Drinking Water Assessment Report:
Climate resilient drinking water solutions for Khulna and Satkhira

Prepared for Government of Bangladesh and United Nations Development Program –
By WaterAid Bangladesh

Abbreviations

BBS	:	Bangladesh Bureau of Statistics
BDT	:	Bangladeshi Taka
BOT	:	Build – Operate – Transfer
BWDB	:	Bangladesh Water Development Board
CBO	:	Community Based Organisation
CCTF	:	Climate Change Trust Fund
DHTW	:	Deep Hand Tube Well
DPHE	:	Department of Public Health Engineering
EC	:	Electrical Conductivity
FC	:	Faecal Coliform
GIS	:	Geographic Information System
GIZ	:	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOB	:	Government of Bangladesh
HH	:	Household
ICCAD	:	International Conference on Computer Aided Design
ITN-BUET	:	International Training Network – Bangladesh University of Engineering and Technology
JMP	:	Joint Monitoring Programme
KM	:	Kilometre
LGSP	:	Local Government Support Project
LPCD	:	Litre Per Capita Per Day
LPD	:	Litre Per Day
MAR	:	Managed Aquifer Recharge
MIS	:	Management Information System
MoEF	:	Ministry of Environment and Forest
NAPA	:	National Adaptation Programme of Action
O&M	:	Operation and Maintenance
PPP	:	Public Private Partnership
PPT	:	Parts Per Thousand
PRA	:	Participatory Rapid Appraisal
PSF	:	Pond Sand Filter
PWS	:	Piped Water System
RO	:	Reverse Osmosis
RWH	:	Rain Water Harvesting
RWHS	:	Rain Water Harvesting System
SHTW	:	Shallow Hand Tube Well
SMC	:	School Management Committee
Sq.km	:	Square Kilometre
TC	:	Total Coliform
TDS	:	Total Dissolved Solids
TSS	:	Total Suspended Solids
UNDP	:	United Nations Development Programme
UNICEF	:	United Nations Children's Emergency Fund
UP	:	Union Parishad
WAB	:	WaterAid Bangladesh
WSP	:	Water Safety Plan
WSP-WB	:	Water and Sanitation Program – The World Bank

Contents

1 Introduction

1.1 Project Background and Objectives

This report comprises a comprehensive drinking water supply and demand analysis of the communities (hereinafter called as 'the study') of 39 Unions[1] under 5 selected Upazilas[2] of Khulna and Satkhira Districts of Bangladesh, and proposes climate-resilient technology solutions to provide year-round, safe and sustainable water supply for the communities. The operation and access to these technological solutions will be accompanied with proven interventions to improve or create institutional arrangements/mechanisms, which will, particularly, facilitate women's empowerment. This report will provide relevant information for the Green Climate Fund (GCF) project proposal, entitled "Enhancing adaptive capacities of coastal communities, especially women, to cope with climate change induced salinity". As part of the design process and development of the feasibility study for the project, WaterAid Bangladesh is playing an anchoring role to support GOB-UNDP by leveraging its long and demonstrated sectoral experience as well as outsourcing consultancy services.

1.2 Methodology

The study was mainly based on qualitative research methods, i.e. a Participatory Rapid Appraisal (PRA) process for identification and mapping of functional[3] and potential[4] drinking water sources (as per agreed definitions – see footnotes 3 & 4) in the targeted communities at household, community, and institutional levels. A comprehensive literature review of secondary sources complements primary data and facilitates the identification of the most feasible interventions.

The PRA process involves two stages of participatory community consultations – firstly, at Ward level (i.e. Ward PRA on water source mapping) with knowledgeable community members (both men and women) represented by various social groups (comprising 8-10 participants in each session), e.g. elected Ward members, teachers, housewives, religious leaders and social workers[5]. The participants of Ward level PRA session were selected and invited by the concerned Ward member[6]. In the PRA session, social maps were developed and the existing functional and potential water sources were identified in the maps. Further, the proposed need of water points were assessed by the participants. A checklist was used in PRA sessions to collect demographic, technology options (being used for drinking water purpose), water sources, disasters, climate change and gender-related information from each union under the study, and then information was compiled per upazila and then per district. Table 1 to Table 6 presented below show the total and upazila wise gender-disaggregated participant numbers of community and Union Parishad (UP) representatives who attended the PRA process/sessions undertaken at ward and union levels.

At union level, nine ward maps were compiled by using union maps where all ward level information of existing (including potential) water technology options were first plotted, and thereby, based on identified gaps, (in terms of coverage of households and pocket areas where there are no options) proposed technology options were cited/plotted in consultation with respective UP Chairman and Members (both male and female) including the secretary. Upazila-wise representatives in PRA sessions are presented in Table 1 to Table 6.

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[1] Out of a total 49 Unions under five specific upazilas selected by GOB/UNDP

[2] Upazilas include 3 e.g. Paikgacha, Koyra and Dacope from Khulna District, and 2 e.g. Shyamnagar and Assasuni from Satkhira District

[3] Water sources/options that are currently being used by the local communities for drinking purposes (i.e. non-saline)

[4] Water sources/options that are newly installed but yet to be operational as well as options that are presently not working/functional but with little repair and maintenance those will become functional

[5] Community members and ward members are different, while a UP Ward is a lowest tire of Bangladesh local government structure beyond Union Parishad (a union consists of 9 wards) and constituted by a number of communities/villages

[6] Ward Member is one of the elected representatives of the lowest tire of local government structure i.e. UP

Table 1: Total representation of communities and local government representatives in the PRA process

Upazila	# of Union	# of UP Wards	# of PRA sessions	# of Participants by Upazila			Population
				Male	Female	Total	
Assasuni	10	90	100	633	341	974	242,056
Dacop	9	81	90	546	286	832	137,681
Koyra	7	63	70	418	157	575	193,934
Paikgacha	5	45	50	294	105	399	109,258
Shyamnagar	8	72	80	457	259	716	216,125
Total:	39	351	390	2348	1148	3496	899,054

Male: 67.2%   Female: 32.8%

Table 2: Participants who attended the PRA process at Paikgacha Upazila

Name of Union	# of Union	# of Wards	# of PRA sessions	# of Participants by Union			Population
				Male	Female	Total	
Deluti	1	9	10	57	19	76	15,555
Chandkhali	1	9	10	64	21	85	37,735
Garaikhali	1	9	10	55	22	77	22,806
Lata	1	9	10	53	24	77	10,856
Soladana	1	9	10	65	19	84	22,307
Total:	5	45	50	294	105	399	109,259

Male: 73.7%   Female: 26.3%

Table 3: Participants who attended the PRA process at Koyra Upazila

Name of Union	# of Union	# of Wards	# of PRA sessions	# of Participants by Union			Population
				Male	Female	Total	
Amadi	1	9	10	63	19	82	33,184
Bagali	1	9	10	52	25	77	34,478
Koyra	1	9	10	55	28	83	33,231
Moharajpur	1	9	10	55	20	75	31,069
Moheswaripur	1	9	10	64	20	84	29,993
North Bedkashi	1	9	10	66	26	92	15,225
South Bedkashi	1	9	10	63	19	82	16,756
Total:	7	63	70	418	157	575	193,936

Male: 72.7%   Female: 27.3%

Table 4: Participants who attended the PRA process at Dacope Upazila

Name of Union	# of Union	# of Wards	# of PRA sessions	# of Participants by Union			Population
				Male	Female	Total	
Bajua	1	9	10	61	30	91	15,754
Banishanta	1	9	10	53	35	88	14,607
Dacope	1	9	10	55	34	89	7,048
Kailashganj	1	9	10	59	36	95	14,517
Kamarkhola	1	9	10	68	27	95	13,897
Laudubi	1	9	10	54	41	95	9,223
Pankhali	1	9	10	63	32	95	15,570
Sutarkhali	1	9	10	67	22	89	44,127
Tildanga	1	9	10	66	29	95	30,060
Total:	9	81	90	546	286	832	164,803

Male: 65.6% Female: 34.4%

Table 5: Participants who attended the PRA process at Shyamnagar Upazila

Name of Union	# of Union	# of Wards	# of PRA sessions	# of Participants by Union			Population
				Male	Female	Total	
Atulia	1	9	10	54	39	93	30,413
Burigoalini	1	9	10	52	40	92	24,914
Gabura	1	9	10	54	25	79	31,115
Kaikhali	1	9	10	68	28	96	24,608
Kashimari	1	9	10	61	36	97	26,657
Munshiganj	1	9	10	51	27	78	31,832
Ramjan Nagar	1	9	10	57	32	89	21,932
Padmapukur	1	9	10	60	32	92	24,654
Total:	8	72	80	457	259	716	216,125

Male: 63.8% Female: 36.2%

Table 6: Participants who attended the PRA process at Assasuni Upazila

Name of Union	# of Union	# of Wards	# of PRA sessions	# of Participants by Union			Population
				Male	Female	Total	
Anulia	1	9	10	62	39	101	24,710
Assasuni	1	9	10	54	41	95	23,625
Bardal	1	9	10	69	33	102	28,038
Budhata	1	9	10	72	29	101	29,540
Durgapur	1	9	10	70	29	99	16,201
Kadakati	1	9	10	55	40	95	14,121
Khajra	1	9	10	47	45	92	26,047
Kulla	1	9	10	67	29	96	24,562
Sreeula	1	9	10	74	23	97	25,962
Pratapnagar	1	9	10	63	33	96	29,251
Total:	10	90	100	633	341	974	242,057

Male: 65.0% Female: 35.0%

The results of the analyses of collected-data are presented in Chapter 8: Upazila and Union Profiles. The climate resilient recommendations were based on: resiliency to observed and project climate change impacts including salinity, rainfall variability, and cyclone risks, gender sensitive and sustainable technological options per site, community preferences, accessibility, and nationally acceptable, appropriate technological options for saline coastal zones of the country. Nationally recognized standard and proven[7] Operation and Maintenance (O&M) models[8] have been considered for cost estimation and recommendations on institutional arrangement/mechanism of each proposed water supply technology option.

This synthesis report is developed based on a desk review of available secondary references and primary data collected through the PRA process in the upazila communities. During the development of union and upazila reports, a separate review of relevant secondary data sources was undertaken, particularly relevant to the studied unions and upazilas.

2 Coastal Context

2.1 Low Lying Coastal Areas

The coastal zone of Bangladesh includes 19 districts alongside the coastline of 710 km. The coastal zone extends over 47,150 sq km area and has a population of 38.52 million[9]. The coastal zone is different from the rest of the country and has been characterized by three features: (i) Level of tidal fluctuations, (ii) Salinity condition (both surface and ground water), and (iii) Risks of cyclone, storm surge and tidal influence.

