such as water hyacinth, algae, water grass and other bushes. The coverage of vegetation inside the canal was collected from the field. Further these data were analyzed and presented in and **Table 3.5**. It is found that 71% of the total surveyed pond falls under (< 25) % vegetation coverage, 29% under (25 –40) % vegetation coverage. From **Table 3.5** it is observed that 5 canals out of 7 have vegetation coverage within 25% limit range.

Table 3.5: Percentage % of vegetation coverage of Canal

District	Upazila	Union	Village	Total Canal	< 25%	25% - 40%	40% – 60%	>60%
Rangamati	Borkol	Bhushonchora	Choto Harina	7	5	2	0	0
Total (%)				**100%**	**71%**	**29%**	**0%**	**0%**

Physical Water Quality (color)

The preliminary water quality assessment is investigated mainly by observing the color. The color of the 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 April-May. The pond water colors are presented in **Table 3.6**. Good quality pond water has the color of ash, is clean water and is very clear. The Normal quality indicates the grey, brownish and some green color. The bad quality means the black, muddy and deep reddish color.

Table 3.6: Village-wise pond water color information

District	Upazila	Union	Village	Total Canal	Water Color		
					Good	Normal	Bad
Rangamati	Borkol	Bhushonchora	Choto Harina	7	0	6	1
Total (%)				**100%**	**0%**	**86%**	**14%**

Color data analysis result (**Table 3.24**) shows that 86% of the total surveyed canal has the normal water quality in terms of color, 14% of the total surveyed pond has the good water quality

Identification of potential canals for safe water options

The physical parameters of the canals were collected from the field and analyzed. The present study on canal survey only examines the physical parameters which will help in identify the potential canals for further investigation and selection with potential for drinking purposes. A water quality monitoring program could provide alternative safe water options from the initially identified canals for further assessment. It is not practically viable or it would be very cost effective to monitor the water quality for all the canals for safe water options. Therefore, screening the ponds to identify potential ponds for alternate safe water technology through further water quality tests is necessary.. Possible grading of the canal will be useful for adaptation of safe water technology especially for PSF (CEGIS, 2005). The criteria were used for calculating of potentiality considering the design or recommended standards 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 canal 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 canal 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.
- 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 canal.

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 canal, (iv) physical water quality of canal water (color of the canal water). Different **tables (3.7 to 3.12)** were generated containing the indicator parameter and their score values. The relative score value has been used for the calculation of potential canals with the upper limit value of 1 and lower limit value of 0 at different scale of interval. Further individual weighting factors for each indicator were assigned and the weighting factor for each indicator are given in **Table 3.11**. 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

Table 3.7: Criteria for % of vegetation coverage of the canal (V1)

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

Table 3.8: Criteria for usage of canal 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 3.9: Criteria for physical color of canal water, (V3)

Water color	Score
Good	1
Normal	0.5
Bad	0

Table 3.10: Criteria for canal Volume, (V4)

Canal 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 3.11: Weights of different indicators

Indicator Parameter	Weights
V1	**0.2**
V2	**0.3**
V3	**0.2**
V4	**0.3**

Table 3.12: Potentiality class of the canal

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 canal were calculated and analysis results were presented in **Table 3.13**. From the computation result of potential canals, it is observed that the total canals have very less or low potentiality in Choto Harina, Rangamati.

Table 3.13: Village wise apparently potential canals

District	Upazila	Union	Village	Total Canal	No of Potential canals	
					Potential score, VF	Potential class
Rangamati	Borkol	Bhushonchora	Choto Harina	7	0.25	Low/ Less

3.6 Water Resource Map

Water resource mapping is a crucial component of the geographical approach to land hydrology and the water sector. It is extremely helpful in addressing water issues and managing water resources. The unique characteristics of water resources distinguish them from other natural resources. They are characterized by a dual natural-social essence, with the water functioning as both a component of the natural environment and one of the main producing forces, with a significant impact on social history, infrastructure, and region formation. The water resources not only contain mass and energy characteristics, but they also provide the basis for human livelihoods and economic growth. Water resource map of Choto Harina has been done by GIS. Maps is provided below.

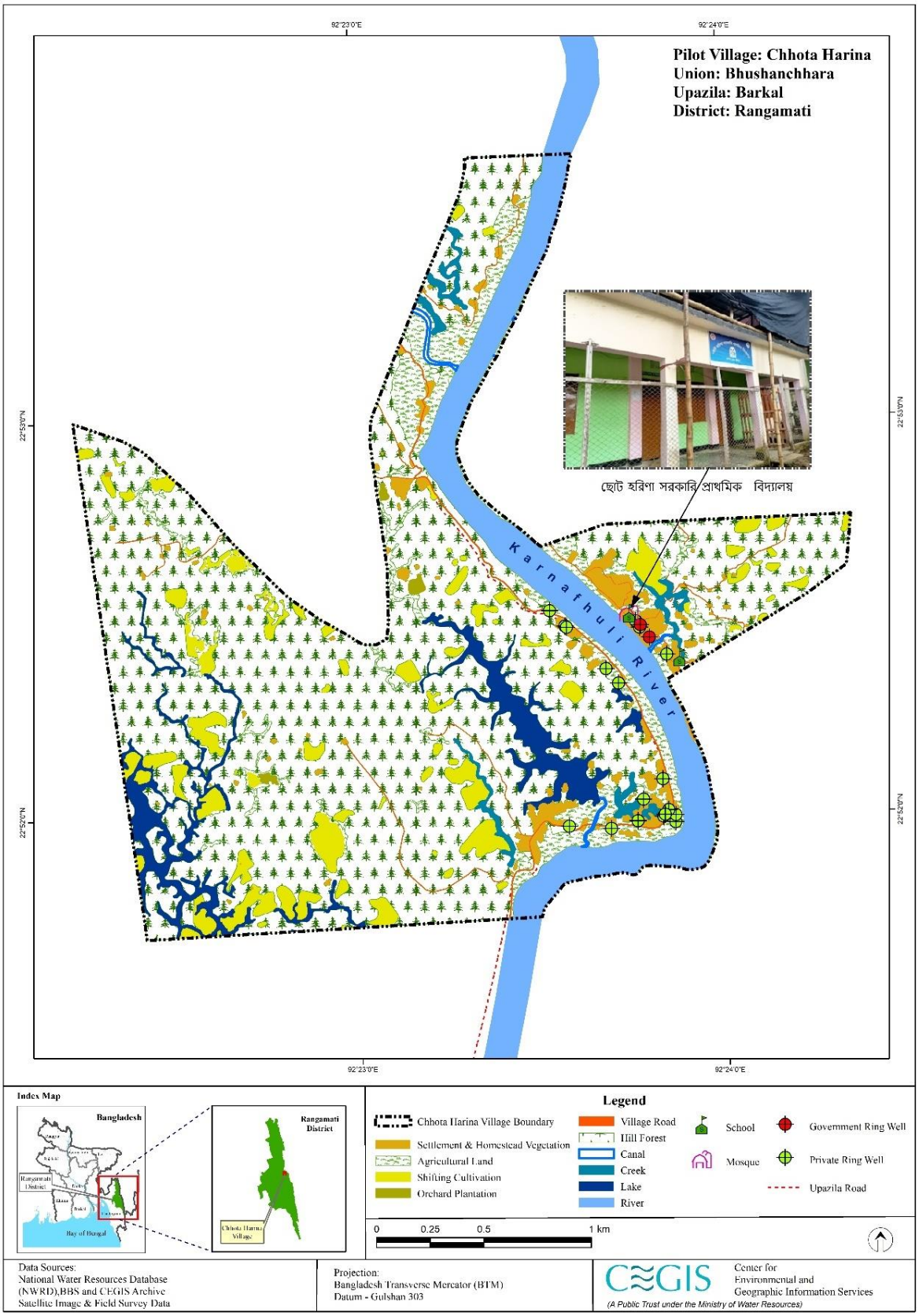

Figure 3.7: Water Resource Map of Choto Harina village

3.7 Dot Density Map

Dot density maps are a simple but incredibly powerful approach to displaying density variations in geographic distributions throughout a landscape. A dot-density map is a thematic map that shows the values of one or more numeric data fields on the map using dots or other symbols. On a dot-density map, each dot represents a certain quantity of data. Dot density maps of Choto Harina is providing below:

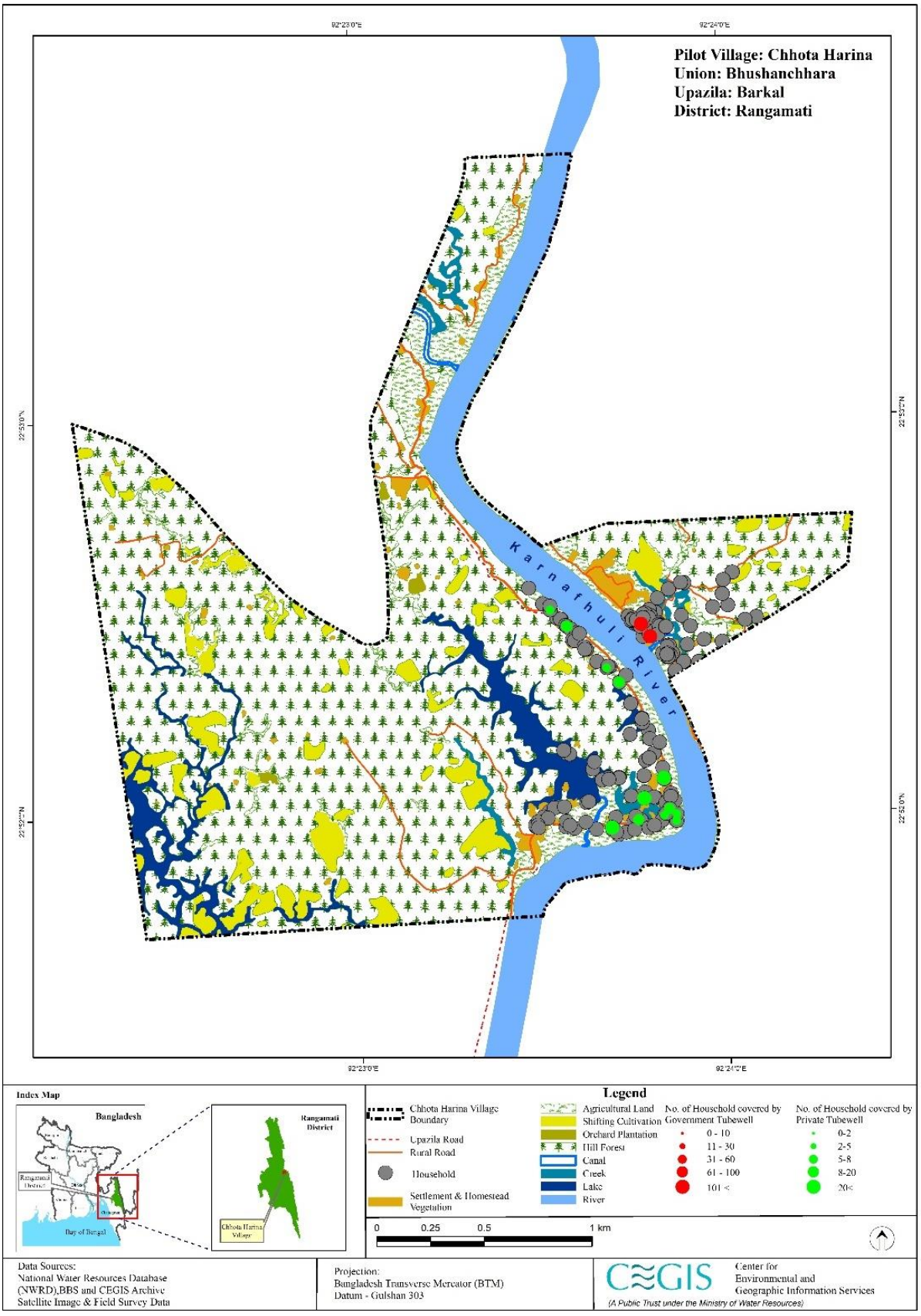

Figure 3.8: Dot density map of Choto Harina

3.8 Planning Area Delineation

Delineating formal regions or areas entails assembling local units that share traits per a set of clearly defined criteria that differ significantly from units outside the region based on a set of selected criteria. This report delineates the planning area delineated for the one village in the hill district 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 one village in the hill district 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) is a mediumly needed intervention zone, and Planning Block-3 (PB-3) is a less needed intervention zone. The term "service area" refers to 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. This is because systemic and financial limitations prevent all workers, machines, and technological equipments from being used simultaneously. Therefore, a tentative planning zone with tentative locations for the interventions sorted by priority is proposed in this report for the on village in the hill district area.

Choto Harina, Rangamati

50 Rainwater Harvesting Systems (RWHS) and 50 Ring wells have been proposed for Choto Harina village. Instead of the typical two households, one RWHS is proposed. Each intervention includes an average of two households, and there are eleven 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. Total of 72 households were chosen for the RWHS Intervention. 50 ring well have been proposed, as opposed to the average of two households. The intervention ID-82 has been assigned to a maximum of 6 households. The average distance between households and ring well interventions is 7 meters. Fifty RWHS, 50 ring wells, distributed among three planning blocks in Choto Harina village, are the proposed intervention, depending on the necessity for the technologies.

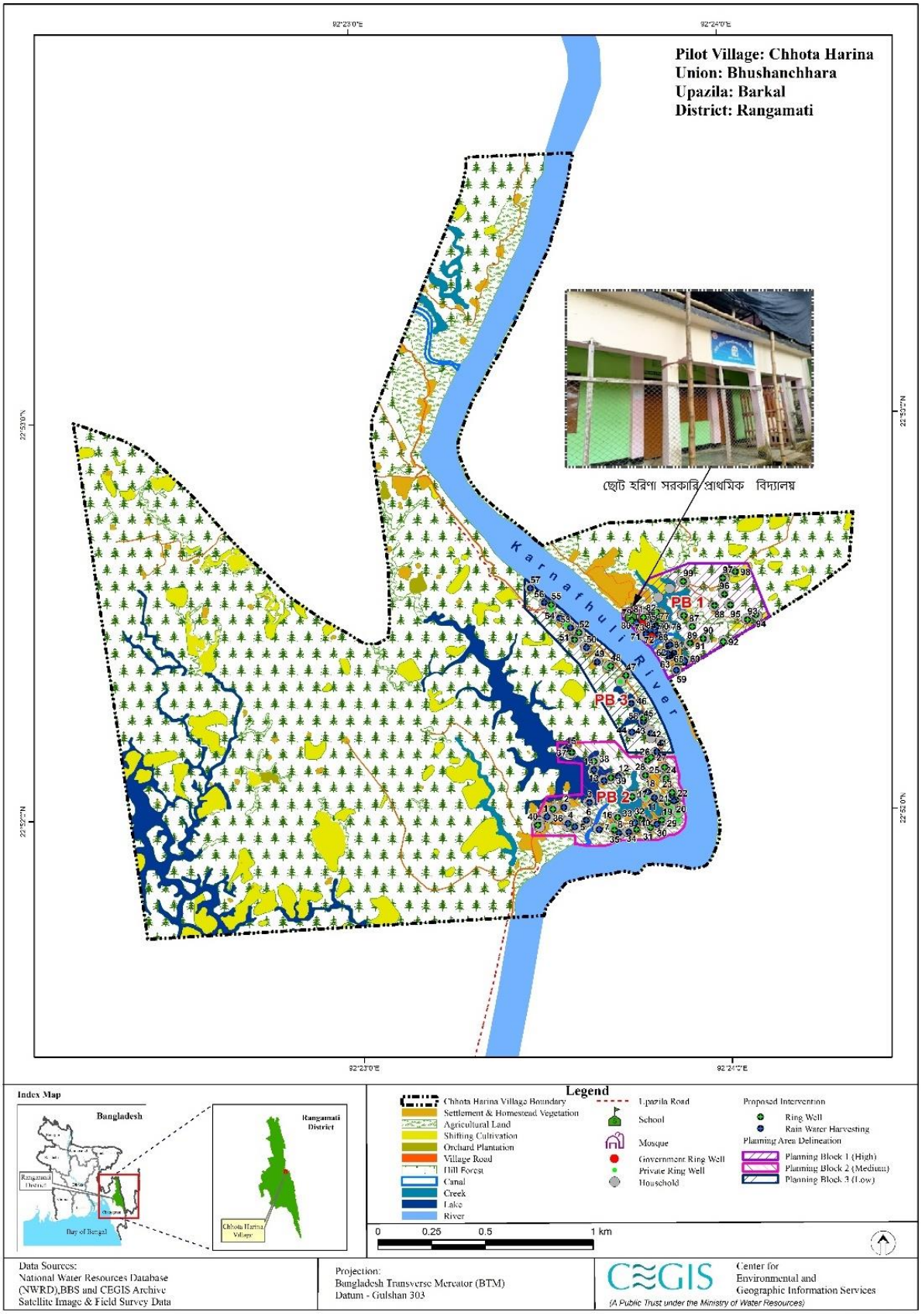

Figure 3.9: Planning area delineation of the village Choto Harina

3.9 Demand Analysis

Demand analysis of the water supply and sanitation of the village is described below:

3.9.1 Water Supply demand

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

a) Current Demand

The current demand for overall water use per person-day has been assessed based on data available[2] of the Chottoharina. The previous two years (2021 and 2020) data are related to the population growth[3] rate. On the basis of households in the six villages, the annual average overall water demand for a village is calculated. Details are given in the following Table**.**

b) Future Demand

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

Table 3.14: Current Demand for Overall Water Use (Litre)

District	Village	Number of households (hh)	hh size (4.2)	Number of Persons	Overall water Demand (Litre)		Annual Overall Water Demand (Lac Litre)		
					Daily (Litre/ person)	Monthly	2020	2021	2022
Rangamati	Chota Harina (mouza)	850	5.03	4276	299285	8978550	1050	1064	1077
			Total	**4276**	**299285**	**8978550**	**1050**	**1064**	**1077**

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

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

Based on the population growth rate, the demand for drinking water forecasted through the 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 25 years. In this case, the Linear Regression model is used for the projection. As the population increases in the village, the water demand has been estimated at an increasing trend over the years. There are three observations in the analysis, i.e., past water use, business as usual projection for a period, and forecasted for 25 years. "Overall Water Demand and Projection before the Project" and "Average Overall Water Demand and Projection after implementation" of the village are calculated. The yearly average overall water demand per village is estimated at five years gap from the 2020- 2045 year. Yearly average overall water demand before the project and after the implementation of plain land is estimated for the 2020- 2045 years at five years gap shown in the following **Table 3.15**

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

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

Table 3.15: Before Project and after implementation of project Overall Water Demand and Projection

Year	Yearly Overall Water Demand (Lac Litre) before project	Yearly Overall Water Demand (Lac Litre) after project implementation
2020	1050	1050
2025	1119	1119
2030	1187	1544
2035	1256	1633
2040	1325	1723
2045	1394	1812

Two Types of graphs have been generated from the forecasted data. Before implementation, the graph has a linear trend with an upward direction, and after implementation, the graph has also an upward direction. Both graphs for the village have been shown in **Appendix III.**

Various constraints 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 meant to meet the demand for water in the project.

3.9.2 Sanitation demand

Identify the need for public investments by assessing:

I. Current Sanitation Status

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[4]. According to the survey questionnaire survey, latrine types and number identified in the Chotto harina village. Total number of various latrines is calculated at 182 number. It indicates that some of the hhs do not have any latrine. About 25% of the hhs have not any latrine. In the following Table, pit latrine i.e., single pit appears about 102 and ventilated improved pit (VIP) stands at 34 number. Pit latrines need more cost for frequent cleaning of feces (waste matter remaining after food has been digested and discharged from bowels) in the pits. These are not environment friendly latrines. The following Table shows the current latrine status in Hill Districts.

Table 3.16: Current Latrine Types and Number in the Chotta harina Village

District	Village	Type of Latrine						
		Pit	Double Pit	VIP[5]	Flash	Septic Tank	Other place/ others	Total
Rangamati	Chota Harina (mouza)	102	0	34	20	7	19	182
Total		**102**	**0**	**34**	**20**	**7**	**19**	**182**

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

[5] Ventilated Improved Pit latrine: Through the pipe outside, the flow of fresh air keeps the superstructure free of odours.

II. Current Demand

Current demand analysis for investment covers the conversion single pit and construction of a twine pit latrine for better sanitation conditions specially latrine type (single pit and twine pit). The following Table shows the current number of conversions of single-pit latrines to twine-pit latrines

For demand projection, the previous two years (2021 and 2020) data have been estimated and 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 have taken for calculation of the previous data. Based on the assumption, of gradually improved economic conditions, the previous 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 Chotta harina village and adjacent areas have been calculated. Details are given in the **Table 3.17**.

Table 3.17: Current Sanitation of Chotta harina Village and Adjacent Area

District	Village	Number of HH	HH size (4.2)	Number of Persons				Number of converted twin pit Latrine			Number of complete twin pit Latrine		
					Converted twin Pit Latrine	Complete Twin Pit Latrine	Total Twin Pit Latrine	Year 2022	Year 2021	Year 2020	Year 2022	Year 2021	Year 2020
Rangamati	Chota Harina (mouza)	850	4.2	3570	390	250	640	390	410	430	250	247	244

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 a period of 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 be decreasing trend over the years. These are shown in **Table 3.18**.

Table 3.18: Before Project implementation Conversion Number of Single Pit Latrine and Projection

Year	Single Pit Latrine
2020	430
2025	330
2030	231
2035	131
2040	32
2045	0

A linear trend with a downward direction is found from the forecasted result for the individual village for 25 years which have been shown in **Appendix III.** 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.

2. Future Demand

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

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.**

Table 3.19: After Implementation Conversion of Single Pit and Construction of Twine Latrine

Year	Converted twin pit from single pit	Increase number of new twin pit latrine	Projected Complete twin pit latrine
2020	430	244	244
2025	330	260	260
2030	231	358	275
2035	131	379	291
2040	32	400	307
2045	0	420	323

The related graphs after the implementation of the project have been shown in **Appendix III**. Various constraints 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 meant to meet the demand for water in the project.

4. Intervention and Options for Water Supply and Sanitation

4.1 Options for Interventions

ChotoHarina village is out of capacity to meet up its water demand specifically of drinking water demand and lack of sanitation facilities. In this context, the technical study team CEGIS has developed an intervention plan to resolve both water supply and sanitation problems.

Water Supply

The technical team suggested sustainable and eco-friendly measures; where measures are related to both surface and ground water-based solutions to address water supply-related problems. All of the measures are collectively capable of addressing the current scarce situation in terms of water supply along with drinking water. Suggested water supply technologies are described below:

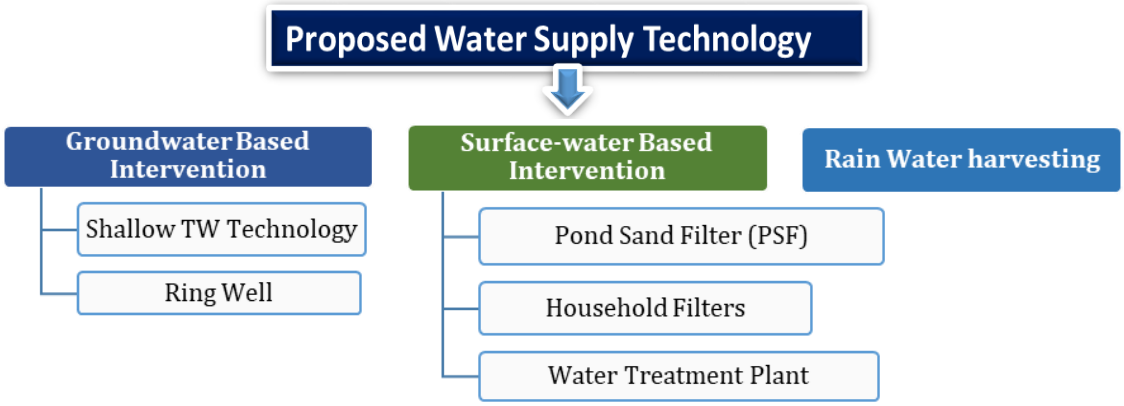

Figure 4.1: Proposed Water Supply Technology

No. 6 Hand Tubewell

A shallow/Deep Hand tubewell is a well with the purpose of tapping ground water from porous zones. Different types of tube wells are used in Bangladesh for groundwater abstraction. No. 6 Hand Tubewell is a shallow tubewell technology that is the most popular one of this technology; as there are at least five million of these all over the country. Hand pumps are manually operated pumps; they use human power and mechanical advantage to move fluids or air from one place to another. The general components of a No.6 handpump tubewell are: handpump, blind pipe, strainer (screen) and sand trap. It is a suction mode handpump. A vacuum is created within the cylinder of the pump by raising the piston and water enters into the cylinder to fill-up the vacuum. In the second stroke when the piston is lowered down, the water enters in the upper chamber and comes out through the spout when the piston is again raised to create vacuum.

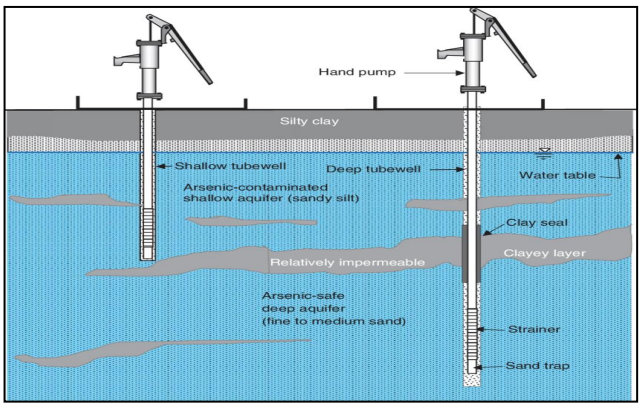

Figure 4.2: Manually operated shallow tubewells

The stroke length is 240mm. No.6 handpump is introduced by UNICEF, DPHE and also private sector. The suction hand pump can practically extract water from a depth of 7.5m or 24 feet from ground level. This intervention is appropriate for the locations where the topography is flat in the village. There are certain flat locations where aquifer property is suitable to establish hand tube wells.

Ring well

The oldest and most common kind of well is a water well, to access groundwater in underground aquifers. The well water is drawn up by a pump, or using containers, such as buckets or large water bags that are raised mechanically or by hand. Water can also be injected back into the aquifer through the well. Wells were first constructed at least eight thousand years ago and historically vary in construction from a simple scoop in the sediment of a dry watercourse. Placing a lining in the well shaft helps create stability, and linings of wood or wickerwork date back at least as far as the Iron Age.

The oldest method of groundwater withdrawal for water supplies is the dug well. Ring well is a similar technology of extracting GW compared to dug well. A dug well is typically excavated below the groundwater table and then lined with stones, brick, tile, or other material to prevent collapse. A ring well is an extension of a dug well that is lined with 1.0 m to 1.10 m-diameter rings. The well's depth is determined by the depth of the water table and its seasonal fluctuations. Wells should be at least 1 m deep and at least 1m above the lowest water table. To meet increased water demand, community wells should be dug deeper to provide a larger surface area for water entry. Private wells are typically less than 10 meters deep, whereas communal wells are typically 20-30 meters deep.

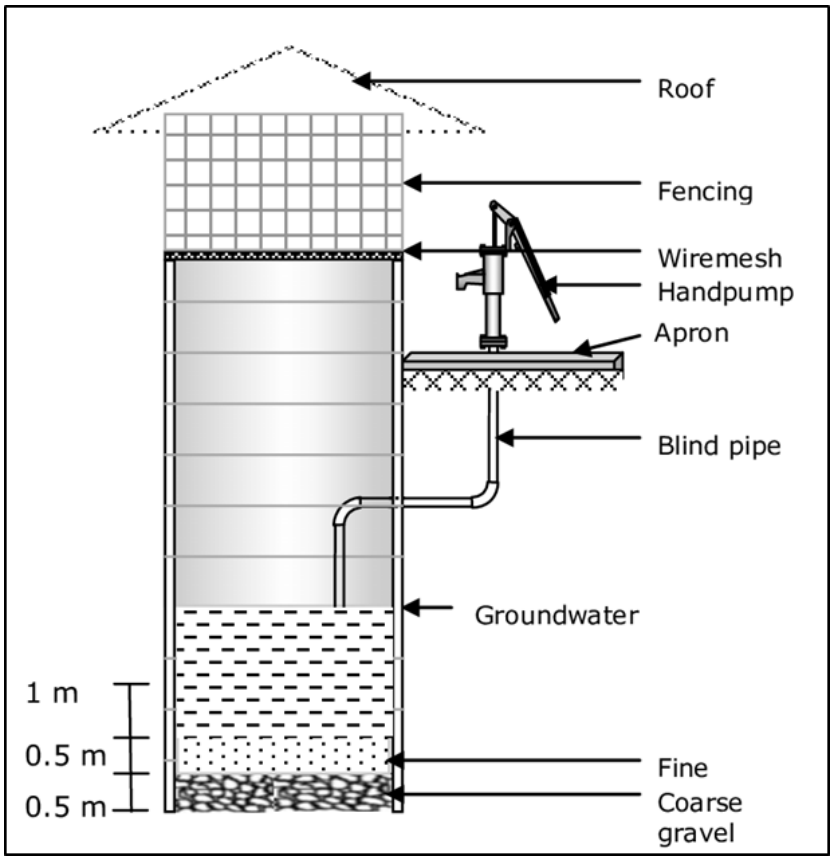

Figure 4.3: Schematic view of an improved dug well design.

Pond sand Filter (PSF)

A pond sand filter is a slow sand filter unit that is used for surface water treatment. If the turbidity of the water is high, a horizontal roughing filter is required. Raw pond water is pumped up from the

pond; the turbidity passes through the roughing filter and is discharged into the filtration unit. An under drainage system filters the water before collecting it in a clear water reservoir.

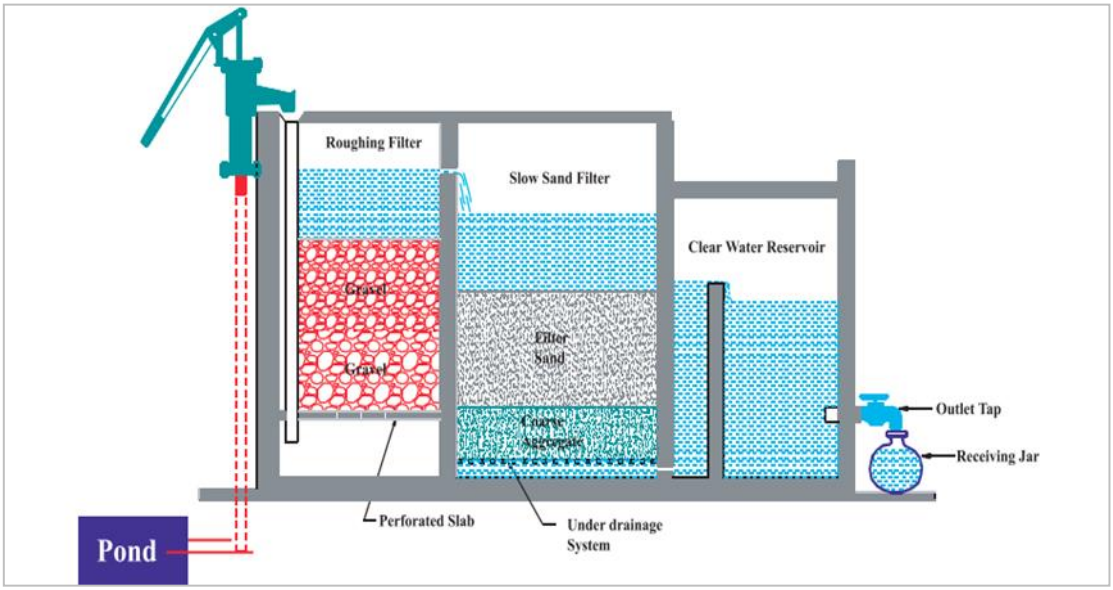

Figure 4.4: Pond Sand Filter

Household Filters

Conventional Households Filter (CHF or Pitcher Filter)

At the household level, this filter is made of pitchers. This is made by stacking a number of pitchers. As shown in Fig. 5.6, one above the other contains different filter media. The top pot receives raw water, while the bottom one receives filled water. Water is primarily clarified in this process through mechanical straining and adsorption, depending on the type of filter media used. Arsenic may not be removed by a standard pitcher. Because it draws arsenic-free water from surface water sources, the treated water is arsenic-free.