The 19 coastal districts have been further divided into interior (7 districts, 48 upazilas) and exposed (12 districts, 99 upazilas) zones, with regards to distance from the coast or the estuaries, under the Integrated Coastal Zone Management Project (ICZMP) of Water Resources Planning Organization (WARPO). The zone is characterized by a vast network of rivers and channels, enormous discharge of water with huge amount of sediments, many islands, the Swatch of No Ground (underwater canyon located 45 km south of the Sundarbans in Bangladesh), shallow northern Bay of Bengal, strong tidal influence and wind actions, tropical cyclones and storm surges.

The coastal zone has been divided into three regions based on the hydro-morphological characteristics, (i) The Ganges Tidal Plain or the Western Coastal Region, (ii) The Meghna Deltaic Plain or the Central Coastal Region and (iii) The Chittagong Coastal Plain or the Eastern Coastal Region (Pramanik, 1983 cited in Islam, 2001; BUET and BIDS, 1993). The average elevation of the coastal zone ranges from 1-2 m in the southwest and from 4-5 m in the southeast[10] (see Figure 2). The low-lying flat topography and dynamic morphology of the zone significantly contributes to its vulnerability to sea level change.

[7] National Encyclopedia of Bangladesh
[8] Cited standards and models are detailed and referred to their relevant sources (including examples) in the Section 7 titled "institutional arrangement/mechanism"
[9] BBS 2011
[10] Assesment of Sea Level Rise on Bangladesh Coast through Trend Analysis, July 2016

Figure 1. Affected areas in coastal zone

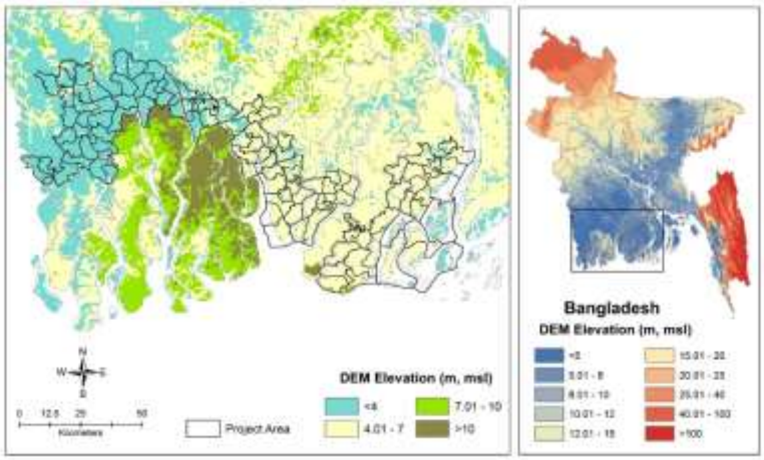


Figure 2: Elevation Map of the Southwest Coastal Zone (prepared using NASA's SRTM data)

The coastal zone extends from the Bangladesh-India border in the west to the Tetulia River in the east. It is mainly covered by the Sundarbans mangrove forest, greater Khulna and part of Patuakhali District. The zone is relatively stable because of the mangrove forest which acts as a natural barrier against cyclones, storm surges and soil erosion. Swamps, tidal flood plain and natural levees are found with numerous tidal creeks. This zone is a semi active delta mostly composed of silty loams or alluvium washed down from the Himalayas[11].

The coastal area is a tidal river zone with narrow levees adjoining the numerous tidal rivers and creeks which are criss-crossed along the region. The western part of the South West region remains more saline than the eastern part. This is because of the Gorai River, distributary from the Ganges, is the only significant upstream fresh water source in the western part of the region, and suffers a serious decline in dry season freshwater inflows under post-Farakkha condition. The eastern part of South West region remains less saline as it receives freshwater flow from the Padma and lower Meghna River through Arial Khan, Bishkhali and Buriswar River (IWM, 2014). As a result, salinity levels in the region decrease from west to east as well as from south (the Bay of Bengal) to north. It has been reported that saline river water accumulates more than 150 km inland in the west during dry season but only 50 km in east.

As protection against the instability of low-lying lands, 129 polders were built in the coastal region by a project supported by the Government of Netherlands.

2.2 Hydrological Systems and Climate

The spatial distribution of temperature shows that the coastal zone is relatively warmer in the winter and the thermal gradient is positive towards the south [Figure3(a)]. The temperature is very high in the central western part of the country, which extends up to the western coastal zone, whereas the eastern coastal zone has a slightly milder temperature [Figure3(b)]. The maximum temperature in April is relatively low in the northeastern and southeastern part of the country. In the coastal area, the temperature increases from east to west in the summer.

[11] Islam, 2001

Bangladesh receives on an average 2,425 mm of precipitation/year, having a standard deviation of around 286 mm. Most of the precipitation occurs in the monsoon season (June-September) amounting to 1,750 mm which is 72% of the total annual precipitation. The pre-monsoon season receives about 17% of the annual precipitation. The post-monsoon season occupies 9.1% of the annual precipitation. The winter is relatively dry and receives only 1.5% of the annual precipitation.[12] (Figure 4)

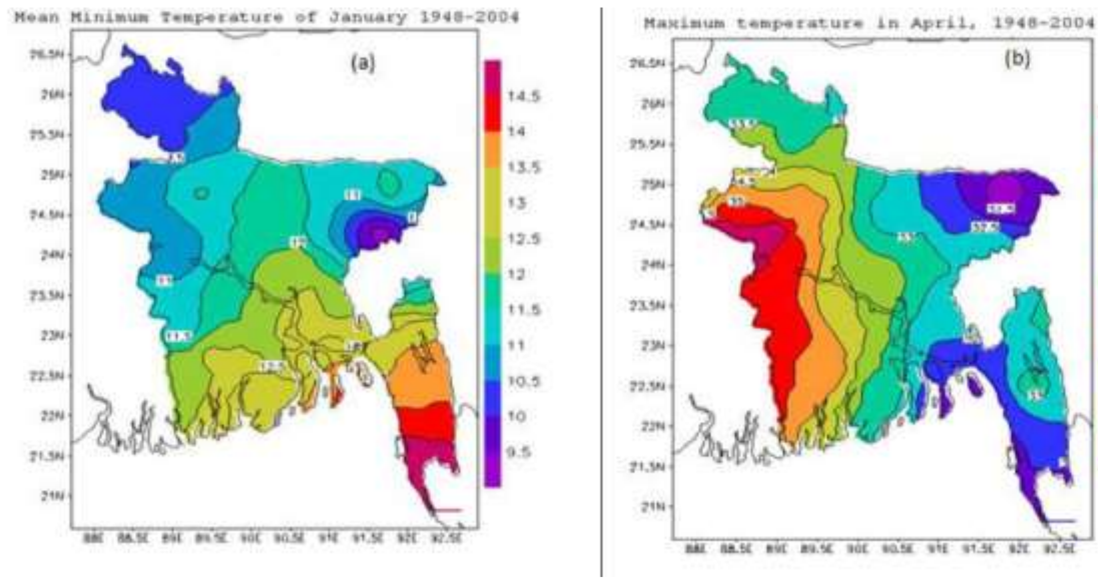
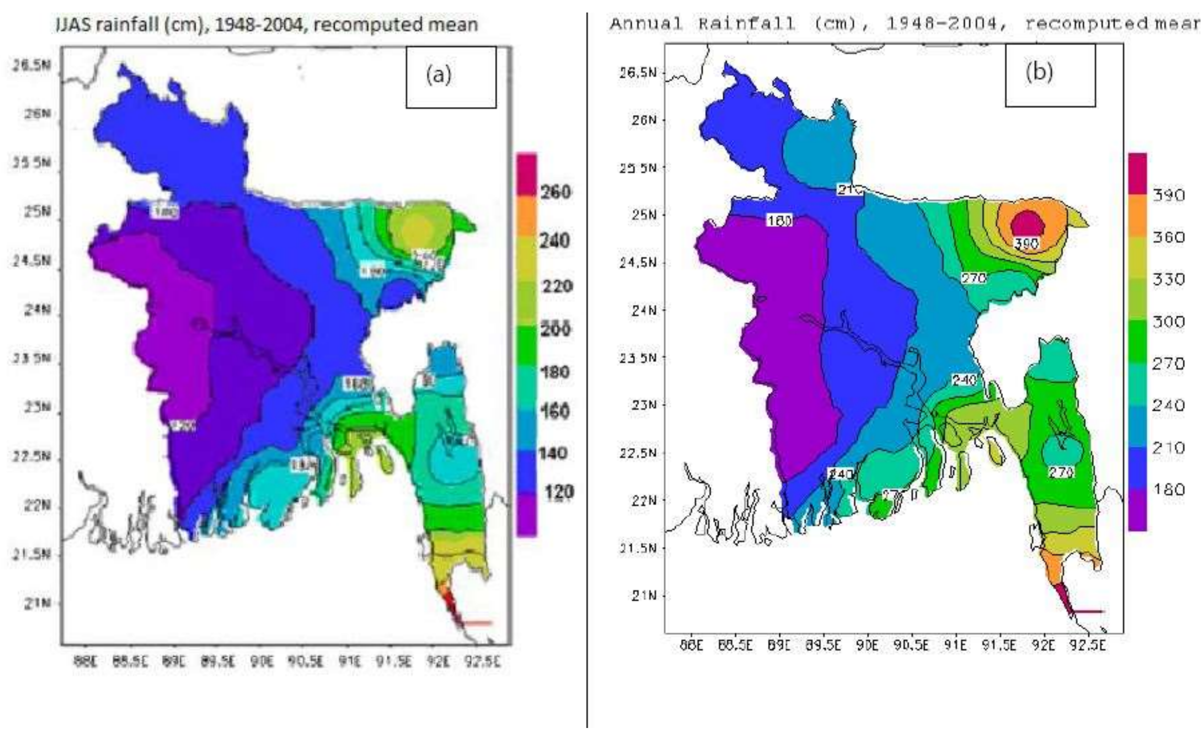


Figure 3: Geographical distribution of climatology of the minimum and maximum temperature in (a) January and (b) April[13]



[12] Bangladesh Delta Plan 2100; Climate Change, August 2015

[13] Bangladesh Delta Plan 2100; Climate Change, August 2015

Figure 4: Distribution of monsoon precipitation (a), and annual precipitation (b) in cm[14]

The geographical variation of annual and monsoon precipitation is large in Bangladesh [Figure 4 (a,b)]. The wettest parts of the country are the north-east and south-east where monsoon precipitation is around 2,000-2,800 mm and the total annual precipitation between 3,000 and 4,000 mm.[15] Relatively low precipitation is obtained in central-western Bangladesh which is oriented in the north–south direction. The low precipitation area bulges towards central Bangladesh. The distribution pattern is more or less similar for both annual and monsoon. The geographic distribution of annual precipitation shows that the coastal zone experiences around 1800-4000 mm of precipitation, but it is relatively higher over the southeastern coastal zone and gradually decreases towards the west.[16] The deficit and excess precipitation from normal becomes critical causing droughts and floods. Low pre-monsoon and monsoon precipitation and high temperature in these seasons have caused the western part of the delta to become highly drought-prone. Excessive precipitation over Bangladesh and in the upper catchment of the Ganges Brahmaputra and Meghna (GBM) River system causes devastating floods. The floods of 1974, 1988, 1998 and 2007 are worth mentioning. Further reference is made to the baseline studies on water resources and disaster management.

2.3 Socioeconomic Condition

2.3.1 Population

The last official census of Bangladesh was carried out in 2011, according to which the population stood at 142 million. The World Bank reported that, the population of Bangladesh was 161 million in 2015 and the average population density for the country was 1237 people per sq. kilometre which ranked 10th in the world. This high density is partly due to a rapid population boom that occurred in Bangladesh in the latter part of the 20th century. The coastline is 734 km, involving coastal and island communities of about 50 million people, nearly one-third of the total population of Bangladesh. The coastal zone covers 19 out of 64 districts facing or in proximity to, the Bay of Bengal, encompassing 153 Upazilas (MoWR, 2006). Out of these 19 districts, only 12 districts meet the sea or lower estuary directly. The coastal zone covers 47,201 square kilometre land-area, which is 32% of total landmass of the country (Islam, 2004). Pramanik (1983) divided the Bangladesh coastal zone into three regions namely; eastern, central and western coastal regions (Hossain and Hossain, 2008).

Population density in the eastern coastal districts (i.e. Chittagong, Cox's Bazar, Noakhali) is 1136 per sq.km, while in the Central coastal districts (i.e. Jalokathi, Pirojpur, Barisal, Bhola, Barguna, Patuakhali) the population density is 630 per sq.km and 475 per sq.km in the western coastal districts (i.e. Khulna, Satkhira, and Bagerhat).

2.3.2 Economic Status

Although the country has made considerable progress over the last few decades in growing the country's economy, with an average GDP growth rate of 5.72% since 1994 that peaked in 2016 at 7.05%, much of the population still finds itself below the poverty line. Additionally, while the percentage of the population in poverty has decreased in the last decade, the percentage of those in extreme poverty has remained the same.

Along with the Rangpur area, the southwest of Bangladesh is amongst the poorer regions of the country. About 16-35% of people living in Khulna are considered to be extreme poor; whereas in Barisal the

[14] Bangladesh Delta Plan 2100; Climate Change, August 2015
[15] Bangladesh Delta Plan 2100; Climate Change, August 2015
[16] Bangladesh Delta Plan 2100; Climate Change, August 2015

percentage of extreme poor ranges from 6% of less in the southern most districts, and more than 35% in the city[17].

The economy of Khulna is predominantly agricultural. But its economy is also dependent on the Sundarbans and Mongla port. According to the current agriculture census, the total holdings of the district is 503 thousand of which 41.31% holding are farms those produce varieties of crops, namely local and HYV paddy, wheat, jute, vegetables, spices, pulses, oilseeds, sugarcane and others. Various fruits like mango, banana, Jackfruit guava, coconut and betel nut etc. are grown. Fish of different varieties abound in the district as in other parts of the country. Varieties of fishes caught from rivers, tributaries, channels and creeks and even from paddy field during the rainy season. Besides crops, livestock and fishery are main source of household income. There are a number of Jute mills which plays a vital role in the economy. The status of non-agricultural activities are low in the district.

The rural economy of Satkhira is predominantly agricultural. Out of total 436,178 holdings, 252,036 were farm holdings and produce varieties of crops, namely, local and HYV rice, vegetables, spices, pulse and others. Fruits available in the district are banana, jackfruits, papaya, guava, olive etc. Besides crops, fishery and forestry are other sources of household income. Prawn is one of the main export items of Bangladesh, which is abundantly available in the district. Prawn farming in the coastal area is the most important economic activities of the households. The district is very rich in forest resources. The Sundarbans is another source of income of the people of Satkhira District.[18]

2.3.3 Gender roles

Bangladesh has a high level of gender inequality, particularly prevalent in rural areas, which importantly hinders overall development. The life of a woman in Bangladesh is shaped by the patriarchal, patrilineal and patrilocal nature of the social system, with heavily gendered power structures greatly limiting women's roles in the social, political and economic spheres. Although Bangladesh has made significant progress in poverty, human development and gender equality indicators over the last few decades[19], poverty and inequality remains prevalent, and the social status of Bangladeshi women remains very low, especially in rural areas[20]. Central to the issue of gendered inequality, is that Bangladeshi women suffer under a particularly high burden of unpaid work, responsible for a range of essential household functions such as collecting water, providing childcare, and producing half of the food at the household level, yet making up only a quarter of the industrial workforce[21].

In the southwest coastal region, women's activities are assigned based on gender roles. Whereas men often leave the house for income generating activities, women take care of the domestic space and tend to what is known as "reproductive labour" as oppose to "productive labour". Most household activities are done by women, with women in charge of ensuring safe drinking water for their families, which can often mean having to travel long distances to access a relatively clean water source. That is, a lack of safe drinking has a strong negative impact on women in relation to the time required for water collecting water from distant, unsafe and unsustainable sources. This heavy unpaid time burden directly affects women's ability to finish household chores, creates household discord, and perhaps most importantly jeopardizes their ability to focus on any productive livelihood interventions.[22] Although external actors may assume that extreme-poor women and women headed households would be likely to seek safe water access points where available, even if at a distance, women in the target districts reported that a long walk to a safer tube well is regarded

17 ICCCAD, March 2017

18 BBS Census 2011

19 ADB, 2010

20 Ferdushi, 2011

21 Kabeer, 2011

22 CGC, 2013.

as a luxury to them. In light of their household work burdens, women cannot waste time collecting safe water, and often resort to pathogen-laden or contaminated surface water, which in turn compounds their vulnerability when they become sick and further impoverished through lost wages and the costs of recovery (including medication).

Additionally, women have less decision-making power and are often rendered immobile at the onset of an environmental hazard (while husband and sons often migrate elsewhere to look for work)[23.] That is, despite their central role in household activities, women's decision-making power remains extremely limited at the household level, and is even more limited in regard to broader political processes. Given that women's roles in decision-making is higher in areas such as food preparation and distribution, resolving food deficits and household work, women are central in assuring household food security as livelihood strategies shift due to slow-onset impacts such as salinity and are assigned higher responsibility in disaster preparedness, particularly in regard to the storage of food and water, during rapid-onset disasters. For a more comprehensive discussion of gender roles, women's access to resources and decision-making power, please see Annex XIIIe: Gender Assessment and Action Plan.

[23] ICCCAD, March 2017

3 Climate Change Impacts on Coastal Drinking Water Sources

The coastal areas of Bangladesh are highly vulnerable to the impacts of climate change, including from cyclones and tidal surges. The impacts of climate change have had a significant impact on available potable water, on both surface and groundwater in coastal areas. The main climatic factors contributing to water scarcity in coastal areas are salinity in surface and groundwater due to sea level rise and tidal surges, and a variation in precipitation patterns. Hence, observed and projected climate change impacts on water sources are of prime importance when selecting appropriate technologies in coastal area. This chapter is a review of available information from secondary sources on the impact of sea level rise, rainfall and natural hazards on water sources in coastal areas.

3.1 Salinity in Groundwater

High salinities both in monsoon and dry season in the South-West coast and along Passur-Shibsa system of this area are associated with the decreasing upstream freshwater flow as well as siltation of the major channels[13]. According to a separate study of IWM[13], the salinity level in Rupsa River will increase due to climate change in 2050. From the model used in the study, it is evident that more salinity will intrude through Baleswar-Bishkhali River system due to climate change. This is because Passur-Shibsa system is already affected by higher salinity as there is no upstream flow for that river system during dry period (February-May). It is evident from the model that almost all the area under less than 1 ppt of salinity will be changed to more than 1 ppt by the year 2050 due to climate change[24].

The findings from a World Bank[25] study on coastal aquifers of Bangladesh suggests that the direct impacts of sea-level rise on coastal inundation and extent of storm surges is of greater concern on groundwater conditions than classical lateral intrusion. High salinity in groundwater was reported in most of the Unions during the PRA process. Due to this high salinity, groundwater cannot be used in most of areas. Therefore, there is a concern among local communities on availability of fresh water in this shallow aquifer in future due to salinity intrusion in this area. Saline intrusion is discussed further in Section 3.3.

3.2 Precipitation and water availability

The coastal region receives approximately 2,900 mm rainfall every year but more than 70% of this rainfall occurs during monsoon (June to September) every year[26] in Bangladesh. However, there is almost no rainfall for 4 to 6 months during dry season (November to March/April)[27]. Although it is predicted that rainfall levels on average could become greater, the pattern may become more irregular over coming decades[28].

Models of climate change suggest higher than average monsoon rainfall in the future, with the findings of Agrawala et al.[29] reported in the key government publications. There is predicted to be an overall increase for all seasons in mean seasonal rainfall of approximately 100 mm, with a maximum during the pre-monsoon (March, April and May) and monsoon (June, July and August) seasons. Increase in the mean seasonal rainfall is seen particularly in the coastal regional stations of Sitakunda, Patuakhali, Kutubdia and in Khulna, in the

[24] Study report, Local level hazard maps for flood, storm surge and salinity, 2013
[25] World Bank, 2010
[26] Rahman and Akter, 2011
[27] Rahman and Dakua, 2012
[28] MoEF, 2005
[29] Agrawala S, Ota T, Ahmed A, Smith J, Aalst Mv (2003) Development and climate change in Bangladesh: focus on coastal flooding and the Sunderbans. Organisation for Economic Co-operation and Development (OECD)

range of 1.2 to 2.1 mm/year. Decreases in the pre-monsoon seasonal rainfall is evident in the coastal regional stations of Bhola and Madaripur, with a range between 3-19 mm/year decrease. Increases in the monsoon rainfall is observed in the coastal district stations of Kutubdia, Mongla, Sitakunda and in Teknaf, in the range between 21-42 mm/year increase.[30]

Since the variation of rainfall will be sensitive in terms of geographic locations, many areas will endure water logging, turbidity as well as sedimentation problems in the country. Overtime, the availability of fresh water will decrease due to salt water intrusion and regional rainfall patterns. Occurrence of water-borne diseases will increase while water treatment and water supply infrastructure will face challenge. Rainfall is one of the major components for recharging groundwater. Thus, water options could be experienced on seasonal water depth variations in terms of layer status.