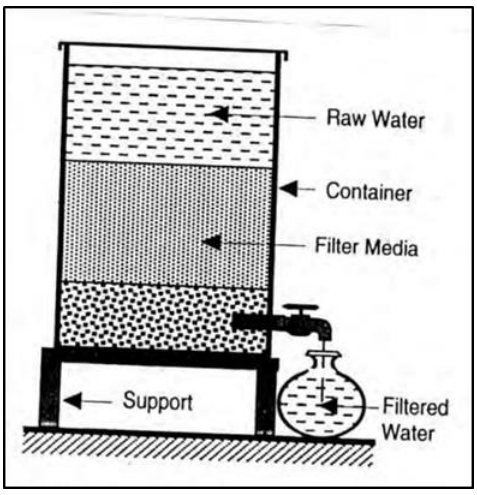

Figure 4.5: Small Household Sand Filter

Figure 4.6: Pitcher Filter

Small Sand Filter (SSF)

It will be built by laying a layer of well-graded sand 300–450 mm thick on a 150–225 mm thick base. As seen in Fig. 5.5, a cylindrical container is filled with coarse aggregates. Filtered water is collected from the bottom after the soil has been filled with water. It is necessary to prevent the filter bed from drying out. If the media are kept submerged in water at all times, full efficacy or at least filtration is achieved. Arsenic itself is not present in the SSF unit. Because it draws arsenic-free water from surface water sources, the treated water is arsenic-free.

Rain Water Harvesting Plant

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. Studies reveal 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. Rainwater harvesting is a technology is a nature based solution by collecting rainwater for its use in drinking purposes. About 203 cm rainfall occurs annually in Bangladesh. The rain water is safe if it maintained hygienically. The main limitation of this option is non-availability of rain water round the year. But it can be widely used as supplementary source.

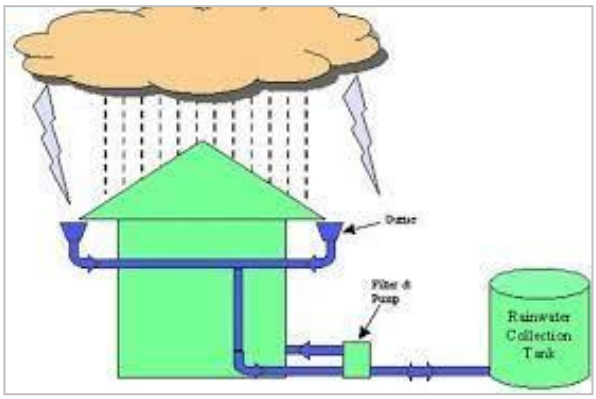

Figure 4.7: Sample Rainwater Harvesting Plant

Usually the considered village's water sources get drastically shorten of water supply during dry and post monsoon period of every. In that time, the natives have to suffer immensely by scarcity of water. In this context, rain water harvesting plant is suggested at Chotoharina which will store water hygienically and supply during crisis period.

Water Treatment Plant

Village people are much dependent on surface water. They usually fulfil their domestic demand by surface water from canals or Karnafully River. Many of them even drink those water. As the selected village is get stocked out of water supply from other sources except river water, so that surface water treatment plant can resolve the scarcity problem in that period.

A water treatment plant can resolve the water crisis situation, by extracting water from Karnafully River and supplying to the dwellers after retrieving of it's hygienic state by proper treatment. It has been tested and found that the treated water from a PSF is usually bacteriologically safe or within tolerable limits and lab effectiveness is about 99.98% for protozoan, 90-99% for bacterial, and variable for viral reduction. Field effectiveness studies have documented E. coli removal rates of 80-98%. In this backdrop, a water treatment plant is suggested to ensure water supply throughout the year.

Table 4.1: Technological Solutions related to Water Supply

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
Chotoharina Bhusonchora, Barkal, Rangamati.	1. Hand Tubewell 2. Pipe Water supply 3. Ringwell	1. No. 6 Tubewell 2. Dug Well 3. Pond Sand Filter (PSF)F ilters 4. Rainwater Harvesting Plant 5. Water Treatment Plant	1. 50 Ringwell 2. 50 Rain water Harvesting Plant

Sanitation

In the context of sanitation issue, technical team has also suggested effective and nature based solution to resolve the current sanitation deficiency in Chotoharina. Suggested intervention to improve the sanitation technology are:

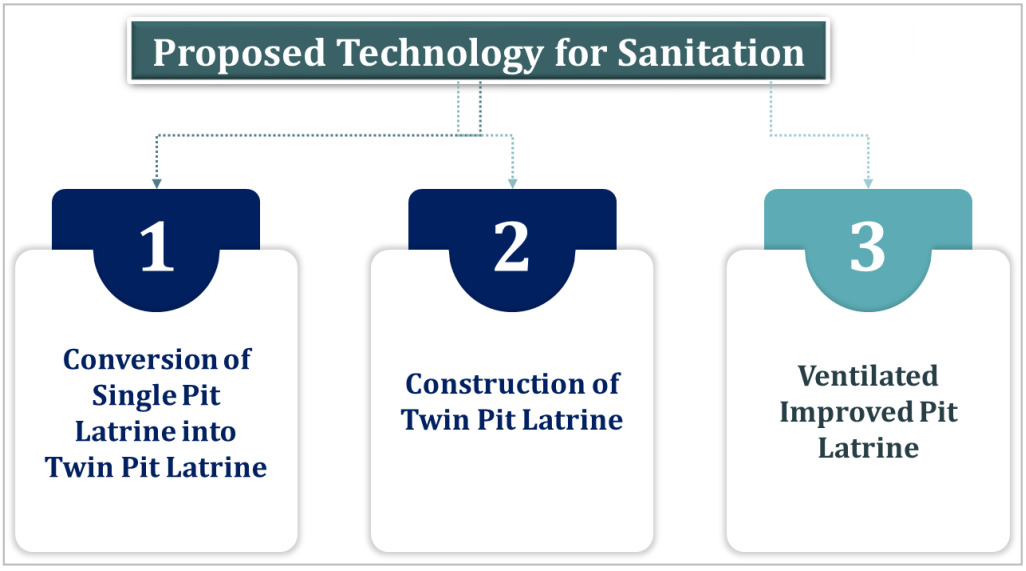

Figure 4.8: Proposed Technology for Sanitation

Conversion of Single Pit Latrine into Twin Pit Latrine

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

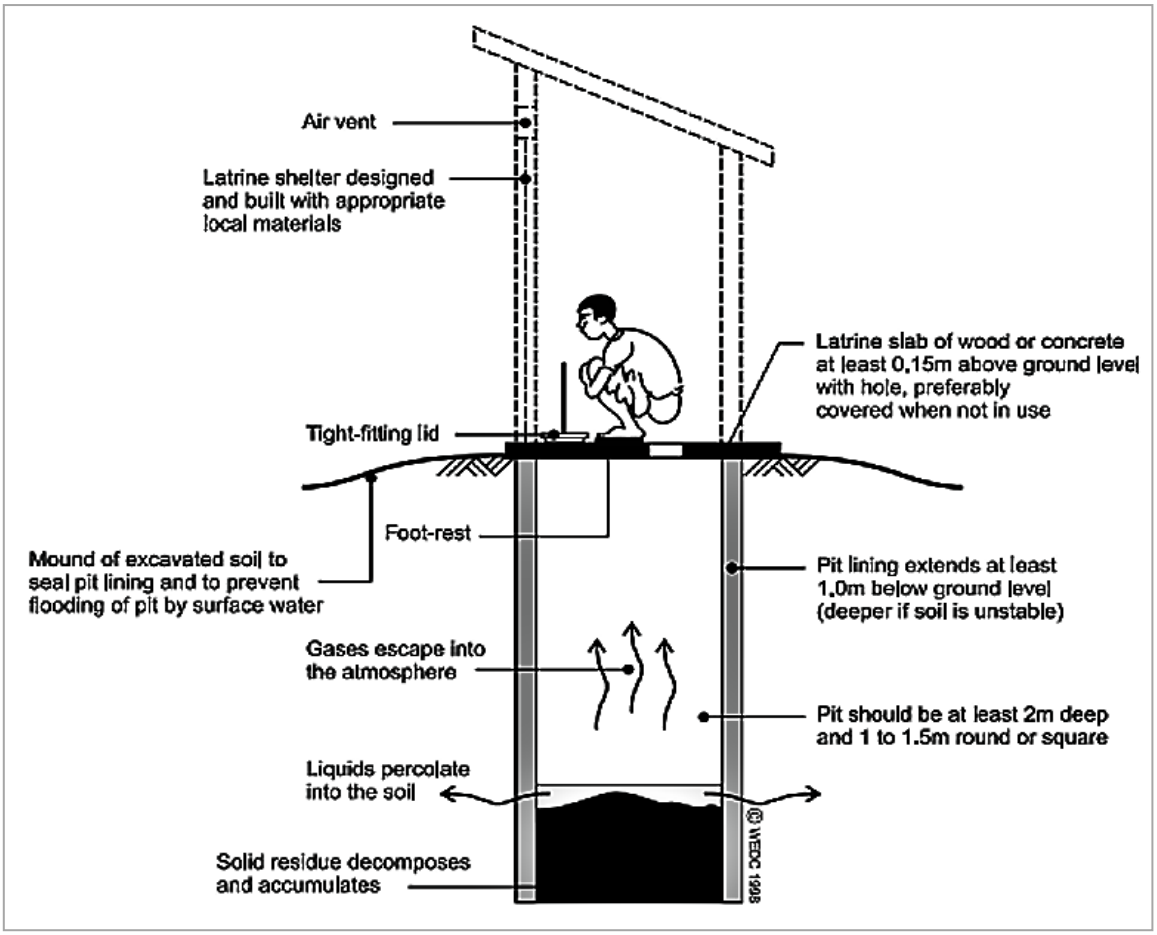

Figure 4.9: Sample Single Pit Latrine

Construction of Twin Pit Latrine

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

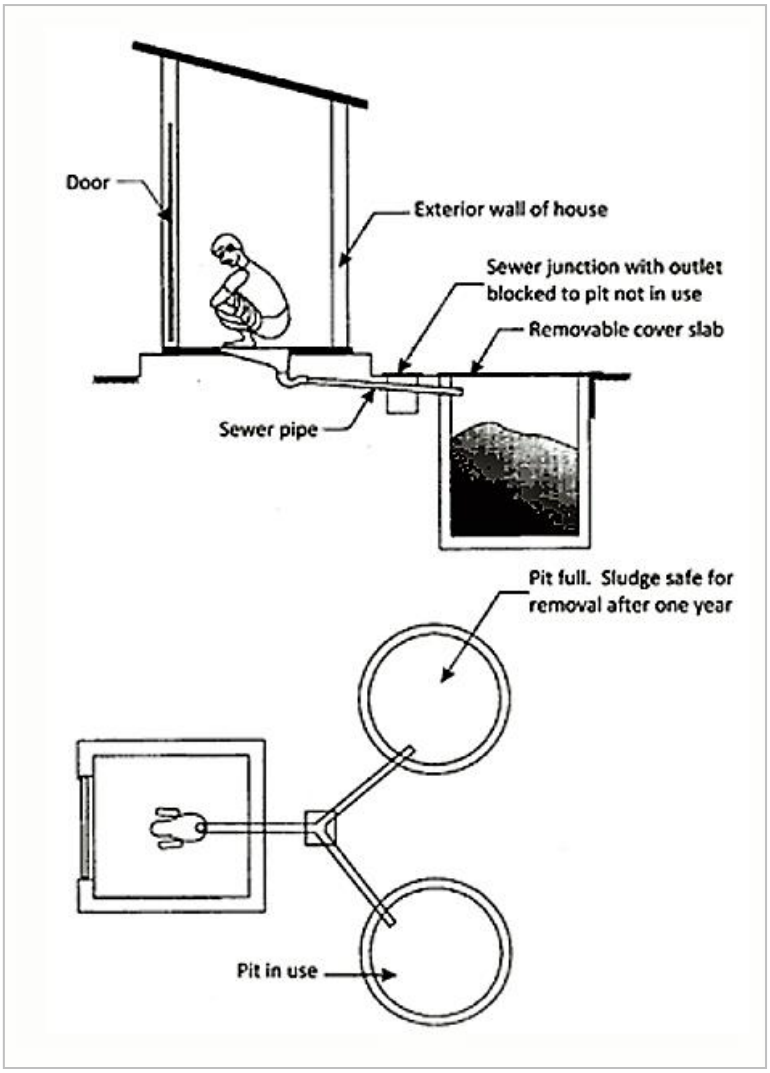

Figure 4.10: Sample Twin Pit Latrine

Ventilated Improved Pit Latrine

VIP latrine can be constructed with a single pit or twin pit system. It is improved conventional pit latrine. This latrine has a tall vertical black vent pipe with a fly screen fitted outside the superstructure to trap flies and reduce odor nuisance. As non-water dependency is it's significant character; suitable for water scarce areas. Small amount of water is required to clean the squat ting slab occasionally. This latrine has less chance for transmission of excreta related disease. This latrine can be updated into pour flash latrine. Construction and maintenance is easy. Apart from the advantages, it has disadvantages also as risk of GW and SW contamination.

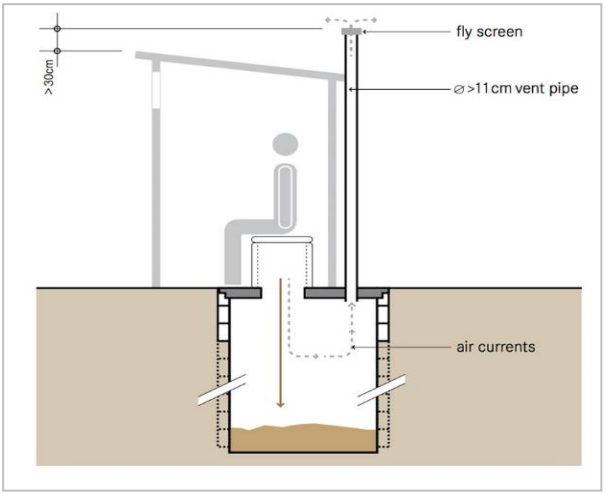

Figure 4.11: Sample VIP Latrine

Sometimes pit needed to be moved or second pit need to be constructed in case of filling of previous pit.