Meanwhile, there is acute water stress in some parts of the region, where surface water and groundwater have shown an alarming situation vis-a-vis irrigation and safe drinking water. Increased rainfall brings water borne infectious diseases from one place to another through runoff whereas scanty rainfall often leads to desertification in an area. A number of people will lose year-round access to safe drinking water due to irregular rainfall. Thus, recurrent costs for water supply and public health will increase. Bangladesh will be at a high risk from climate change induced moisture stress and resulting phonological drought impacts. Given reductions in mean dry season rainfall it is likely that dry spells may increase/lengthen with negative consequences for water availability/soil moisture.

In a study conducted by IUCN in 2015, areas with less or equal to 380 mm throughout the dry season (Nov-May, NWMP) has been termed as the rainfall stressed area. Inadequate rainfall means that there is insufficient water for the ground water and surface water to recharge, which consequently has negative effect on the provision of water supply. Water is used for multiple purposes such as drinking, domestic, industrial use, and environmental use etc. The rainfall stressed areas have been identified by analyzing the rainfall data of 34 BMD stations with a time range of 1948 to 2008. The districts identified as rainfall stressed are Jessore (99.64%), Satkhira (63.29%), Khulna (57.33%), Narail (55.96%) and Bagerhat (16.34%).[31]

Table 7 summarizes the modelling data that represents climate change scenarios for the country under three different timelines.

Table 7: Temperature and precipitation scenarios used in GoB documents

Timeline	Mean Temperature Change (°C)			Mean Precipitation Change (%)			Sea Level Rise (cm)
	Annual	DJF	JJA	Annual	DJF	JJA	
2030	1.0	1.1	0.8	5	-2	6	14
2050	1.4	1.6	1.1	6	-5	8	32
2100	2.4	2.7	1.9	10	-10	12	88

Note: December, January, February indicates dry season, comprising of December, January and February, while June, July and August indicates peak monsoon, comprising of June, July and August months[32].

Winter months (December, January, February) will become warmer and drier while monsoon months (June, July and August) will become warmer and wetter. One of the key temperature effect is evaporation, the rise

[30] Climate Change Vulnerability of Drinking Water Supply Infrastructure in Coastal Areas of Bangladesh, IUCN 2015
[31] Climate Change Vulnerability of Drinking Water Supply Infrastructure in Coastal Areas of Bangladesh, IUCN 2015
32 Ministry of Environment and Forest (2005). National Adaptation Programme of Action (NAPA): Final Report. Ministry of Environment and Forests (MoEF), Government of the People's Republic of Bangladesh, Dhaka

in temperature will increase the rate of evaporation which also need to be incorporated to understand the impact of climate change. The rise in temperature also raises concern for water quality. Higher temperature will increase the water density with higher presence of nutrient which will no longer remain safe for drinking and other uses.

3.3 Impact of Saline Intrusion Due to Sea Level Rise

The intrusion of saline water from the sea into the inland is hazardous for the environment. Saline water contaminates sweet water resources rendering it unusable for drinking. Salinity damages the fisheries, crops and biodiversity of the Sundarbans, with significant decline in small-fish biodiversity over the last few decades. About 14698 sq. km area is exposed to high salinity of 1 ppt under zero sea level rise. Severely affected districts are Bagerhat, Bhola, Chittagong, Cox's Bazar, Jessore, Khulna, Lakshmipur, Narail, Noakhali and Satkhira, with more than 15% of the area under 1 ppt saline zone.[33]

According to predictions, sea level rise and salinity intrusion will reduce fresh water options in areas where 53% of the area has been affected by salinity already. The potential consequences include: An increase in water treatment expenses and an increase in salt water intrusion into groundwater due to low elevation as well as hydraulic structure, a reduced access to safe drinking water options, a negatively impact on public health concerns and coastal livelihoods and an encroachment of the salinity front. Low saline water areas (0-1ppt) will decrease from 11% to 9% and 4% by 2050 and 2100 respectively, and high saline areas (20ppt-25ppt) will increase from 13% to 16% and 18% for the same years.[34] Based on model predictions, the population exposed to high salinity (>5 ppt) is expected to increase to 13.6 million in 2050 and to 14.8 million in 2080.[35] According to another estimate, the area under 1 ppt salinity line will increase to 17.5% (1 ppt) and area under 5 ppt salinity will increase to 24% by 2050. So, there will be around 7% increase in area under 5 ppt salinity levels (CEGIS, 2011). A study by the World Bank (2010) predicted that with a sea level rise of 62 cm, the cyclone-induced storm surges will inundate an additional 15 % of the coastal area by the year 2050.[36]

3.4 Impact of Cyclones and Tidal Surges on Coastal Drinking Water Sources

3.4.1 Extreme Weather Events

Bangladesh is affected with hazards of different types such as flood (river flood and flash flood), drought, cyclone, storm surge, erosion, salinity intrusion, earthquake etc. The occurrence, extent and intensity of these hazards vary from region to region of the country. But the coastal morphology influences the propagation of storm surges in those areas. Inundation due to flooding and storm surges differs based on the land elevation and surface form. In the last 200 years more than 70 cyclones have hit the coast damaging life and properties.

Devastating cyclones hit the coastal areas of Bangladesh almost every year usually accompanied by high-speed winds, sometimes reaching 250 km/hr or more and 3-10 m high waves, causing extensive damage to life, property and livestock. Most of the damage occurs in the coastal regions of Khulna, Patuakhali, Barisal, Noakhali and Chittagong and the offshore islands. The storm surges that accompany the cyclones of the Bay of Bengal cause more destruction in the coastal areas and offshore islands of Bangladesh than the very strong winds that are associated with the cyclones[37].

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[33] Climate Change Vulnerability of Drinking Water Supply Infrastructure in Coastal Areas of Bangladesh, IUCN 2015
[34] Ibid.
[35] CEGIS, 2006
[36] World Bank, 2010
[37] Banglapedia, 2003

In the Meghna estuary, the 1970 Cyclone (Nov 12-13) with cyclonic surge of 3.05 m to 10.6 m high with wind speed of 222 km/h occurred during high tide causing most appalling natural disaster claiming 0.3 million human lives. On the 29 April 1991, a devastating cyclone hit Chittagong, Cox's Bazar, Barisal, Noakhali, Patuakhali, Barguna and Khulna along with tidal bore of 5-8m high with wind speed of 240 km/h which killed 150,000 human-beings, 70,000 cattle head, and the total loss was approximately BDT 60 billion.

Cyclonic storm Aila in 2009 was one of the worst natural disasters to affect Bangladesh. Torrential rains from Aila resulted in 190 fatalities and at least 7,000 injuries across the Khulna and Satkhira Districts. Approximately 9.3 million people were affected by the cyclone, of which 1 million were rendered homeless. The area is also constantly threatened by flooding.

In the coastal zone, half of the area is threatened with cyclonic storm surge. Around 45% of the area and 4% of the area are threatened by storm surges of more than one metre and less than one metre height respectively. There are 13 districts which are vulnerable to storm surges of more than one metre, namely Bagerhat, Barguna, Barisal, Bhola, Chittagong, Cox's Bazar, Feni, Jhalokhati, Khulna, Lakshmipur, Noakhali, Patuakhali, and Pirojpur Districts. For a storm surges of less than one metre, the districts at risk are Bagerhat, Barisal, Khulna, Lakshmipur and Pirojpur.[38]

3.4.2 Impact on Water Related Infrastructure

According to local people, the coastal embankment was badly damaged during the Cyclone Aila causing intrusion of salt water into the fresh water ponds in the Union. The effect of Aila and saltwater intrusion due to sea level rise on surface water sources (e.g., ponds), left a very limited number of fresh water ponds as a drinking water source for people living in many villages in these districts. The vulnerability of ponds to saltwater intrusion from storm surge and sea level rise can be reduced through raising the height of pond embankments.

Saline inundated traditional ponds or surface water-bodies become unsuitable for human consumption after a cyclone has made impact, like Aila. District-wise, according to a water infrastructure damage assessment after Cyclone Aila, conducted by DPHE, suggested that among the affected districts, Khulna and Satkhira were the worst affected areas, where 278 PSFs were damaged. The situation was acute in Gabura and Burigoalini Unions of Satkhira District, where the majority of the drinking water sources were damaged. Many people resorted to drinking polluted water.

3.5 Social impacts

Climate change is likely to adversely affect women more than men, on a range on indicators. Impacts on women include increased burden on time through resource collection, increased injuries and mortalities from extreme weather, increased incidence of GBV and increased health impacts including hypertension and water borne diseases. The gendered impacts of climate change are discussed in Annex XIIIe: Gender Assessment and Action Plan.

In regard to access to water, it is clear that as the acute and chronic shortage of safe drinking water is likely to become more pronounced in the coastal belt, this will impose further hardships on women, who are primarily responsible for collecting drinking water for their family. That is, in 90% of the households in the area, women collect drinking water and must travel a long distance (2-3 km) by crossing rivers, unfinished

[38] Ibid.

and unsafe roads (*kacha*) and bamboo bridges requiring significant time (1-2 hrs) and effort[39]. In addition, some women have to pay for transport when it is not possible to walk such long distances, resulting in further marginalization of the poor and women-headed households. Children of women with children under 5 years old suffer disproportionately, as they are left at home while their mother collects water from remote places. The need to collect water from distant and often unsafe sources is a significant source of stress and tension within households, especially in times of water scarcity and this stress falls disproportionately on women. Poor access to safe drinking water sources increase the risk of waterborne disease-incidence, which negatively impacts women (as they are the primary caregivers when a household member is sick), and increase negative impacts of drinking saline drinking-water on the health of pregnant women.

Secure access to water has a positive impact on gender relations and family well-being, and ensuring water access has a direct impact on women's health, time and workload. Women can save at least 1-2 hours daily, if the water source is made available near their homes in the dry season, based on the reported amount of time many women spend on water collection in the target districts.

3.6 Health implications

Water resources and safe water supply systems are threatened by both climatic and non-climatic factors in the coastal zone. A number of climate factors or climate induced hazards include cyclone and storm surges, floods, droughts, saline intrusion, erratic behaviour of rainfall along with non-climate factors such as arsenic contamination, industrial pollution, affecting both surface and groundwater resources. On the health issues, incidences of a number of diseases including diarrhoea, malaria, dengue, Kalazar, HIV/AIDS, enteric fever, anthrax, avian influenza, Nipah virus infection, leptospirosis, acute respiratory infections (ARI) in recent years are alarming.[40] Of them, dengue, malaria, diarrhoea, Kalazar have already been referred to as climate sensitive diseases.[41] Cholera is likely a re-emerging infectious disease in the country, which is sensitive to climate parameters (temperature and sun shine).[42]

Health risks due to climate change are predicted to increase all over Bangladesh. The country is likely to be affected mostly by vector-borne and waterborne diseases. Studies suggest that a number of diseases and health problems including malaria, dengue, Kalazar, cholera, malnutrition and diarrheal diseases are associated with climate related factors such as temperature, rainfall, floods, and droughts.[43] These were also found to be associated with non-climatic factors including poverty, lack of access to safe drinking water and sanitation and poor sewerage system.[44] According to a study, the incidence of diarrhoea (32%) and dysentery (44%) is high in the potential project areas, because pond water was utilized as a main drinking water sources, without any further treatment and with poor sanitation.[45] Some of the recent research findings on climate change and health issues in Bangladesh are stated below:

- Seasonal peak of Escherichia coli diarrhoea coincides with the time when food is contaminated due to higher bacterial growth caused by high temperature.[46]
- Increase in rotavirus diarrhoea in Dhaka by 40.2% for each 1°C increase of temperature above 29°C.[47]
- Increase of cholera incidences is associated with increase of sea surface temperature.[48]

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[39] PRA Livelihood Study results
[40] Impact of CC on Water Resources and Human Health; Md. Golam Rabbani, Saleemul Huq and Syed Hafizur Rahman
[41] Confalonieri et al. 2007
[42] Wagatsuma et al. 2003; Confalonieri et al. 2007
[43] ibid
[44] Cruz et al. 2007
[45] Impact of CC on Water Resources and Human Health; Md. Golam Rabbani, Saleemul Huq and Syed Hafizur Rahman
[46] Rowland, in Shahid 2010
[47] Hashizume et al. 2008
[48] Feldacker 2007

- Number of non-cholera diarrhoea cases in Dhaka increases with higher temperature, particularly those individuals at a lower socioeconomic and sanitation status.[49]

Moreover, consumption of sodium through drinking saline water forms a significant part of the total sodium intake in these areas.[50] The association between excessive sodium intake and increased risk of hypertension is widely known (e.g., WHO 2012). Furthermore, Khan et al. (2014)[51] have found an association between drinking water sodium and pre-eclampsia (a condition in pregnant women characterised by high blood pressure) in a salinity prone area in southern Bangladesh. People residing in highly vulnerable coastal segments may have hypertension/high blood-pressure attributable to drinking water salinity.[52]

Increased salinity of freshwater resources has substantially increased health hazards of the coastal communities[53].The project targeted population has high exposure to saline drinking water which contributes to hypertension and cardiovascular diseases[54] and mortality[55], especially among vulnerable groups such as expecting mothers[56], young children[51] and young adults[57].

3.7 Impacts on Khulna and Satkhira Districts

3.7.1 Khulna District[58]

The Khulna District is characterized by increased frequency of disasters, especially cyclones, increased salinity, both in drinking water and impacts on agriculture, and increased frequency of flooding and inundation from high tide, tidal surges, river erosion, and embankment erosion. Flooding is reported to be caused by a variety of factors, sometimes together and sometimes separately, including heavy rain (more frequent heavy rain events), high tides (the nature of tides were described as having changed, and that now during high tide times the sea water rises even higher, flooding houses, fields, and roads), tidal surges (sometimes discussed as linked to storms and sometimes discussed as more like very high tides and not part of storm events), river erosion (collapse of land and/or embankments leading to inundation from the river), and as a result of cyclones and storms. Flooding also ranged from localized flash floods (such as from high tides) to prolonged periods when whole areas were underwater for many weeks and months (such as from tidal surges or destruction of embankments). Key consequences cited across these different varieties of flood events are:

- Damage to buildings and infrastructure – including houses, schools, roads, and fields –sometimes leaving people homeless.
- Buildings and fields flooded for considerable periods of time – sometimes leaving people homeless.
- Children unable to go to school.

[49] Hashizume et al. 2008
[50] Hoque and Butler 2016
[51] Khan et al. 2014
[52] Houque et Al. 2016
[53] World Health Organization (2014). Noncommunicable Diseases (NCD) Country Profiles - Bangladesh. From: http://www.who.int/nmh/countries/bgd_en.pdf.
[54] Sayeed, M. A., Rahman, A. S., Ali, M. H., Afrin, S., Rhaman, M. M., Chowdhury, M. M. H., & Banu, A. (2016). Prevalence of hypertension in people living in coastal areas of Bangladesh. Ibrahim Medical College Journal, 9(1), 11-17.
[55] Dasgupta, S., Huq, M., & Wheeler, D. (2016). Drinking water salinity and infant mortality in coastal Bangladesh. Water Economics and Policy, 2(01), 1650003.
[56] Khan, A. E., Ireson, A., Kovats, S., Mojumder, S. K., Khusru, A., Rahman, A., & Vineis, P. (2011). Drinking water salinity and maternal health in coastal Bangladesh: implications of climate change. Environmental health perspectives, 119(9), 1328.
[57] Talukder, M. R. R., Rutherford, S., Phung, D., Islam, M. Z., & Chu, C. (2016). The effect of drinking water salinity on blood pressure in young adults of coastal Bangladesh. Environmental Pollution, 214, 248-254.
[58] Climate Change Study Book by UNICEF Bangladesh, May 2016

- Drinking water crisis – fresh water ponds flooded, Pond Sand Filters and other water sources contaminated also.
- Crop losses and livestock deaths.
- Danger of drowning for children and women.
- Many people dying as a result of tidal surges.
- Child marriage increases for poor families trying to recover from impacts of flood events.
- Disruption to all types of services, including education, health treatment, businesses, communications, and physical access to markets/meeting travel needs.
- Financial crisis, especially for poor families.
- Increased water-borne and skin diseases.

Increased salinity after cyclones had always been a problem, but one that people previously eventually recovered from. However, communities felt that increased salinity is now a daily problem because of the increased impacts of tidal surges. It was not only water surface supplies that suffering salinity; both groundwater and cropland were also described as saline, with the result that they felt they were suffering a constant crisis of saline water and infertile land.

The consequence of salinity has been perceived as a big crisis for drinkable water, not just after disasters but all the time. According to the study, water has to be collected from further away, and less is available even there. Children and adolescents felt that there was more malnutrition and disease because of water crisis. They also felt that land was not producing as much crop because of the salinity of the soil and water. They reported that it affected the availability of food and the overall economic wellbeing of their family. Vegetable, rice, and fruit production were reported to be declining every day, blamed on decreasing fertility of soil due to not enough rain to wash away the salinity of the soil, and to replenish the ground water and surface water used in crop production. The trees were also reported to be dying, particularly coconut trees and some local varieties of fruit, which were now no longer available for the children to eat.

Cyclones are of highest concern to all the adult community groups, not just for the severity of their impacts, but because it was felt that they have become more frequent. Therefore, it is no longer just a case of the severity of the impacts, but the cumulative impacts as there is less time to recover before the next one. Communities said that every year now a cyclone is formed in the bay, and whilst the cyclone does not always reach land and impact them, there are more warnings and more worry for six to ten days that a cyclone may come. When cyclones do come there are multiple impacts including tidal surge, river erosion, and embankment erosion/destruction. Houses, schools, school materials, crops, trees, roads, sanitation systems, and fish farms are damaged or destroyed. Human lives are lost, as are cattle and other animals. Assets are lost, both through the disaster itself, and through theft if people have gone to cyclone shelters or other places. Tubewells, ponds, and rivers are filled with saline water. There are diseases, especially diarrheal diseases. Children are unable go to school, with some schools closed for about 2 months, and their education is hampered.

3.7.2 Satkhira District[59]

Significant land-cover change happened in Satkhira District between 1999 and 2012. Water coverage increased due to the increase in shrimp culture ponds. The built-up and bare land-type increased due to the secondary effects of disasters. For example, the area is surrounded by coastal embankments, creating water logging during high tide. This water logging is prolonged because land grabbing and siltation on the riverbeds

[59] Natural disasters and land-use/land-cover change in the southwest coastal areas of Bangladesh Md Modasser Hossain Khan • Ian Bryceson • Korine N. Kolivras • Fazlay Faruque • M. Mokhlesur Rahman • Ubydul Haque, 2014

causes the natural drainage systems to be blocked. Subsequently, salinity intrusion occurs in both agricultural land and other areas.

The salinity situation was worsened after Cyclone Sidr in 2007 and Cyclone Aila in 2009[60] with most of the freshwater sources contaminated due to salinity intrusion and water logging. Although high salinity levels in this region have existed for a long time, within the last four decades, the salinity of the coastal zone increased 3.02 %[61]. Construction of shrimp ponds and infrastructure for shrimp farms contributes to the intrusion of saline water in the coastal zone[62].

Increasing salinity is worsened by occurrences of climate-disasters like cyclones, storm surges and water logging and thus compounds the changes in land-use activities, with the consequences of shrimp farming, restricting rice cultivation, impacting negatively on income and expenditure, creating a water crisis and decreasing employment opportunities.

Under a scenario of 30 cm sea level rise (SLR), the surface water salinity pattern will experience significant changes. The present dry season saline front (2 ppt) is projected to move 30 km to 70 km north affecting most of Khulna, Jessore, Barisal, Patuakhali, and Noakhali (greater) Districts[63]. With a 1m SLR, the saline front is projected to move further north on the north-eastern side of Bangladesh.