Table 4.2: Technological Solutions related to Sanitation

Name	Existing and Demanded Options	Proposed Intervention Options	Final Selected Options
Chotoharina Bhusonchora, Barkal, Rangamati.	1. Pit Latrine 2. VIP Latrine	1. Conversion of single-pit latrine to twin pit latrine 2. Complete twin-pit latrine 3. Ventilated Improved Pit Latrine	1. Conversion of 390 single-pit latrine to twin pit latrine 2. 250 Complete twin-pit latrine

4.2 Guideline for Proposed Interventions

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

Table 4.3: Technical guideline of water supply for proposed interventions for Choto Harina

Sl	Intervention	Technical Guidelines
1.	6 no. Tubewell	• 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 a. 2 Deep TW must be at least 2500 ft apart from each other, b. Every Shallow TW must be at least 1700 ft away from a Deep TW. c. Shallow TWs should be at least 800 ft apart from each other.
2.	Ring well	• The type of source and soil (must allow safe excavation) • Existence of an aquifer. Alternatively, dry riverbeds may provide a water source during dry-season. • The level of the groundwater (deep enough: protection against contamination of groundwater; but not too deep: safety of excavation, high effort) • The quantity of available water (also in the perspective of a long-term perspective); the future recharge potential • The quality of the water confirmation via test boring
3.	Surface Water Treatment Plant	• 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)
4.	Rainwater harvesting Plant	• Feasible where average rainfall is 1600 mm per annum. • There should have required catchment area for rain water harvesting • Surface run-off rainwater harvesting is appropriate for the location • Both storage or storage with GW recharge collection system can are suitable for Chotoharina. • Water Demand Criteria

Sl	Intervention	Technical Guidelines
		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 • Calculation of Required Water and Available Water • First Flush Diverter • Storage Tank • Treatment of Rainwater

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

Table 4.4: Technical guideline of sanitation for proposed interventions for Choto Harina

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).;
- Gradual community cost-sharing and introduction of economic pricing for services;
- Assigning priority to under-served and un-served areas;
- Local Government institutions/Paurashavas to bear increasing share of capital cost;
- Improvement of the existing technologies and conduct of continuous research and development activities to develop new technologies;
- 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 Perceptions on Proposed WASH Intervention

The pilot villages have water scarcity and sanitation problem. Geograpghy problem which affects the water supply to the rural people. So, some interventions have been proposed to the areas through assessment and people's opinion. People believes that the following interventions will mitigate the crisis they have faced now. Water will be available through the year round. So they will no longer face the lack of water. The implementation of the project will ensure safe drinking water and proper sanitation. It helps to bring back healthy life. People suffered from water borne diesis 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 to save time providing them sufficient water. Some people purify their water. If the intervention has been implemented, they don't need to purify water. It will save fuel. People get affected by many types of worm due to unconscious sanitation. If proper sanitation can be provided it will help them to overcome the problems.

4.5 Socio-Economic Impacts of the proposed Intervention

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 regards;
- 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 dismantled properly it will generate odor and unhygienic condition;

4.6 Issues and challenges

Presently, ChotoHarina village is lack of proper water supply system and sanitation facilities. In terms of modernizing both water supply and sanitation aspects, some issues and challenges arise.

- Most people are illiterate and don't have enough knowledge about safe and hygienic sanitation and water supply.
- Many people drink surface water directly from nearby canals or Karnafully due to difficulties in retrieving the hygiene condition of abstracted water and lack of hygiene knowledge.
- The village has poor communication with the district headquarter. In other words, the waterway is the only medium to get reach the village due to the absence of direct road connection.
- There is no connection with the national power grid in the village. Solar plants and generators are the options to generate electricity.
- Poor transportation and lack of electricity made the development of infrastructure difficult to enhance both water supply and sanitation.
- Hilly topography is also a challenging factor to develop any infrastructures to enhance water supply and sanitation.
- Water supply is not available year-round from sources like tube wells, ring wells, springs, etc.

- Aquifer property is insufficient to keep relying on GW. After a few meters from the GL, a stony layer is found usually, making it difficult to install DTW.
- No water management group was formed to maintain and look after the current water supply and sanitation systems.
- Most people of the village are not economically solvent. It's difficult to bear the additional expense to improve their water supply and sanitation systems. Selected options for Intervention

Final selected options for interventions for Choto Harina is tabulated below:

Name	Final Selected Options
Choto Harina, Rangamati	1. Ring well 2. Rainwater Harvesting.

5. Design and Cost Estimation

5.1 Introduction

Water supply and sanitation are fundamental human rights and vital aspects of our civilization. In every developing country, access to safe drinking water and adequate sanitation is a major concern, particularly in rural regions. The primary issue of this project is sanitation, hygiene, and water supply, which has been approved with the broader goal of reducing mortality by providing safe water, and sanitation facilities, and improving community hygiene attitudes. ChotoHarina village is out of capacity to meet up its water demand specifically of drinking water demand and lack of sanitation facilities. In this context, the technical study team CEGIS has developed an intervention plan to resolve both water supply and sanitation problems.

5.2 Water Supply System Design

Water supply system design for Choto Harina is described below:

Ring Well

Technical Guideline

- The type of source and soil (must allow safe excavation)
- Existence of an aquifer. Alternatively, dry riverbeds may provide a water source during dry-season.
- The level of the groundwater (deep enough: protection against contamination of groundwater; but not too deep: safety of excavation, high effort)
- The quantity of available water (also in the perspective of a long-term perspective); the future recharge potential
- The quality of the water confirmation via test boring

Schematic Drawing

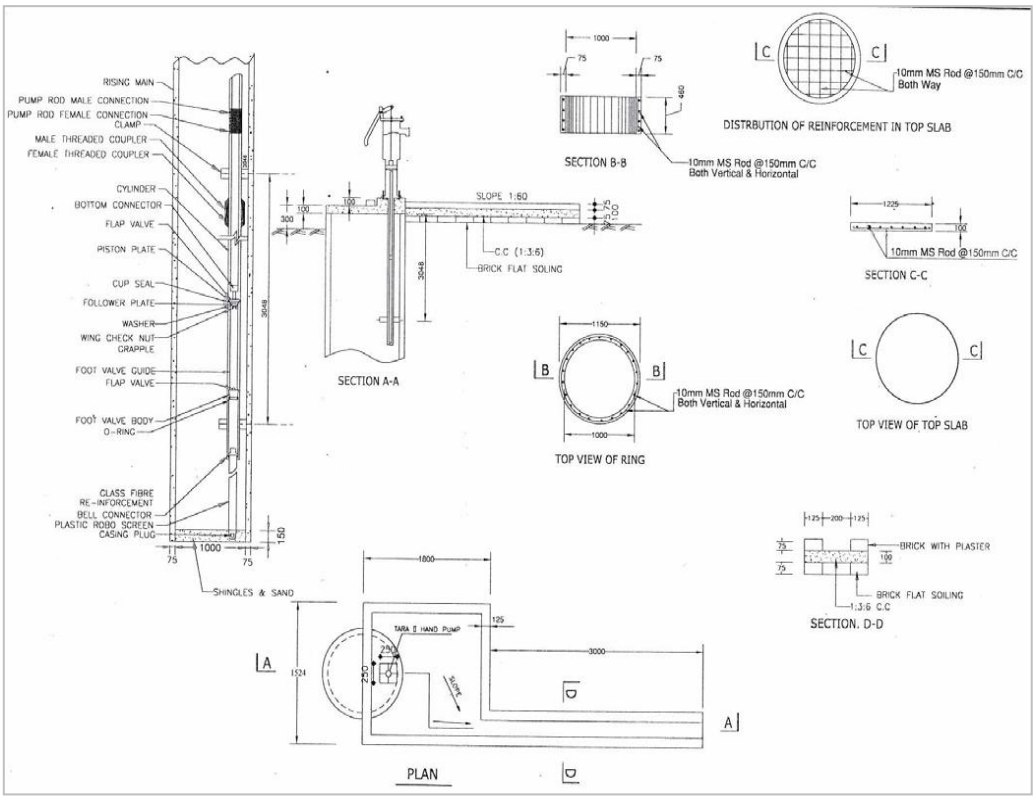

Figure 5.1: Schematic Drawing of Ring Well

Rainwater Harvesting

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

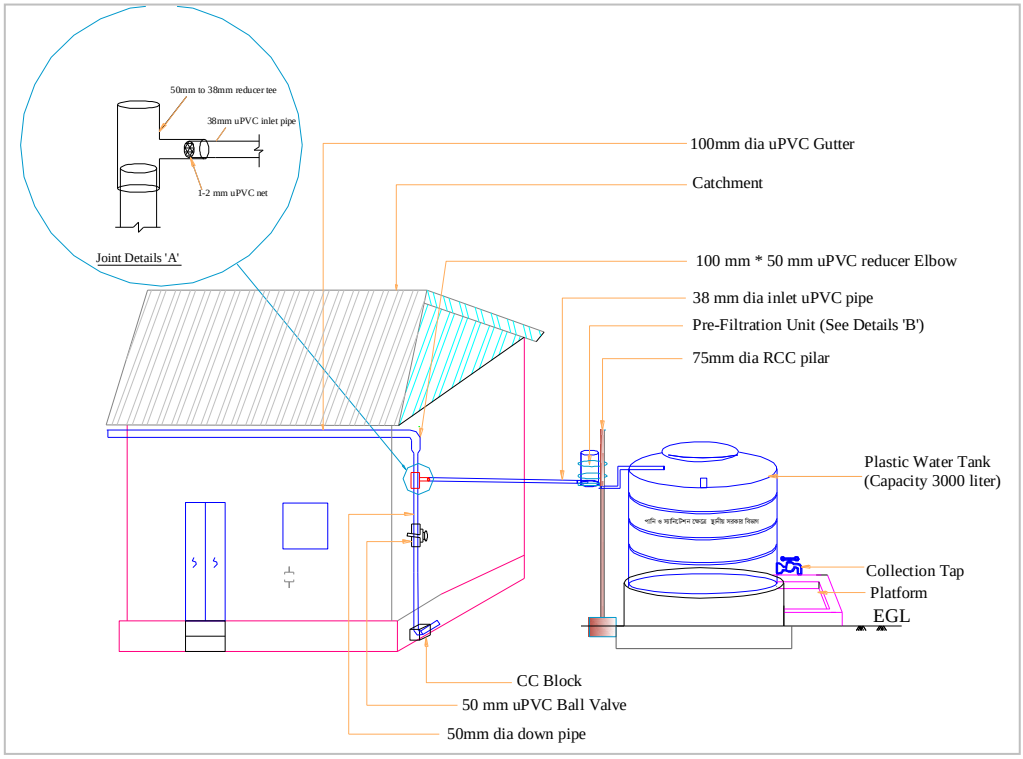

Figure 5.2: Typical drawing of rainwater harvesting

Table 5.1: Interventions for Choto Harina

Name	Tubewell with Submersible Pump
Choto Harina, Rangamati	1. Ring Well-50 2. Rainwater Harvesting-50

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 health risks, including exposure to helminth eggs. The emptying process also can 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 full pit to 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 a soil amendment in homestead gardening. The decomposition process usually takes 12–18 months, and household members use the second pit during this time..

Given the limitations of single-pit latrines and the health hazards associated with emptying fresh excreta, the single converting pit to double-pit pour-flush latrine system may significantly 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, some barriers exist 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.

Schematic Drawing

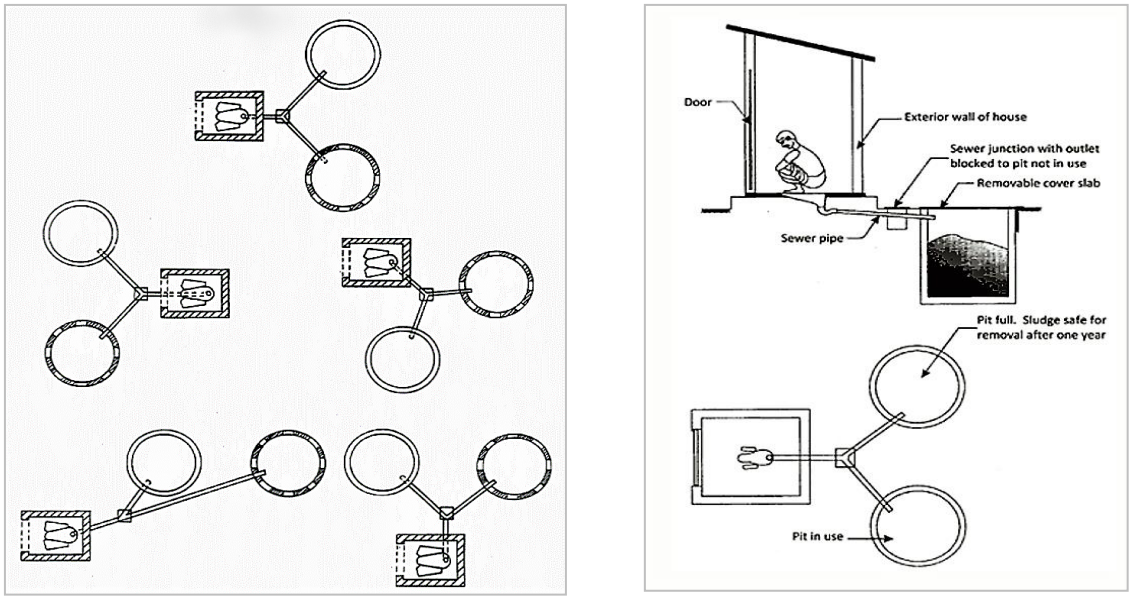

Figure 5.3:Conversion of single pit to twin pit latrine

Twin pit latrine

When a single pit latrine becomes full, users must empty it themselves, risk exposure to fresh feces, and pay for 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 the 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 they 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 the service life of the 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 the 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 the dry condition, Roy et al., 1982)

=0.025~0.034 m^3 /p/yr (Under the 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 not readily decomposed)

Table 5.2: 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

Schematic Drawing

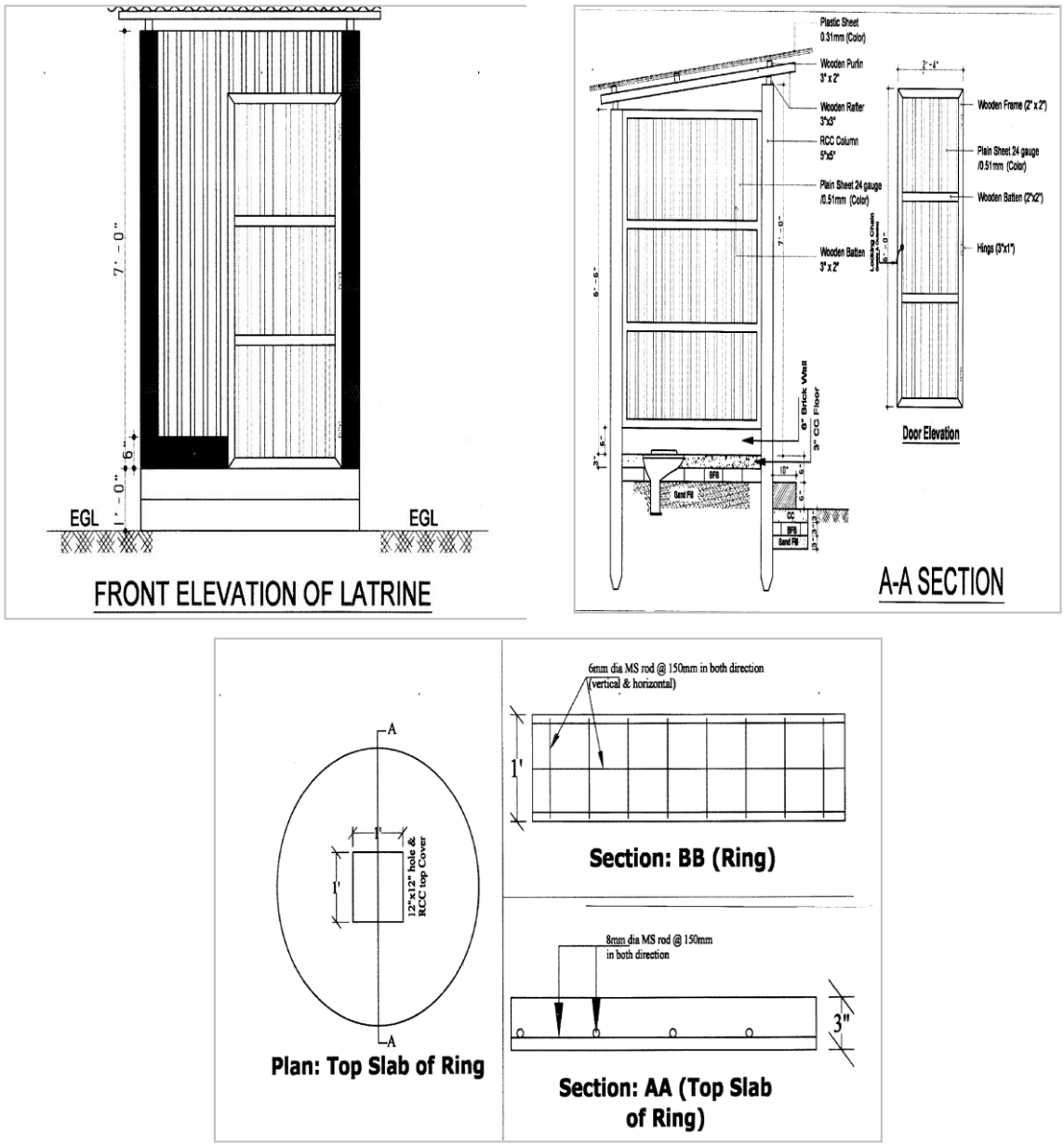

Figure 5.4: Plan of latrine with twin pit

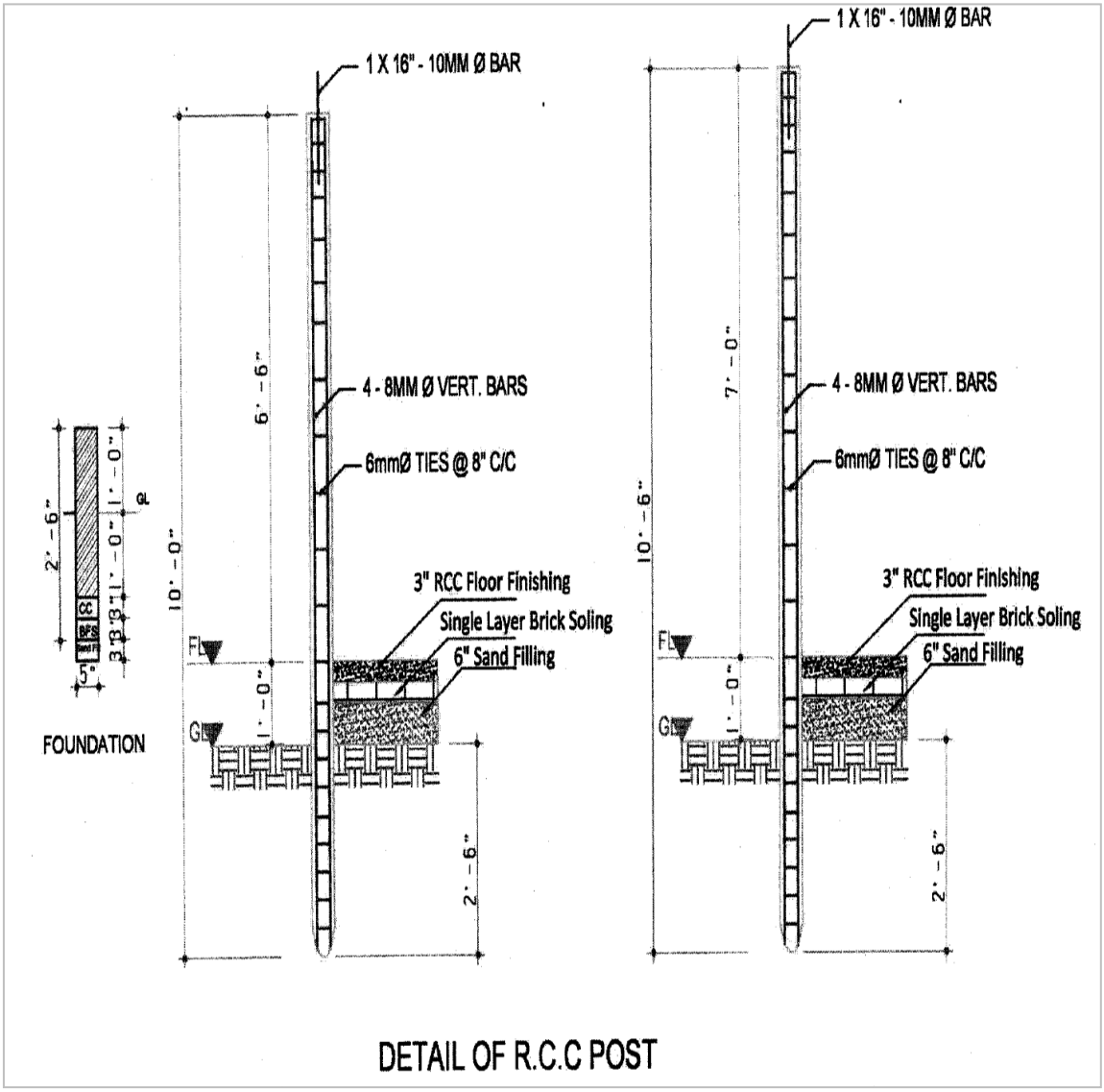

Figure 5.5:Detail Design of RCC

5.4 Cost Estimation

The cost estimation of the water supply of hill area is described below:

Capital Cost of Water Supply

Ring Well Cost:

Estimate of Ring well with 6 No Hand Pump					
Sl No	**Item of Works**	**Unit**	**Quantity**	**Unit Rate (BDT)**	**Total (BDT)**
1	Identification of appropriate aquifer for Ring Well by drilling of 38mm dia borehole up to required depth by any suitable method, collection of soil sample for each 1.0m intervel analysis of these samples etc. All complete as per direction of the Engineer in Charge (E/C).	Item	1	4000	4000

Estimate of Ring well with 6 No Hand Pump					
Sl No	**Item of Works**	**Unit**	**Quantity**	**Unit Rate (BDT)**	**Total (BDT)**
2	Mobilization of equipment, materials, including piling equipment (such as drilling rig, welding machine, generator, construction materials for labour shed etc.) and arrange non-saline & clean water (of drinking-water quality) for entire construction & curing works and site clearance etc. all complete as per direction of the Engineer in Charge (E/C).	Item	1	5000	5000
3	Digging 1.53m dia vertical well of required depth after taking all kinds of safety measures in all kind of soils/ sttony layers and stacking excavated soils at a suitable place besides the well, protecting the wall with timber works, bailing out of water etc. All complete as per direction of the Engineer in Charge (E/C).				
	a) 0-6m	m	6	1600	9600
	b) 6-15m	m	9	1800	16200
4	Construction of RCC (1:2:4) ring having inner dia 1.0m height 0.46m and thickness 75mm with supplying and fabrication of 10mm dia MS rod @ 150mm c/c in horizantal & vertical directions, making climbing supports with 12mm dia MS rod and casting concrete with 19mm down graded khoa (from pick jhama brick) & 1.6FM clean sand (free from clay) etc. All complete as per drawing with supplying all materials and mould set including curing for at least 7days as per direction of the Engineer in Charge (E/C).	Each	34	1500	51000
5	Placing of RCC ring into 1.53m dia well with all sorts of precautionary measures and supplying all necessary equipments. Alignment of the ring must be vertical, leaving equal space out side of the rings. One ring should be placed upon another as per direction of the Engineer in Charge (E/C).	Each	34	120	4080
6	Supplying and placing of khoa and coarse sand filter materials at the bottom of ring well, Puttig picked jhama brick khoa in three layer, first layer 38mm size khoa 100mm thick, second layer 25mm size khoa 100mm thick, third layer 12mm khoa 100mm thick and sylhet sand 100mm thick as per drawing and direction of the Engineer in Charge (E/C).	Item	1	850	850
7	Backfilling wih coarse sand outside the rings from the bottom of the ringwell upto 3.5m downfrom top of the ringwell including compacting properly layer by layer with water etc. as per direction of the Engineer in Charge.	m^3	3	620	1860

Estimate of Ring well with 6 No Hand Pump					
Sl No	**Item of Works**	**Unit**	**Quantity**	**Unit Rate (BDT)**	**Total (BDT)**
8	Construction of Sanaitary Seal (1:1.5:3) outside of the rings from ground level up to 1.0m depth from ground including supply of cement, sand, Khoa (12mm down graded) as per direction of the Engineer in Charge.	m^3	0.19	6240	1185.6
9	Joining of ring of ring-well with cement-sand (1:2) and plastering ring well surface with cement-sand (1:4) as per direction of the Engineer in Charge.	Joint	33	100	3300
10	Supplying and installation of following materials according to departmental secfication. Materials could be used in cronstraction works only after having satisfactory test result as per direction of the Engineer in Charge.				
	No. 6 Hand Pump 30kg (±3%)	No	1	4540	4540
	a) Pump head base including 100mm dia 600mm long MS/GI nipple.	m	1	500	500
	b) Best quality 62.50mm dia uPVC Cylinder pipe made of uPVC pipe with SS lining 800mm long, complete with foot value recever.	Each	1	1200	1200
	c) 38mm dia uPVC threaded column pipe (3m long)	m	13.72	100	1372
	d) Best Quality 9mm (±0.5mm) dia S.S pump rod X 10ft long each, Filtted with M-12 male/female threaded connector, Hexagonal shape 1.5" dia Rubber rising main Centralizer fitted in every joint of piston rod.	m	13.72	100	1372
	e) 38mm dia GI Socket	Each	5	100	500
	f) Solvent Cement (100g Tube)	Tube	1	150	150
11	Installation of tubewell in required height from the RCC slab of ringwell including supplying of 38mm dia GI pipe and other material etc. All complete as per direction of the Engineer in Charge (E/C).	Each	1	300	300
12	Construction and settling of 100mm thick RCC (1:2:4) cover/slab (1150 mm dia) including fabrication of 10mm dia MS rod @ 150mm c/c in both direction, making provisions for 70mm dia hole in th e slab including supplying all the materials with 12mm thick plaster with neat cement finishing curing at least for 14 days etc.All complete as per direction of the Engineer in Charge (E/C).	m^3	0.25	6600	1650
13	Supplying, fitting and fixing 2nos 12mm dia M.S rod for holding of PVC pipe vertivally including 50mm x 6mm and 25mm x 6mm M.S plate with nut-bolt and making circular clamp which welding in the 2nos 12mm dia M.S rod both end. Clamp with M.S rod joint in ringwell climbing rod and PVC pipe with nut-bilt according to drawing etc. All complete as per direction of the Engineer in Charge (E/C).	set	2	210	420

Estimate of Ring well with 6 No Hand Pump					
Sl No	**Item of Works**	**Unit**	**Quantity**	**Unit Rate (BDT)**	**Total (BDT)**
14	Supplying, fitting and fixing of 38mm dia 0.6m long GI pipe with required bend for vent pipe as per drawing and fitting it on the ringwell cover slab with clamp etc. All complete as per direction of the Engineer in Charge (E/C).	Item	1	500	500
15	Construction of 250mm x 250mm x 200mm RCC block at the bottom of the pump and 150mm high footboard with 12mm NCF plastering using 19mm down grade picked jhama brick Khoa, sand and portland cement and curing etc. All complete as per direction of the Engineer in Charge (E/C).	Item	1	420	420
16	Compaction of soil around the ring well to make platform and filling the gap of around the site of ringwell from coarse snd to sanitary seal with excavated eart etc. All complete as per direction of the Engineer in Charge (E/C).	Item	1	720	720
17	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.	Item	1	1200	1200
18	Construction of concrete drain (1:2:4) with supplying all the materials as per drawing. All complete as per direction of the Engineer in Charge (E/C).	m	1	800	800
19	Disinfection of the ringwell with 1kg bleaching powder in water and bailing out water after one day untill smell of bleaching powder is gone. All complete as per direction of the Engineer in Charge (E/C).	Item	1	280	280
20	Water sample collection and test: Collection of water sample and testing for arsenic and fecal coliform by DPHE lab as per direction of the Engineer in Charge (E/C).	Test	2	600	1200
	Total Cost				**114199.60**

Rainwater Harvesting Cost:

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	L.S.	1.00	150.00	150.00

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

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

Sl. No.	Item of Works	Unit	Quanty	Unit Rate (BDT)	Total (BDT)
	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
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	P/Test (Fixed Item)	3.00	600	1,800.00

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

Table 5.3: Capital Cost estimation for Choto Harina Village

Village	Final Selected Intervention		Capital Cost (Tk.)
	Name	Number	
Choto Harina, Rangamati	1. Ring Well	50	5709980
	2. Rainwater Harvesting	50	2,548,471

Capital cost estimation for sanitation

Capital cost estimation of plain land is described below:

Single-pit to the twin-pit latrine

Design consideration of single pit to twin pit latrine is

- Single Pit Latrine that is being converted to Twin Pit Latrine Must be operational
- Water for washing should be adequate
- For Single Conversion , Pit must be Offset from latrine super structure
- An inspection Pit is required to handle the feces in pits properly; it is a simple Y-shaped mechanism..

- The Toilet should be in usable form. Otherwise, the latrine repair cost is to be added to the estimated cost.