Nearly 6 million people are already exposed to high salinity (>5 ppt), but because of climate change the number is expected to increase to 13.6 million in 2050 and 14.8 million in 2080, with the population in Khulna, Satkhira, and Bagerhat most affected. This will not only make household water supply scarcer,

3.8 Targeting of beneficiaries

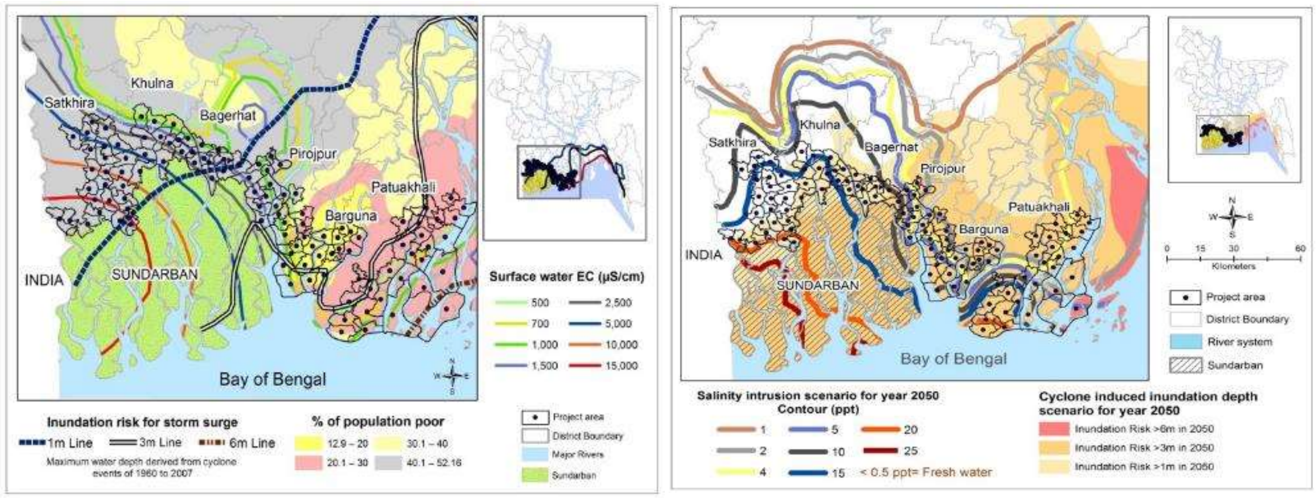
Identification of target districts and unions: A total of six districts (namely Satkhira, Khulna, Bagerhat, Pirojpur, Barguna and Patuakhali) were identified as potential project areas due to their high exposure to climate induced salinity and disasters, and impacts on the poor, vulnerable populations of these coastal communities.

Figure 5 (a) shows current inundation risk and surface water salinity overlain with current poverty levels, whereas Figure 5 (b) shows future projected inundation risk and surface salinity by 2050. Higher surface water salinities are to be found in Satkhira, Khulna, and Bagerhat Districts, as are a greater percentage of poor, highlighting that districts to the west are currently the most vulnerable and suffer the highest impacts due to salinity (Figure 5 (a). However, Figure 5 (b) shows that future increases in salinity intrusion and cyclone induced inundation will occur in districts to the east; Patuakhali, Barguna, and Pirojpur, increasing the impacts on livelihoods and drinking water. Districts to the west, especially Satkhira and Khulna with the highest salinities, should therefore be targeted first with future replication and scale to the other vulnerable districts further east.

In Khulna and Satkhira a total of 39 unions (18 in Sathkira and 21 in Khulna) were selected. These unions were chosen as they:

(i) face the highest levels of experienced and projected salinization; and
(ii) are home to a particularly large poor population as revealed during the PRAs and data analysis.

60 Khan et al. 2010
61 Miah 2010
62 Rahman et al. 2011
63 Dasgupta S., et al. (2014). Facing the Hungry Tide: Climate Change, Livelihood Theats, and Household Responses in Coastal Bangladesh. World Bank Policy Research Working Paper No. 7148. December



(a) (b)

Figure 5: (a) Current inundation risk and surface salinity, overlain with poverty leves; (b) future (2050) modelled salinity intrusion and cyclone induced inundation risk

Identification of targeted wards: The wards in each of the 39 unions were analysed in depth to identify the most vulnerable communities to climate change. For this exercise, poverty and Digital Elevation Model (DEM) maps were produced using data from a national census study and PRAs. The wards were selected based on the following criteria:

- Current and projected salinity levels: Maps of salinity for soil as well as ground water were used to detect those wards most affected by and vulnerable to climate-induced salinization processes (see Figure 4(a) and (b)). Additionally, land-use change data (1995, 2005, and 2015) were considered to identify wards where major shifts from agriculture towards aquaculture usage took place, as a potential indicator of salinization processes.

- High exposure of beneficiaries to salinity intrusion due to low elevation: Wards with a low elevation were considered being particularly vulnerable to salinity intrusion (see overall elevation map in Figure 2, union specific elevation maps showing ward elevations are included in the union reports. See Annex 3 for the 5 sample Union Reports of Burigoalini, Kulla, Lata, Maharajpur, and Tildanga Unions. The remaining union reports are in Annex II (d)).

- High levels of poverty: Maps were produced and considered that detected particularly poor people based on a multi criteria poverty index (MCPI) with the indicators of: (i) income poverty; (ii) percentage of day labourers; and (iii) a satellite imagery analysis of housing structures (see annex 1 for more details on the approach to calculate of the MCPI).

Through this process a total number of 101 out of 350 wards in the targeted 39 unions were identified as potential project areas. The targeted districts are discussed further in Section 2.5.

3.9 Description of Targeted Districts – Phase I: Khulna and Satkhira

3.9.1 Khulna District

Khulna District was established in 1882. The total area of the zila is 4394.45 sq. km. (1696.70 sq. miles) including 2348.55 sq. km (906.78 sq. miles) reserve forest area. The Sundarbans, the largest mangrove forest of the world, occupies 166814 hectares of this zila. It is located in between 21°41' and 23°00' north latitudes and between 89°14' and 89°45' east longitudes. It is bounded by Jessore and Narail zilas on the north, Bhairab River and Bagerhat zila on the east, south by the Bay of Bengal and west by Satkhira zila. [64]

The demographic profile of Khulna District as recorded in the Bangladesh Bureau of Statistics (BBS) 2011 Population and Housing Census is summarised in Table 8 and Table 9.

Table 8: Demographic Information of Khulna District (BBS, 2011)

Area (Km²)	# of Upazila	# of Municipality	# of Union	# of Mouza	# of Village	Population		Density (per sq. km)	Literacy Rate (%)
						Urban	Rural		
4394	9	2	69	751	1123	777,588	1,540,939	528	60.1

Table 9: Upazila wise Information of Khulna District (BBS 2011)

Name of Upazila	Area (Km²)	Union	Mouza	Village	Population	Density (per sq km)	Literacy Rate (%)
Batiaghata	248.31	7	127	172	171691	691	54.9
Dacope	991.56	10	26	97	152316	154	56
Dighalia	77.16	4	29	43	115585	1498	54.3
Dumuria	454.23	14	189	240	305675	673	52.6
Koyra	1775.40	7	71	133	193931	109	50.4
Paikgacha	411.19	10	149	212	247983	603	52.8
Phultala	56.83	3	18	29	83881	1476	59
Rupsa	120.15	5	64	78	179519	1494	58.2
Terokhada	189.49	6	32	99	116709	616	48.5

Khulna is the third largest economic centre in Bangladesh and Mongla, one of the major sea ports of the country is situated in Khulna. The major sectors are jute, chemicals, fish and seafood packaging, food processing, sugar mills, power generation and shipbuilding. The region has an Export Processing Zone which has attracted substantial foreign investment. This infrastructure plays a vital role in the city's economy, which also depends upon fishing and salt industries. Main sources of income are agriculture 34.90%, non-agricultural labourer 6.22%, industry 3.51%, commerce 19.60%, transport and communication 5.17%, service 18.27%, construction 1.99%, religious service 0.21%, rent and remittance 0.78% and others 9.35%.[65]

3.9.2 Satkhira District

The total area of the district is 3,817.29 sq. km. (1473.86 sq. miles) of which 1632.00 sq.km. is under forest. It is located between 21º36' and 22º54' north latitudes and between 88º54' and 89º20' east longitudes. The Satkhira District is bounded on the north by Jessore District, east by Khulna District, south by the Bay of Bengal and west by West Bengal state of India.

The demographic profile of Satkhira District as recorded in the BBS 2011 Population and Housing Census is summarised in Table 10 and Table 11.

[64] BBS 2011
[65] Banglapedia, 2016

Table 10: Demographic Information of Satkhira District (BBS, 2011)

Area (Km^2)	# of Upazila	# of Municipality	# of Union	# of Mouza	# of Village	Population		Density (per sq km)	Literacy Rate (%)
						Urban	Rural		
3817.29	7	2	79	916	1440	197616	1788343	520	52.07

Table 11: Upazila wise Information of Satkhira District (BBS 2011)

Name of Upazila	Area (Km^2)	Union	Mouza	Village	Population	Density (per sq km)	Literacy Rate (%)
Assasuni	374.81	11	143	241	268754	717	49.83
Debhata	173.21	5	59	125	125358	724	54.82
Kalaroa	231.42	12	112	136	237992	1028	50.94
Kaliganj	333.78	12	243	254	274889	824	51.78
Satkhira Sadar	398.57	14	119	237	460892	1156	56.51
Shyamnagar	1968.23	13	127	218	318254	162	48.62
Tala	337.24	12	150	229	299820	889	50.88

Most of the peoples of southern part of Satkhira depend on pisci-culture, locally called *gher*. There are 86 dairies, 322 poultry farms, 3046 fisheries, 3650 shrimp farms, 66 hatcheries and one cattle breeding centre. The main exports are shrimp, paddy, jute, wheat, betel leaf, and leather and jute goods.[66] Main sources of income are agriculture 62.56%, non-agricultural labourer 4.33%, industry 1.51%, commerce 16.23%, transport and communication 3.03%, service 4.86%, construction 1.01%, religious service 0.19%, rent and remittance 0.34% and others 5.94%.[67]

4 Drinking Water Sources, Supply and Access

4.1 Freshwater Availability

Table 12 and Table 13 show the drinking water sources of Khulna and Satkhira Districts as recorded in the Population and Housing Census 2011. The “Tubewell” category includes both shallow and deep tube wells. The "Others" category includes pond sand filters and rainwater harvesting. Managed Aquifer Recharge (MAR) was introduced as a drinking water source after 2012, so was not included in the 2011 BBS data. Table 12 and Table 13 show that most of the upazilas in Khulna and Satkhira Districts recorded tubewells as the main source for drinking water in 2011. There are areas where tubewells are not successful to produce low saline water. Moreover, failure of existing tubewells to yield water of satisfactory quality is quite frequent. As a result, people use contaminated water from unprotected rivers, ponds, and shallow wells. Rainwater harvesting is also popular in many areas but access is limited due to the high cost of buying tanks with sufficient capacity for the dry season. Piped water supply (the “Tap” category) is available only in major urban centres in the coastal area covering a small percentage of total population.

[66] Wikipedia
[67] Banglapedia

Table 12 and Table 13 include saline and non-saline water sources. As shown in the tables, the BBS statistics mainly make a distinction between tube-well and other sources, but to understand the real challenges the seasonal variance of water availability needs to be considered. The non-saline drinking water sources that provide safe year-round supply are a subset of the data recorded in the 2011 Census. The availability of safe non-saline drinking water for year-round supply for the targeted 101 wards of Khulna and Satkhira Districts is discussed in Section 6.1 Gaps in Baseline Non-Saline Coverage.