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 of the site before commencing actual physical work and during the 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, and dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer-in-charge, where, payments are to be based on ground area determined by the Engineer-in-charge and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer-in-charge.	Sqm	3.00	169.00	507
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

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
5	One layer brick flat soling in foundation or in floor with first class/picked jhama bricks including preparation of bed and filling the interstices with local sand, leveling etc. complete and accepted by the Engineer-in-charge.	Sqm	0.75	420.00	315.00
6	Mass concrete (1:3:6) in floor with cement Sand (F.M. 1.2) and picked jhama chips including breaking chips, screening, mixing, laying, compacting to levels and curing for at least 7 days in/c the supply of water, electricity and other charges and costs of tools and plants etc. 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, thermal, fire resistivity properties etc. as per BSTI approved manufacturer standards or ASTM, BS/ISO/IS standards fitting and fixing in position with sockets, bends, of uPVC Pipe with all accessories such as round grating /domed roof grating bands, sockets etc. approved and accepted by the Engineer- in-charge.	RM	3	407	1221
10	R.C.C. Ring : Construction, Supplying, fitting and fixing of RCC rings of inner dia 48 inch and outer dia 52.5 inch, height 12 inch and thickness 2.25 inch having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C in horizontal & vertical directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc., w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, labor and transportation, VAT and IT)	Each	8	800	6400

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
11	R.C.C. Slab for soak well: Construction, Supplying, fitting and fixing of RCC (1:2:4) slab having 52.5 inch dia 3 inch thick having ratio of cement, sand and khoa (1:2:4) with supplying & fabrication of 10 no. MS/GI wire @ 6 inch C/C both directions, making climbing supports and casting concrete with 1/2 inch down-graded khoa (from picket brick) & 1.5 FM clean sand, crude oil etc., w/c ratio 0.45 including curing for at least 7 days, all complete as per drawing and direction of the Engineer-in-charge. (Including cost of all materials, 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**

Twin pit latrine

The capital cost estimation of the twin pit latrine is described below

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 of the site before commencing actual physical work. During the contract period and demobilization after completion works under contract are to be accepted by the Engineer-in-charge. This work shall cover clay cleaning and clearing, cutting or filling, and dressing the project area on and in the ground to an extent that all the events of works of the project can be executed smoothly in a working environment with a particular attention on safety and security in all respects, and to stockpile the end outcome to a place for disposal agreed by the Engineer-in-charge, where, payments are to be based on ground area determined by the Engineer-in-charge and be proportionate to the percentage progress of work under contract as a whole in all respects and approved by the Engineer-in-charge.	Sqm	7.50	169.00	1267.5
2	Earth work in excavation in all kinds of soil for foundation trenches including layout, providing center lines, local bench-mark pillars, levelling, ramming and preparing the base, fixing bamboo spikes and marking layout with chalk powder, providing necessary tools and plants, protecting and maintaining the trench dry etc., stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer-in-charge, subject to submit method statement of carrying out excavation work to the Engineer-in-charge for approval. However, engineer‟s approval shall not relieve the contractor of his responsibilities and obligations under the contract. Earthwork in excavation in foundation trenches up to 1.5 m depth and maximum 10 m lead: in soft clayey soil/ loose sand / silt	Cum	12.75	88	1122
3	Sand filling in trenches and plinth with sand having F.M-0.5 to 0.8 in 150 mm layers including leveling, watering and compaction to achieve minimum dry density of 90% with optimum moisture content (Modified proctor test) by ramming each layer up to finished level as per design supplied by the design office only etc. All complete and accepted by the Engineer in charge.	Cum	0.85	635	539.75
4	Supply, fitting and fixing of R.C.C Pre Cast Concrete (pillar ratio of cement, sand and khoa 1:2:4) having with 3nos 6mm dia M.S Bar in horizontal and tie bar #10 MS Wire at 8-inch C/C vertical directions. Column Size 4-inch x 4 inch and 108-inch long. fitting the same vertically in the ground as per drawing and direction of EIC.	Each	4	500	2000
5	Supplying and laying of single layer polythene sheet weighing one kilogram per 6.5 square meter in floor	Sqm	0.6	42	25.2

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	or any where below cement concrete complete in all respect and accepted by Engineer-in-charge.				
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 complete as per drawing & direction of the engineer-in-charge.	Cum	0.40	6647.00	2658.80
8	125 mm brick works with first class bricks in cement sand (F.M. 1.2) mortar (1:4) and making bond with connected walls including necessary scaffolding, racing out joints, cleaning and soaking the bricks for at least 24 hours before use and washing of sand curing at least for 7 days in all floors including cost of water,electricity and other charges etc. all complete and accepted by the Engineer.	Sqm	5.14	917	4713.38
9	Providing minimum 12 mm thick cement sand (F.M. 1.2) plaster with neat cement finishing to plinth wall with cement (1:4) up to 150 mm below ground level including washing of sand, finishing the edges and corners and curing at least for 7 days, cost of water, electricity, scaffolding and other charges etc. all complete in all respect as per drawing and accepted by the Engineer-in-charge. (Cement: CEM-II/A-M) ground floor.	Sqm	7.92	280	2217.60
10	Supplying, fitting and fixing of Bangladesh pattern, long pan with foot-rest, made of vitreous China clay and preparing the base of pan with cement mortar (1:4) and with wire mesh or rods, if necessary in all floors including making holes wherever required and mending good the damages and fitting, fixing, finishing etc. complete with all necessary fittings and connections approved and accepted by the Engineer-in- charge. 530 mm x 430 mm x 210 mm size, 12.5 kg of weight Color : White	Nos	1	1737	1737.00

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
11	Supplying 50 mm inside dia best quality uPVC waste and ventilation pipe having specific gravity 1.35 - 1.45, wall thickness 2.5 mm - 3.0 mm, and other physical, chemical, 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
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	Sqm	18.03	547	9862.41

Item No	Description of Items	Unit	Quantity	Rate	Amount in Taka
	etc. all complete and accepted by the Engineer-in-charge.				
17	Supply and installation of 38mm x 38mm x 3mm angle section as fitting the same on roof and fence with necessary materials including necessary wielding anti corrosive red/gery oxide paint etc. all complete and accepted by the Engineer-in-charge.	Rm	30	90	2700
18	**Other Supplies & Accessories fitting, fixing & supplying**				
18.1	Stud Nail (2.5 inch)	kg	2	80	160.00
18.2	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
18.3	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
18.4	Hinges	Nos	3	50	150.00
18.5	Screw for Hinges	Dozen	1	100	100.00
18.6	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
18.7	PVC pipe (1.5 dia) Gas Pipe	Ft	20	25	500.00
18.8	uPVC Long Trap (4" dia)	Nos	1	250	250.00
18.9	uPVC pipe (4" dia)	Ft	20	85	1700.00
	Total =				**49846.64**

Table 5.4: Capital cost for sanitation of Hill Area

Village	Final selected intervention		Cost	Total cost	Capital cost
	Name	Number			
Choto Harina,Rangamati	1. Single pit to twin pit latrine	390	16368.85	6383852	18845512
	2.Twin pit latrine	250	49846.64	12461660	

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 40 villages, 15 villages were selected to pilot the project and a detailed survey was conducted in these 15 villages. Study 4 concentrates on the water supply options in the selected village that falls in the hill district of Rangamati and a feasibility study of intervention in this village called Chota Harina is conducted in this section.

Both financial and economic analysis are done to judge the feasibility of the planned intervention to increase access to safe water. Chota Harina is a village in the southern hill district of Rangamati in the Chittagong hill tracts of Bangladesh. Geologically, the districts constitute of highlands where safe water sources are few and far between. Survey data shows there are 215 households in this village, and approximately 860 people live there. The sources of water used by the citizens in this village are given below.

Community Tubewell	Ring Welll	Tubewell	Personal Poject/pond	Hand dug well	Pond/River	Spring	Others
1	86	18	8	12	36	46	8

6.2 Financial Appraisal

Financial cost-benefit analysis of the investment has been carried out to ascertain the financial viability of the project in the village of Chota Harina. Moreover, the analysis measures the investment worth of the proposed intervention to improve existing water sources and build piped water supply system.

Identification of Costs and Benefits

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

Tangible benefits such as the value of time saved due to better access to safe water, health benefits realized as healthcare cost savings and the value of less productive time lost due to decreased rate of the 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 costs:** Cost of building the pipeline system, cost of installing deep tube wells
- **Maintenance costs:** For the sustainability of the project, required annual maintenance costs are necessary. The O&M costs are incurred due to operation and maintenance of the water supply 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 accruing after the implementation of the project. The financial O&M cost is 0.83 Lac.

Table 6.1: Financial Investment (BDT in Lac)

District	Upazila	Union	Village	Number of Household (HH)	Water Supply	Sanitation	Financial Cost (BDT in Lac)
Rangamati	Borkal	Bhushonchora	Chota Harina	215	90	203	293
Sub-total					90	203	293
Physical contingency							14.65
Price contingency							14.65
Total							322

Benefit: Three kinds of benefits are identified for this project and they are discussed below:

- **Time saving due to closer physical access to water and sanitation:** Immediate access and less waiting time for improved water sources means people use this time elsewhere in productive pursuits, giving rise to benefits.
- **Healthcare cost savings due to seeking less healthcare:** Significant and beneficial health impacts are associated with improvements in access to safe water[6]. Therefore, this project's benefits include a 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.
- **Savings related to less productive time losses due to disease**: As people will be sick less frequently than without a project, they will spend less time being sick and will be able to spend this time in productive pursuits, which is a benefit.

Table 6.2: Financial Benefits of the village (BDT in Lac)

Benefits		
Time saved benefit of water supply	**Time saved benefit of sanitation**	**Health benefit**
14	9	45

Analysis

For financial cost-benefit analysis, cash flow is the market value of the net incremental benefit of the project by a 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. The following Table shows the financial cash flow of the project.

Table 6.3: Financial Cash Flow (BDT in Lac)

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit sanitation	Time Saved Benefit water supply	Health Benefit	Total Benefit	
1	87.9		87.9				0	-87.9
2	117.2		117.2				0	-117.2

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

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit sanitation	Time Saved Benefit water supply	Health Benefit	Total Benefit	
3	117.2		117.2				0	-117.2
4		0.83	0.83	9	14	45	67.77	66.94
5		0.83	0.83	9	14	45	67.77	66.94
6		0.83	0.83	9	14	45	67.77	66.94
7		0.83	0.83	9	14	45	67.77	66.94
8		0.83	0.83	9	14	45	67.77	66.94
9		0.83	0.83	9	14	45	67.77	66.94
10		0.83	0.83	9	14	45	67.77	66.94
11		0.83	0.83	9	14	45	67.77	66.94
12		0.83	0.83	9	14	45	67.77	66.94
13		0.83	0.83	9	14	45	67.77	66.94
14		0.83	0.83	9	14	45	67.77	66.94
15		0.83	0.83	9	14	45	67.77	66.94
16		0.83	0.83	9	14	45	67.77	66.94
17		0.83	0.83	9	14	45	67.77	66.94
18		0.83	0.83	9	14	45	67.77	66.94
19		0.83	0.83	9	14	45	67.77	66.94
20		0.83	0.83	9	14	45	67.77	66.94

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 Price contingency 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;
- Only direct benefits are the value of time saved, savings on healthcare costs, and savings on the 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:

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

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)[7] is given below:

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

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).

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

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.

Result

Table 6.4: Result of Financial Analyis (BDT in Lac)

Economic Indicators	Values of the Indicators	Decision Rules
FNPV (BDT in lac)	84	Positive value is acceptable
FBCR	1.32	Value >1 is acceptable
FIRR	17%	≥ 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 greater 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 17% which is the expected compound annual rate of return that will be earned on this project. However, the real rate of return for each year may vary.

Concluding Remarks

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

6.3 Economic Appraisal

Economic adjustments are made to financial data using standard conversion factor after which costs and benefits are appraised from the point of view of the entire economy. Economic analysis measures the investment worth of the project from the perspective of the country as a whole. In this regard, cost-benefit comparison for the investment considering economic value (using efficiency or shadow

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

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 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:

- **Secondary Benefit:** There are numerous secondary 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.
- **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.

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 by applying conversion factors. The economic O&M cost is 0.74 Lac. Using the same approach and method, benefits are also adjusted for the economic values of components. For this purpose, the following guidelines have been used. These are given below:

- Conversion Factor (CF) for various broad components are taken from FPCO Guidelines[8] to adjust local financial prices (eliminating market distortions) for traded and non-traded items;
- 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).

The respective economic cost and benefit components and their values for the village are detailed in the following section.

Table 6.5: Economic Investment COST (BDT in Lac)

Text?	0.3	0.4	0.3					BDT in Lac	
Items of Cost	**Fincial cost**				**Conversion factor**	**Economic cost**			

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

Text?	0.3	0.4	0.3					BDT in Lac	
Year	**Year 1**	**Year 2**	**Year 3**	**Total**		**Year 1**	**Year 2**	**Year 3**	**Total**
Base cost	87.9	117.2	87.9	293	0.902	79	106	79	264
Physical contingency			14.65	15	0.902			13	13
Price contingency			14.65	15	0	0	0	0	0
Total	**87.9**	**117.2**	**117.2**	**322**		**79**	**106**	**93**	**278**

Table 6.6: Economic Benefit components of the village (BDT in Lac)

Benefits		
Time saved benefit of water supply	Time saved benefit of sanitation	Health benefit
13	8	40

Analysis

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 4. 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 6.7: 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	79		79.3				0	-79.29
2	106		105.7				0	-105.71
3	93		92.5				0	-92.50
4		0.7	0.7	13.0	7.8	40.3	61.1	60.4
5		0.7	0.7	13.0	7.8	40.3	61.1	60.4
6		0.7	0.7	13.0	7.8	40.3	61.1	60.4
7		0.7	0.7	13.0	7.8	40.3	61.1	60.4
8		0.7	0.7	13.0	7.8	40.3	61.1	60.4
9		0.7	0.7	13.0	7.8	40.3	61.1	60.4
10		0.7	0.7	13.0	7.8	40.3	61.1	60.4
11		0.7	0.7	13.0	7.8	40.3	61.1	60.4
12		0.7	0.7	13.0	7.8	40.3	61.1	60.4
13		0.7	0.7	13.0	7.8	40.3	61.1	60.4
14		0.7	0.7	13.0	7.8	40.3	61.1	60.4
15		0.7	0.7	13.0	7.8	40.3	61.1	60.4
16		0.7	0.7	13.0	7.8	40.3	61.1	60.4

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Benefit	Total Benefit	
17		0.7	0.7	13.0	7.8	40.3	61.1	60.4
18		0.7	0.7	13.0	7.8	40.3	61.1	60.4
19		0.7	0.7	13.0	7.8	40.3	61.1	60.4
20		0.7	0.7	13.0	7.8	40.3	61.1	60.4

Assumption

- Project's implementation period is 3 years;
- It is assumed that the project's economic life is 20 years;
- Discount rate is 12% 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;
- Standard conversion factor is 0.902

Indicators and the Analysis Results

Economic cost-benefit analysis has been carried out of 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. The positive value of ENPV indicates that the project is profitable, and benefits cover the investment and O&M costs during the 30-year plan period. The formula is given below:

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

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)[9] is given below:

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

Economic Internal Rate of Return (EIRR)

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

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).

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

Result

Table 6.8: Result of Economic Analyis

Economic indicators	Values of the indicators	Decision rules
ENPV (BDT in lac)	85	Positive value is acceptable
EBCR	1.37	Value >1 is acceptable
EIRR	17%	≥ 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 greater 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 17% 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 6.9: Results of Financial Sensitivity Analysis

text	Benefit decreased by 10%	Total cost increased by 10%	Best Case	Worst Case
FBCR	1.20	1.20	1.60	1.09
FNPV (BDT in Lac)	53	58	142	27
FIRR	15%	15%	20%	13%

Table 6.10: Results of Economic Sensitivity Analysis

text	Benefit decreased by 10%	Total cost increased by 10%	Best Case	Worst Case
EBCR	1.25	1.25	1.67	1.14
ENPV (BDT in Lac)	57	63	136	34
EIRR	16%	16%	21%	14%

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.

7.2.1 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

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

Activity/Issues	Anticipated Environmental Impacts	Proposed Mitigation and Enhancement Measures	Responsible Authority
	▪ Occupational health and safety	▪ 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
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.	▪ Avoid land acquisition as much as possible.	PMU, DPHE

Activity/Issues	Anticipated Environmental Impacts	Proposed Mitigation and Enhancement Measures	Responsible Authority
	▪ Loss of income and livelihoods. ▪ Social conflict.	▪ 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.	
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
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

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

Activity/Issues	Anticipated Environmental Impacts	Proposed Mitigation and Enhancement Measures	Responsible Authority
	environment and health of construction workers. • Solid wastes from the labor camp.	▪ 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.	
Offensive odor (from improper disposal of wastes, toilet effluent and faecal sludge)	• Unhygienic condition in the labor camp and construction site, improper disposal and management of liquid and solid wastes.	▪ Adopt proper waste management, effluent and faecal sludge management.	Contractor, PMU, DPHE
Safety Issues	• Construction activities like boring for TW, machinery operations, drilling for pipeline laying, etc.	• Prevent entry of unauthorized personnel and proper storage and control of hazardous materials on site • Health and safety training to the labors • All the labors to wear ID cards and provide adequate PPE • Child and forced labors are not allowed for any form of activities • Site(s) shall be secured by fencing and manned at entry points	Contractor, PMU, DPHE
Labor Issues	• Use of labors for various construction activities.	• Awareness building about prevention of child abuse, child marriage, GBV, sexual harassment, trafficking of women and children as well as illegal drug trade. • Ensure uses of PPE during the construction activities. • Adequate facilities ensuring COVID-19 protocols (PPE etc.) and adequate training on COVID-19 issues • Treated water will be made available at site for labor drinking purpose. • Evacuation facilities for symptomatic labors.	Contractor, PMU, DPHE
Occupational Health and Safety of the Workers and Construction Site	▪ .Lack of proper housing, water supply and sanitation facilities may cause health hazards of the workers. ▪ Improper liquid and solid wastes management cause environmental pollution	▪ 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.	Contractor, PMU, DPHE

Activity/Issues	Anticipated Environmental Impacts	Proposed Mitigation and Enhancement Measures	Responsible Authority
	▪ 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.	▪ 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; ▪ 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			

Activity/Issues	Anticipated Environmental Impacts	Proposed Mitigation and Enhancement Measures	Responsible Authority
Setting up and operation of drilling rig and drilling for installation of DTW	▪ Air and noise pollution affecting nearby settlements. ▪ Stock-pilling of earth.	▪ Consider use of noise attenuator in drilling rigs ▪ Remove stock-piled earth after completion of works.	Contractor, PMU, DPHE
Pump House construction and Electrical works	▪ Air and noise pollution affecting nearby settlements ▪ 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. ▪ Proper training should be provided to the community about the proper use of the sanitary facilities and tube wells.	WATSAN Committee, DPHE

Activity/Issues	Anticipated Environmental Impacts	Proposed Mitigation and Enhancement Measures	Responsible Authority
		▪ 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.