Table 12: Baseline Drinking Water Sources of Khulna District by Upazila (BBS 2011)

Name of the Upazila	Tubewell (%)	Tap (%)	Others (%)
Batiaghata	96.4	0.1	3.5
Dacope	30.6	0.7	68.7
Dumuria	99.9	0.1	0
Dighalia	97.8	1.4	.8
Koyra	44.3	0.3	55.4
Paikgacha	62.4	1.6	36
Phultala	96.9	1.4	1.7
Rupsa	97.7	0.7	1.6
Terokhada	96.8	0.1	3.1

Table 13: Baseline Drinking Water Sources of Satkhira District by Upazila (BBS 2011)

Name of the Upazila	Tubewell (%)	Tap (%)	Others (%)
Assasuni	71.5	1.3	27.2
Debhata	94.4	2	3.6
Kalaroa	97.6	0.6	1.8
Kaliganj	77.8	14.6	7.6
Satkhira Sadar	83.1	14.3	2.6
Shyamnagar	43	0.8	56.2
Tala	95.2	0.6	4.2

More details on local practices for rainwater harvesting and pond water supplies are provided in the sub-sections below.

4.1.1 Household Rainwater harvesting

The household rainwater harvesting system that catches runoff from the household rooftop and stores it for subsequent use is popular in salinity affected areas of the coastal districts but the storage tank capacity is limited by affordability. The most popular household rainwater harvesting tank is a 1,000 L plastic tank and the rainwater is stored for drinking and cooking. There are also plastic tanks of 500 L, 2,000 L, 5,000 L and 10,000 L capacity in the market. In areas where rainwater is the only source of freshwater, people with higher financial capacity can buy tanks as per their need. There are also rainwater storage tanks made of other different materials, e.g., reinforced concrete cement (RCC) tank, ferro-cement tank, earthen jars (motka), etc.

Example tanks installed by Practical Action Bangladesh are shown in Figure 6.

Figure 6: Ferro-cement (left) and brick-made (right) rainwater reservoirs of 3,200 and 3,600 L capacity respectively

Figure 7 shows a 1,000 L plastic tank provided by Caritas Bangladesh. This family has 4 members and they use the stored rainwater for drinking and cooking purposes only. People who cannot afford to buy a tank from the market, are found to be using buckets, jars, pots and other containers to store rainwater as much as possible.

Figure 7: Household rooftop rainwater harvesting system of 1,000 L capacity in Satkhira

Department of Public Health Engineering, through Government funded projects, sometimes distributes rainwater tanks to poor people in these areas for storing water for drinking. There are a large number of NGOs (World Vision, WaterAid, Practical Action, OXFAM, Caritas Bangladesh, Prodipon, Muslim Aid, Uttaran, and many other) working in salinity affected areas to support the poor people who cannot afford to buy tanks from the market. Overall the combined support provided by government and NGOs is inadequate and the water supply projects are not designed for climate change resilience, hence the demand for rainwater harvesting systems is still significant.

In most of the donor funded projects for providing access to safe water to poor people in these areas, rainwater harvesting tanks have been provided for free with households responsible for operations and maintenance including renewals and repairs. There were also a few projects where the beneficiaries have had to pay contribution money (5-20%) to get the support from donors/implementing organizations.

Figure 8 and Figure 9 show use of earthen jars (Motka) in households by people who cannot afford to buy plastic tanks and have not received a donated tank. They use indigenous techniques to collect rainwater from their roofs. The household in Figure 9 has five Motkas for storing rainwater. The capacity of each of Motka is about 100 L. The storage capacity is insufficient for the dry season and the household often have to collect and/or buy water from other sources, e.g., ponds. The Motkas are less expensive to buy than rainwater tanks but are also fragile and do not last for more than 2-3 years. There are also reports about poor water quality due to unhygienic collection of water.

Figure 8: Use of "Motka" for storing rainwater during rainy season in Khulna

Figure 9: Use of "Motka" for storing rainwater at household level in Bagerhat

4.1.2 Community and Institutional scale Rainwater harvesting

Rooftop rainwater harvesting systems at community scale is also practiced in salinity affected coastal areas or in areas where other sources are not available. The major difference between community based systems and household systems is the size of the tank where the tank of community based system stores water for more than one family. The size of the tank depends on the number of target beneficiaries and purpose of use. Community scale rainwater harvesting is mostly supported by NGOs and Government funding. The initiative of local communities to install such systems is rare as the ownership and maintenance of community managed systems needs to be supported by a management model and capacity building.

Community and institution large scale rainwater harvesting systems are mostly installed in schools, bazars (market), government owned properties and institutions, and on lands that are common property of a group of people. However, such systems are also found in few areas on private lands where the land owner is willing to give his/her land for installation of the system. The community scale large rainwater tanks are mainly large plastic tanks of 5,000/10,000 L capacity and RCC/ferro-cement tanks which are sized for the local requirements.

For instance, the rainwater harvesting system shown in Figure 10 is built on land near a temple in Vojpatia union of Rampal upazila under Bagerhat district. The land was provided by the authority of the temple considering the need of fresh drinking water in this area. The capacity of the tank is 18,000 L and 15 families can collect rainwater from this tank throughout the year. Approximately 75 people use this rainwater for drinking purpose only. The tank was designed assuming that 75 people will need 2 liter water per day for drinking where the design period (scarcity period) was assumed to be four months. In this example, it was reported in the PRA by local people that the stored rainwater was sufficient for them for the whole dry season. For water for cooking, households collect water from a nearby fresh water pond. The beneficiaries are supposed to pay BDT 25 every month to the caretaker of the system which would be used to pay caretaker salary and for maintenance of the system. The temple authority collects money for maintenance on an annual basis (25BDT per household per month). The system is managed by a committee consisting of the members of temple authority (some but not all are also beneficiaries of the system). This system was funded by DFID in 2014 where the local people contributed 5% of the total installation cost.

Figure 10: Community scale rainwater harvesting system in Bagerhat near a temple

Figure 11 below shows an institutional scale rainwater harvesting system installed on a school's premises in Dacope union of Dacope upazila under Khulna district. 116 school students and 5 school teachers are the beneficiaries of the system. Before installation of this system, the school authority had to buy water every week. In 2016, Rupantor (a local NGO) with support from WaterAid installed the system. The system collects rainfall runoff from the rooftop and stores the runoff in three tanks, each of which is of 5,000 L capacity.

Figure 11: Rainwater harvesting system in Dacope union of Khulna district

During the PRA interviews, people's perception and acceptance of different rainwater harvesting systems in a coastal area in Bangladesh was found to be very favourable to scaling up of the technology as rainwater is the main sources of drinking and cooking water in the study area. They also mentioned rainwater as their first choice of water sources. Local people are not very aware of the risk of bacteriological contamination because of their perception of the visual quality of the harvested rainwater, which is very satisfactory.

Most of the rainwater harvesting systems are running very well due to high community participation in operations and maintenance and social acceptance of RWH systems is very high in this area. People were found more willing to have household rainwater harvesting systems than community based systems. The success and sustainability of community based systems needs to be ensured with best practice implementation including group-based capacity building and institutional support.

4.1.3 Pond water supplies

The water supply in some of the rural areas of coastal districts is heavily dependent on pond water, especially during dry period when no rain is available. It has been observed in many areas of Satkhira, Bagerhat and Khulna districts where salinity is acute, the fresh water ponds, which are mainly rain-fed, are the only source of water during dry season. Two case studies are provided below for pond water supplies.

The first case study is the Jholmoliya pond (Figure 12) in the Hurka village of Hurka union in Rampal upazila (sub-district) under Bagerhar district. The total area of this rain-fed pond is 8 acres. The pond is surrounded by water bodies and a canal from all four sides that are saline. People of two upazilas under Bagerhat district, Mongla and Rampal, drink water of this pond. People of four unions (Hurka, Rampal, Perikhali and Rajnagar) of Rampal upazila and one union (Burirdanga) of Mongla upazila heavily depend on this pond. It was reported by local authority that approximately 40,000 people collect water from this pond for drinking and cooking water during dry period. Apart from drinking, people of Hurka union use this pond water for homestead gardening during summer. A survey carried out by Caritas Bangladesh under a DFID-CAFOD funded project revealed that approximately 150,000 L water was collected in a single day from this pond during the dry period, when people from remote places collect water from this pond and transport it on water carrying vehicles.

Figure 12: Jholmoliya pond

During the rainy season, the pond becomes full with rainwater. To protect the pond from polluted surface runoff, a protection wall has been constructed with support from Caritas Bangladesh, where local people contributed 5% of the total construction cost. The whole construction work was carried out under supervision of union Chairman and staff of union council. The protection wall is 600mm in height and stops polluted surface runoff from entering into the pond. Every year, the union council takes initiative to clean the pond and to do necessary maintenance works. The local people drink this pond water without any treatment.

The second case study is the Gasi Pond (Figure 13) on 15 katha land in South Chandpai Village of Chandpai union in Mongla upazila under Bagerhat district. Five years ago local people excavated the land to use it for a pond for bathing, washing, cooking etc. After the rainy season, the local people found that the pond water was very sweet and they started using it for drinking also as the groundwater in this area was saline. All the 160 families who live in the South Chandpai village use water of this pond for drinking and cooking. During dry period, people from other neighboring villages also come to collect water. From interviewing local people during the PRA process, it was found that the users drink water from this pond without any treatment or disinfection.

Figure 13: Gasi Pond

4.2 Water Quality

The main issues surrounding water quality are microbial pathogens, arsenic (As) in groundwater and salinity. For decades, the widespread contamination of groundwater by Arsenic (As) in Bangladesh has been recognized as a severe problem.[68] Although it is naturally occurring, arsenic contamination is a continuing public health issue in Bangladesh, potentially affecting millions of people.[69] The geographic distribution of Arsenic varies greatly from one district to another. The greatest concentration is observed in the south and south-east and the smallest concentration in the north and north-west of Bangladesh. Average concentration of Arsenic found in Khulna District is approximately 85µg/L. DPHE has implemented water supply improvement projects to address the arsenic contamination issues with support from funding partners such as JICA and UNICEF (for example the Khulna Water Supply Project). While these development investments are addressing arsenic, the climate-change induced salinity remains a key problem, especially with projected risks.