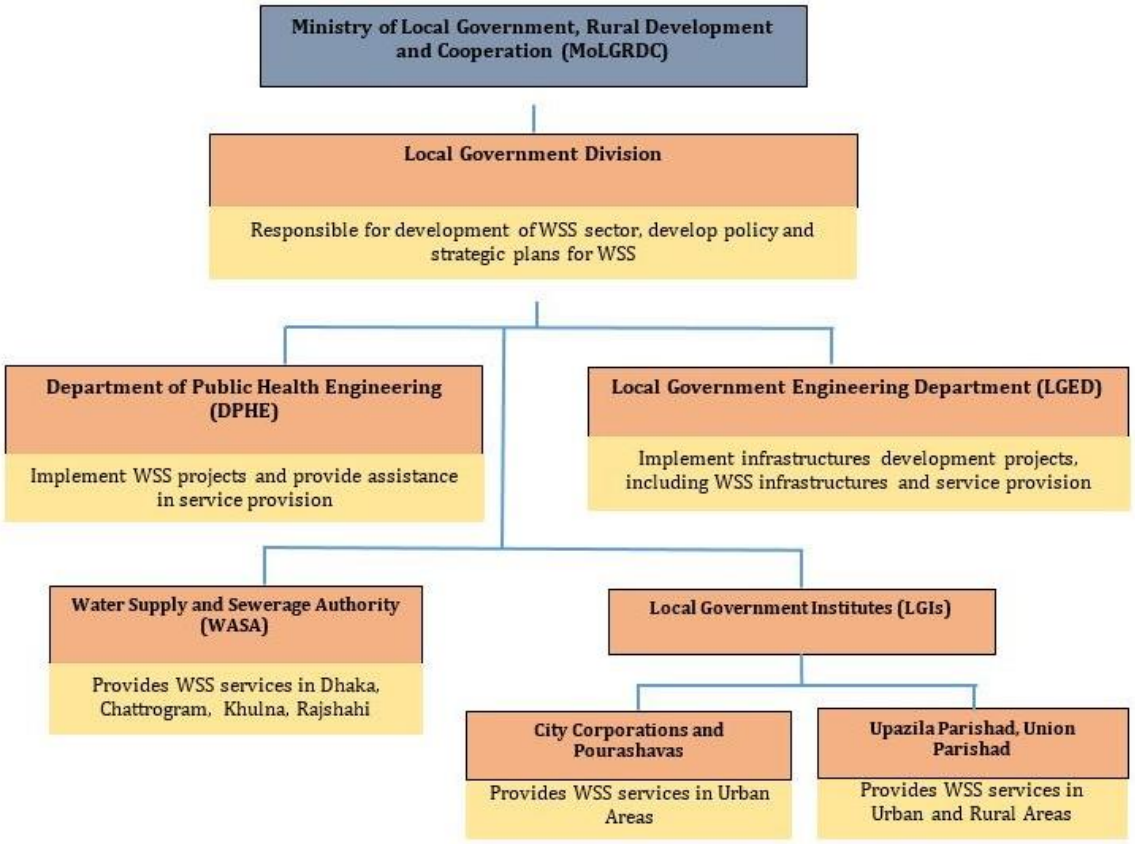

Figure 8.1: Institutional Framework of water supply and sanitation in Bangladesh

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.

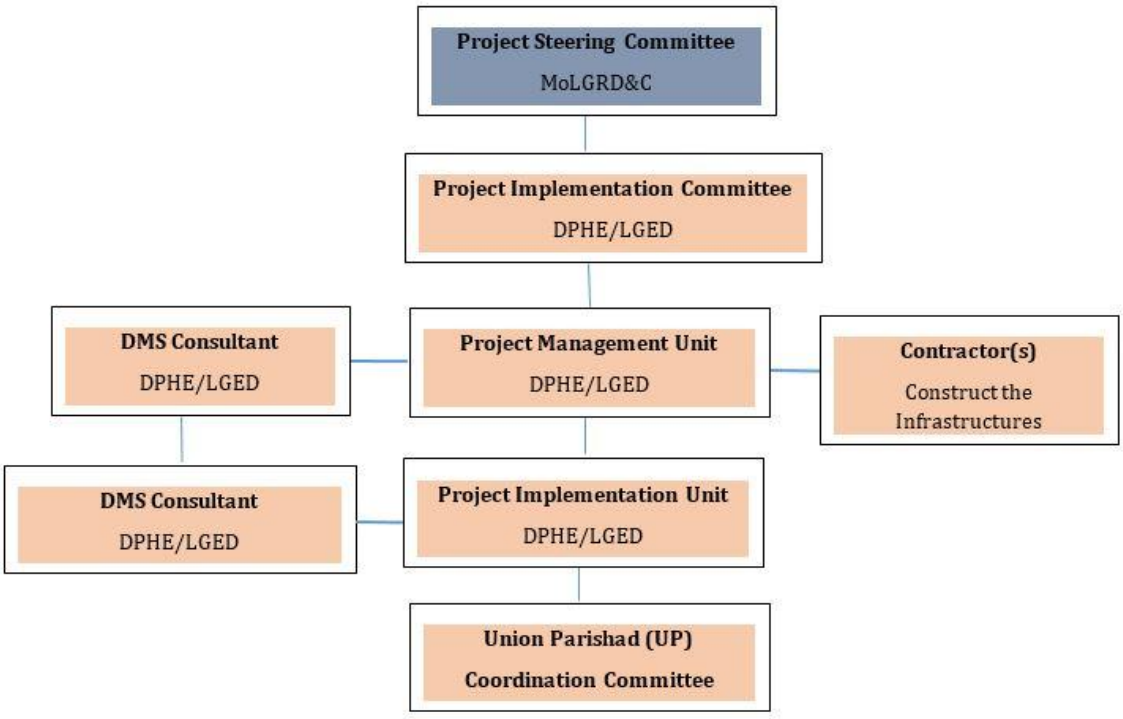

Figure 8.2: Organizational arrangement for project implementation of My Village My Town

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.
text	• 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 has been analyzed in the selected hilly areas ie-Chotoharina (Rangamati). To analyze the conditions a survey has been done by a group of team conducted by CEGIS. Some water samples have been collected during survey. The problem has been assessed by peoples' opinion and laboratory result of water sample testing. Based on problems, some technologies have been selected to solve the issues. Some designs have been formulated for implementation of technologies. Water is a basic needs of human. But the people of hilly areas are deprived due to their geological location. People in this area do not get sufficient water and proper sanitation all the year round. This study helps to meet their water demand and mitigate the poor condition of sanitation.

Some recommendations are-

- Provision of water supply during dry season in areas where pond and river water is the main source and they become dry;
- 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 iron removal treatment plant and water purification treatment plant where iron, odor and sewage problem have been found;
- Negative impacts to the environment should be mitigated;
- Reduce the cost as far as possible for the implementation of the project;
- Toilet need to implement at a safe distance from water source;
- A local team need to form to ensure the proper distribution of water and
- A meeting can be held to address the local people about importance of hygiene in every month.

Appendix I: Methodology

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:

- Development of draft questionnaires,
- Development of data collection tools, and
- 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:

- General Information of the Household,
- Water Supply System,
- Sanitation, and
- 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, and purification of water before drinking, and if the amount of water available at home is sufficient for drinking and cooking. Moreover, the cost of water source maintenance, water scarcity, causes of water shortage, recommendations for improvement, and the cost of improving the water supply system are vividly expressed in the questionnaire.

Sanitation Questionnaire

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

Awareness and Cleanliness Questionnaire

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

Development of data collection tools

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

I. Web-Version and

II. Mobile Version.

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

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 parameters of the questionnaire and tools and other WATSAN-related matters with the DPHE officials. The reconnaissance field visit contributed to refining the existing tools and preparing additional assessments of the tools.

Figure 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

There is 1 **village** in this survey. All the households were surveyed in Choto Harina village 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:

- Field team formation,
- Training the field team,
- Mobilization of the field team, and
- 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 2: GPS used for collection of the geographic location of HHs

Training of the Field Staff

After developing the digital questionnaire in the KoboCollect App, 60 enumerators conduct the field survey of 40 villages. 5 among them were supervisors. The questionnaire included latrine-related terms and other water supply sources. The 60 enumerators divided into 3 groups. A two-day training

program from 20 - 21 June 2022 was arranged to scrutinize the questionnaire and describe the terminology and other potentially confusing parts.

Figure 3: Field Staff Training

Mobilization of the field team

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

Collection of village-wise data using the developed questionnaires

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

I.7 Real-Time Verification of Data collection

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

Figure 4: Verification of Field Data at in-House

I.8 Data Management and Analysis

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

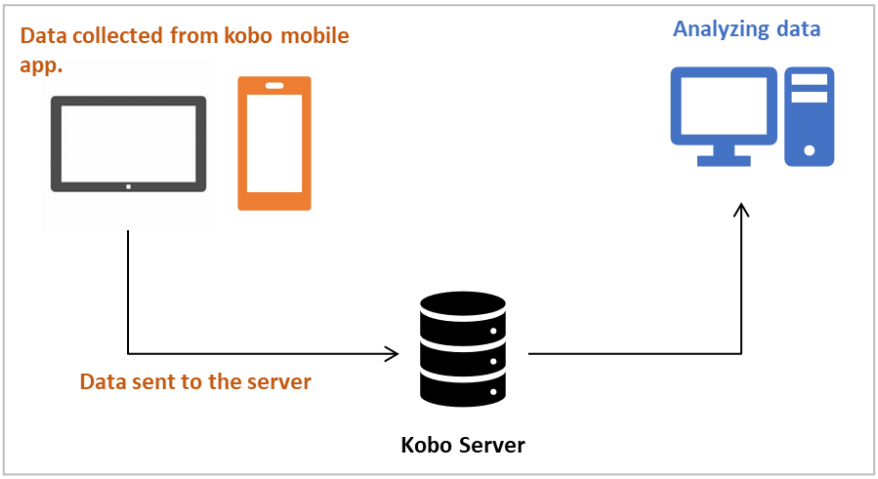

Figure5: Data Collection and Management

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.

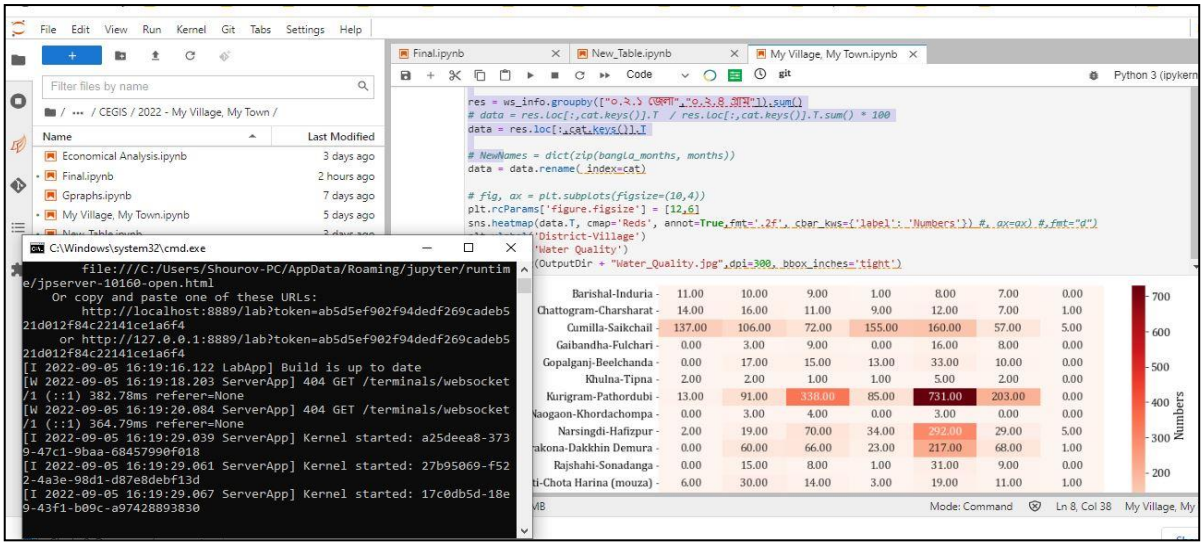

Figure 6: Data Analysis

I.9 Limitations and Constraints

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

Appendix II: Economic 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)
Rangamati	Borkal	Bhushonchora	Chota Harina	215	90	203	293
Sub-total					90	203	293
Physical contingency							14.65
Price contingency							14.65
Total							322

Table: O&M cost

District	Upazila	Union	Village	Number of Household (HH)	Number of Residents (apprx)	Average water source maintenance cost per year	Total Maintenance Cost
						BDT	BDT in Lac
Rangamati	Borkal	Bhushonchora	Chota Harina	215	860	384.14	0.826

Table: Time saved benefit of sanitation

Text						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
Cumilla	Monohorganj	Bipulshar	Shekchail	215	860	0.220	62.50	1080666	0.04407	62.5	216133	9

Table: Time saved benefit of water supply

Text						Without Project			With Project			Net Benefit
District	Upazila	Union	Village	Number of Household (HH)	Number of Residents (apprx)	Total Time Required for Access to Water	Value of Time per Person	Value of Time Required for Access to Water	Total Time Required for Access to Water	Value of Time per Person	Value of Time Required for Access to Water	Value of Time Saved Benefit of Intervenion
						Hour	Tk/hour	BDT	Hour	Tk/hour	BDT	BDT in Lac
Rangamati	Borkal	Bhushonchora	Chota Harina	215	860	0.368167	62.50	1805742.45	0.07363	62.50	361148.4896	14.446

Table: Health benefit

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)
Rangamati	Borkal	Bhushonchora	Chota Harina	215	860	6900	23%	15	84	500	45
Total								15			45

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)
Rangamati	Borkal	Bhushonchora	Chota Harina	215	860	1200	4%	3	14.6	500	8
Total								3			8

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)
Rangamati	Borkal	Bhushonchora	Chota Harina	215	860	5700	19%	12	69.35	500	37
Total								12			37

Table: Financial analysis (BDT in Lac)

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit sanitation	Time Saved Benefit water supply	Health Benefit	Total Benefit	
1	87.9		87.9				0	-87.9
2	117.2		117.2				0	-117.2
3	117.2		117.2				0	-117.2
4		0.83	0.83	9	14	45	67.77	66.94
5		0.83	0.83	9	14	45	67.77	66.94
6		0.83	0.83	9	14	45	67.77	66.94
7		0.83	0.83	9	14	45	67.77	66.94
8		0.83	0.83	9	14	45	67.77	66.94
9		0.83	0.83	9	14	45	67.77	66.94
10		0.83	0.83	9	14	45	67.77	66.94
11		0.83	0.83	9	14	45	67.77	66.94
12		0.83	0.83	9	14	45	67.77	66.94
13		0.83	0.83	9	14	45	67.77	66.94
14		0.83	0.83	9	14	45	67.77	66.94

Year	Cost			Benefit				Cash Flow
	Investment Cost	**Maintenance Cost**	**Total Cost**	**Time Saved Benefit sanitation**	**Time Saved Benefit water supply**	**Health Benefit**	**Total Benefit**	
15		0.83	0.83	9	14	45	67.77	66.94
16		0.83	0.83	9	14	45	67.77	66.94
17		0.83	0.83	9	14	45	67.77	66.94
18		0.83	0.83	9	14	45	67.77	66.94
19		0.83	0.83	9	14	45	67.77	66.94
20		0.83	0.83	9	14	45	67.77	66.94
Total			**260**				**343**	**84**
Financial Net Present Value (FNPV)								84
Financial Benefit Cost Ratio (FBCR)								1.323298371
Financial Internal Rate of Return (FIRR)								17%

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	88	-88	0	97	-97	0	80	-80	0	97	-97
2	0	117	-117	0	129	-129	0	107	-107	0	129	-129
3	0	117	-117	0	129	-129	0	107	-107	0	129	-129
4	62	1	61	68	1	67	75	1	74	62	1	61
5	62	1	61	68	1	67	75	1	74	62	1	61
6	62	1	61	68	1	67	75	1	74	62	1	61
7	62	1	61	68	1	67	75	1	74	62	1	61
8	62	1	61	68	1	67	75	1	74	62	1	61
9	62	1	61	68	1	67	75	1	74	62	1	61
10	62	1	61	68	1	67	75	1	74	62	1	61
11	62	1	61	68	1	67	75	1	74	62	1	61
12	62	1	61	68	1	67	75	1	74	62	1	61
13	62	1	61	68	1	67	75	1	74	62	1	61

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	62	1	61	68	1	67	75	1	74	62	1	61
15	62	1	61	68	1	67	75	1	74	62	1	61
16	62	1	61	68	1	67	75	1	74	62	1	61
17	62	1	61	68	1	67	75	1	74	62	1	61
18	62	1	61	68	1	67	75	1	74	62	1	61
19	62	1	61	68	1	67	75	1	74	62	1	61
20	62	1	61	68	1	67	75	1	74	62	1	61
21	**312**	**260**	**53**	**343**	**285**	**58**	**378**	**236**	**142**	**312**	**285**	**27**
22	FBCR		**1.20**	FBCR		**1.20**	FBCR		**1.60**	FBCR		**1.09**
23	FNPV		**53**	FNPV		**58**	FNPV		**142**	FNPV		**27**
24	FIRR		**15%**	FIRR		**15%**	FIRR		**20%**	FIRR		**13%**

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	79		79.3				0	-79.29
2	106		105.7				0	-105.71
3	93		92.5				0	-92.50
4		0.7	0.7	13.0	7.8	40.3	61.1	60.4
5		0.7	0.7	13.0	7.8	40.3	61.1	60.4
6		0.7	0.7	13.0	7.8	40.3	61.1	60.4
7		0.7	0.7	13.0	7.8	40.3	61.1	60.4
8		0.7	0.7	13.0	7.8	40.3	61.1	60.4
9		0.7	0.7	13.0	7.8	40.3	61.1	60.4
10		0.7	0.7	13.0	7.8	40.3	61.1	60.4
11		0.7	0.7	13.0	7.8	40.3	61.1	60.4
12		0.7	0.7	13.0	7.8	40.3	61.1	60.4
13		0.7	0.7	13.0	7.8	40.3	61.1	60.4
14		0.7	0.7	13.0	7.8	40.3	61.1	60.4
15		0.7	0.7	13.0	7.8	40.3	61.1	60.4
16		0.7	0.7	13.0	7.8	40.3	61.1	60.4
17		0.7	0.7	13.0	7.8	40.3	61.1	60.4
18		0.7	0.7	13.0	7.8	40.3	61.1	60.4
19		0.7	0.7	13.0	7.8	40.3	61.1	60.4
20		0.7	0.7	13.0	7.8	40.3	61.1	60.4
Total			**225**				**310**	**85**

Year	Cost			Benefit				Cash Flow
	Investment Cost	Maintenance Cost	Total Cost	Time Saved Benefit water supply	Time Saved Benefit sanitation	Health Benefit	Total Benefit	
Economic Net Present Value (ENPV)								85
Economic Benefit Cost Ratio (EBCR)								1.378694845
Economic Internal Rate of Return (EIRR)								17%

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	79	-79	0	87	-87	0	72	-72	0	87	-87
2	0	106	-106	0	116	-116	0	96	-96	0	116	-116
3	0	93	-93	0	102	-102	0	84	-84	0	102	-102
4	56	1	55	61	1	60	67	1	67	56	1	55
5	56	1	55	61	1	60	67	1	67	56	1	55
6	56	1	55	61	1	60	67	1	67	56	1	55
7	56	1	55	61	1	60	67	1	67	56	1	55
8	56	1	55	61	1	60	67	1	67	56	1	55
9	56	1	55	61	1	60	67	1	67	56	1	55
10	56	1	55	61	1	60	67	1	67	56	1	55
11	56	1	55	61	1	60	67	1	67	56	1	55

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**
12	56	1	55	61	1	60	67	1	67	56	1	55
13	56	1	55	61	1	60	67	1	67	56	1	55
14	56	1	55	61	1	60	67	1	67	56	1	55
15	56	1	55	61	1	60	67	1	67	56	1	55
16	56	1	55	61	1	60	67	1	67	56	1	55
17	56	1	55	61	1	60	67	1	67	56	1	55
18	56	1	55	61	1	60	67	1	67	56	1	55
19	56	1	55	61	1	60	67	1	67	56	1	55
20	56	1	55	61	1	60	67	1	67	56	1	55
	282	**225**	**57**	**310**	**247**	**63**	**341**	**204**	**136**	**282**	**247**	**34**
	EBCR		**1.25**	EBCR		**1.25**	EBCR		**1.67**	EBCR		**1.14**
	ENPV		**57**	ENPV		**63**	ENPV		**136**	ENPV		**34**
	EIRR		**16%**	EIRR		**16%**	EIRR		**21%**	EIRR		**14%**

Appendix III: Water Supply and Sanitation Demand

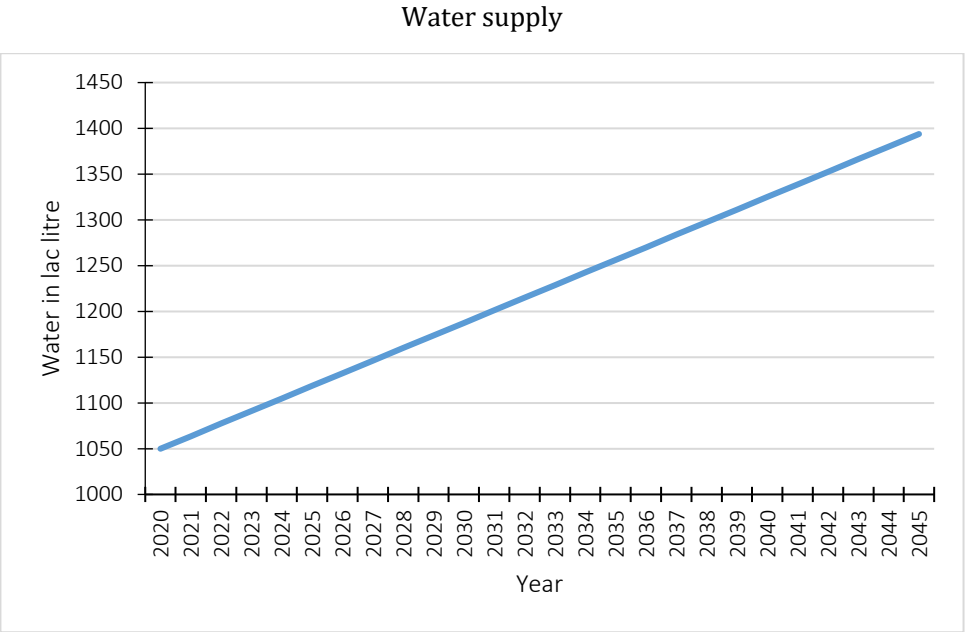

Figure: Yearly overall water demand 2020-2045 period before project implementation

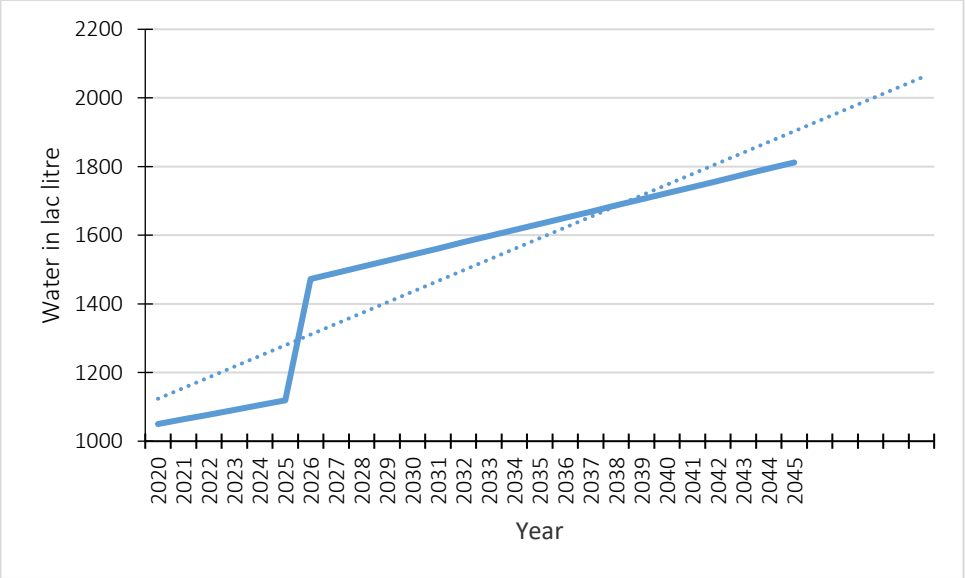

Figure: Yearly overall water demand 2020-2045 period after project implementation

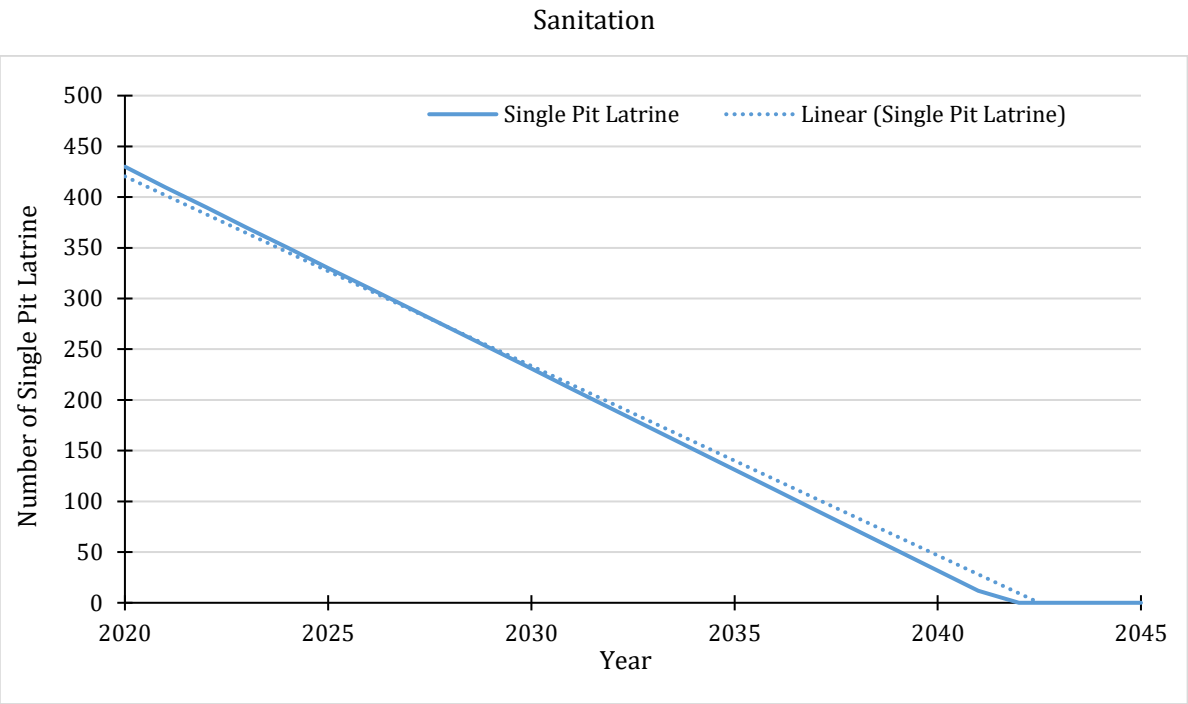

Figure: Before implementation Existing single pit latrine for a period of 2020-2045 period

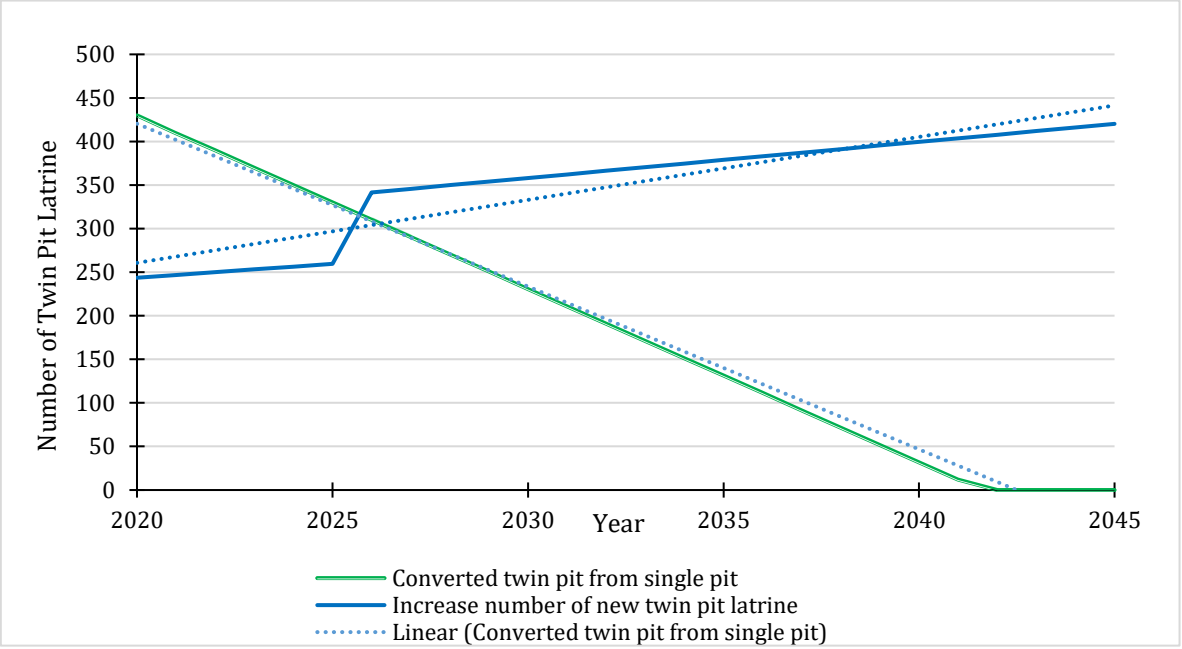

Figure: After implementation Converted and new Twin pit latrine for a period 2020-2045