Salinity has been recognized as a significant water problem in coastal Bangladesh for some time. A study paper titled "Salinity Status in Groundwater A study of Selected Upazilas of Southwestern Coastal Region in Bangladesh"[70] information is provided about the present status of groundwater salinity conditions in the study area which covers nine upazillas of Khulna, Jessore and Satkhira Districts with an area about 1534 km^2. The study reveals that groundwater of southwestern coastal region is mostly saline. This is more prominent in the shallow aquifer. It was found that about 18.37% SHTWs had salinity more than 1000 ppm. The salinity in SHTWs in the upazilas of Jessore and Satkhira was less than 1000 ppm. The situation was found worse in Paikgacha and Batiaghata Upazilas of Khulna. In the study area, approximately 5.6 % deep hand tube wells (DHTWs) showed salinity above 1000 ppm. In contrast, almost all DHTWs in Paikgacha exceeded salinity level. The percentage of DHTW containing salinity more than 1000 ppm in the upazilas of Tala, Dumuria and Batiaghata were 11.1, 5.41 and 2.27 respectively.

5 Past and Ongoing Efforts

5.1 Government-Led Water Supply Programmes and Initiatives

DPHE is implementing a World Bank financed Project "Bangladesh Rural Water Supply and Sanitation Project (BRWSSP) covering 383 unions of 20 districts including Khulna and Satkhira (2012-2017). Under this project, 65 DHTWs, 520 RWHSs and 14 PSFs have been installed in different unions of Khulna and Satkhira Districts.

5.2 Donor Based Water Supply Programmes and Initiatives covering Khulna and Satkhira

There are a number of donor based water supply programmes and initiatives covering the rural areas of Khulna and Satkhira Districts and key programmes are summarised below. In addition, there are three key current initiatives that are being co-ordinated with the proposed project. These are outlined in Section 5.3 Co-ordination with Current Initiatives.

The objective of the First Phase of the World Bank funded Coastal Embankment Improvement Project (CEIP-I) was to improve agricultural production by reducing saline water intrusion in selected polders; The project had five components aimed at increasing community resilience to tidal flooding and storm surges through large infrastructure investments and implementing social and environmental management frameworks and plans. The creation of polders reduces the risk of saline intrusion into surface water ponds in the area.

[68] Ahmed et al. 2006; Ahmed 2011
[69] Chowdhury 2010; BBS 2011
[70] Md. Rezaul Hasan, Md. Shamsuddin and A.F.M. Afzal Hossain, "Salinity Status in Groundwater: A study of Selected Upazilas of Southwestern Coastal Region in Bangladesh," Global Science and Technology Journal, Vol. 1, No. 1, July 2013.

The World Bank funded the Rural Water Supply and Sanitation Project. The project closed June 2017. The objective of the Rural Water Supply and Sanitation Project was to: (a) Increase provision of safe water supply and hygienic sanitation in the rural areas of Bangladesh where shallow aquifers are highly contaminated by arsenic and other pollutants such as salinity, iron, and bacterial pathogens; and (b) Facilitate early emergency response. In part, these will be achieved through the introduction of rural piped water supply schemes in approximately 125 locations, as well as further developing public-private participation models for the construction and management of rural piped water schemes in areas where shallow tube-wells are highly affected by arsenic contamination, salinity, iron, and a low water table. A second component focusses on rural non-piped water supplies, targeting unions with severe shortages of safe water supplies due to shallow aquifer contamination, and with population densities that preclude private sector interest in the provision of piped water supply.

In rural coastal districts, ADB through the Coastal Climate Resilient Infrastructure Project (CCRIP)[71] is improving rural connectivity in a sustainable and "climate-proof" manner with the aim to reduce poverty and increase incomes. The project involves investments in rural roads, bridges, culverts, cyclone shelters and markets, as well as knowledge management and capacity building efforts. The US$ 150 million project is funded by GoB, IFAD, ADB, and the German Kreditanstalt für Wiederaufbau (KfW)[72].

The Rural Water Supply, Sanitation and Hygiene in Difficult and Hard-to-Reach Areas of Bangladesh Project, was implemented by UNICEF and addressed water quality issues. Its aim was to address the fact that many people do not practice key hygienic behaviours including the practice of effective handwashing with soap at key times, as well drinking arsenic-safe water and using improved latrines. The project was developed in collaboration with UNICEF, WHO (World Health Organisation) and UNHCR (United Nations High Commission for Refugees) with financial support from the Dutch government, to increase the access to, utilisation of, and demand for arsenic-safe water, improved latrines and handwashing in schools, health centres and refugees' camps, for an estimated 352,000 people in Khulna, Satkhira, Narail, Patuakhali, Bandarban, Khagrachari, Rangamati and Cox's Bazaar Districts.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has a pipeline project that is focussing on water in the coastal areas with the intention of promoting renewable energy as well as the efficient use of energy through the Renewable Energy and Energy Efficiency programme (REEEP). Among other activities, REEEP has been working in the disaster-affected coastal areas of Bangladesh to provide access to safe drinking water through solar powered pumps and distribution systems since 2010 (project "Solar Powered Plant for Reducing Drinking Water Vulnerability for Coastal Communities"). So far GIZ has piloted 122 drinking water pumping and distribution systems, with capacity ranging from 5,000 litres/day to 30,000 litres/day. These plants currently supply 1.9 million litres of drinking water to approximately 63,000 households every day[73].

The water supply systems draw water from surface ponds, underground sources, and saline water sources. Three different technologies are used, namely Pond Sand Filter (PSF) for surface/pond water, underground water extraction technology for underground sources and desalination technology for saline water sources.

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[71] ADB (2016) Asia Development Bank: Bangladesh: Second Crop Diversification Project. Retrieved from: https://www.adb.org/projects/40534-013/main

[72] CCAFS (2017). Climate-Smart Agriculture 101. Retrieved from: https://csa.guide/csa/coastal-climate-resilient-infrastructure-project-ccrip CCRIP n.d.

[73] GIZ-UNDP Correspondence 2017

Different business models, based on GIZ field experience, have been developed to ensure the sustainability of the plants. Under these business models, the Plant Management Committee (PMC), which includes both local government and community representatives, appoints a Caretaker to the water plants, who is then responsible for the overall plant management and maintenance.

During 1990 – 2015 there were several water supply programmes implemented by various organizations[74] (i.e. national and international NGOs, humanitarian agencies) targeting about 195,864 community people of Dacope Upazila of Khulna District. The programmes covered approximately 18,966 targeted households in the upazila. Through those programmes, a range of water supply technology options were implemented that include construction and repair of PSF, STW, DTW, tank for community and school, solar based PSF with piped network, RWHS at schools, RO plants.

From 2011 to till date, several water supply programmes are being implemented in Dacope Upazila targeting 36,430 community people of which 31,830 are covered already through water supply services and facilities. Such services and facilities include construction and rehabilitation of PSF, STW, DTW, water tanks for communities and schools, RWHS at schools and households, and RO plants. The major implementers of water programmes are World Vision, JJS, Heed Bangladesh, Rupantar, BASD, and Care Bangladesh.

The drinking water supply programmes in the Shyamnagar Upazila of Satkhira District are presented as a detailed example. As per available information[75], four NGOs[76] with the support from international donors[77] have recently[78] (December 2016) completed their drinking water supply programmes in Shyamnagar Upazila. The programmes were implemented targeting about a total of 3,500 community people, and facilitated communities to install and use number[79] of Reverse Osmosis (RO) plants, Rain Water Harvesting Systems (RWHS), and Pond Sand Filters (PSF) as safe drinking water sources.

Specific to unions under the upazila, where drinking water supply programmes were recently completed, a summary of the programmes is presented below in Table 14:

Table 14: Drinking water supply programmes in Shyamnagar

Union	Implementing agency/NGOs	Target beneficiaries	Population covered	Technology options used	Period of programme
Gabura	IRW-B	Community people	180	RWHS	36 months
	Friendship	Community people	1,750	RO plants	48 months
	NGO-PH	Community people	1,800	RO plants	22 months
	Shushilan	Community people	900	DTW, RWHS	12 months
	GIZ	Community people	1,400	RO plants	18 months
Burigoalini	DAM	Community people	1,500	RO	18 months
	Shushilan	Community people	900	RWHS	12 months
Munshiganj	Shushilan	Community-institutions	1,716	RWHS, DTW	11 months
	IRW-B	Community people	3,480	DTW	12 months

[74] Organizations include: ADO, AOSED, DPHE-GOB, GIZ, Prodipan, BASD, Christian AID, BRAC, World Vision, DSK, JJS, Heed Bangladesh, Bangladesh Red Crescent Society, USS, Bachte Shekha.
[75] Source: WaterAid partner NGOs working/worked in the coastal districts (collected in March 2017)
[76] Namely: 1) Shushilan, 2) Friendship, 3) NGO Forum for Public Health, and 4) LEDARS
[77] Yet unknown
[78] Period from exact time the programmes were started and ended-up by when is yet unknown
[79] Yet unknown

Union	Implementing agency/NGOs	Target beneficiaries	Population covered	Technology options used	Period of programme
	GIZ	Community-institutions	4,000	Mini PWSS	24 months
Ramjannagar	IRW-B	Community people	1,600	RWHS	36 months
Kaikhali	Madani Foundation	Community people	500	PSF	12 months
	Caritas Int.	Community people	1,000	PSF, Pond Ex.	24 months
	JCF	Community people	300	RWHS (Tank)	18 months
	GIZ	Community people	500	Mini PWSS	6 months
	Shushilan	Community-institutions	5,000	RWHS, PSF	36 months
Atulia	GIZ	Community people	800	Mini PWSS	18 months
	Shushilan	Community-institutions	6,500	RWHS, DTW	12 months
Padmapukur	GIZ	Community people	1,020	Mini PWSS	18 months
Kashimari	Shushilan	Community-institutions	2,000	DTW	36 months
	IRW-B	Community people	1,000	DTW	12 months
	Madani Foundation	Community-institutions	1,000	DTW	36 months

Similar NGOs, as stated above who were reportedly completed programmes, have also been continuing the implementation of several other/or similar donor[80] assisted drinking water supply programmes targeting rather an increased number (about 20,000) of community people of the upazila. Reportedly[81], they continue to support installing and ensuring community access to similar drinking water options i.e. RO plants, RWHS and PSF. However, these programmes are supposed to be ended up by December 2017.

Specific to unions under the upazila, where drinking water supply programmes are ongoing, a summary of the programmes in Shyamnagar is presented below in Table 15.

Table 15: Union specific programmes in Shyamnagar

Union	Implementing agency/NGOs	Target beneficiaries	Population covered	Technology options used	Period of programme
Gabura	Broti	Community people	3,500	PSF	96 months
	Shushilan	Community people	500	PSF	11 months
	World Vision	Community people	Unknown	Unknown	48 months
Munshiganj	RDA Bogra	Community-institutions	4,032	Mini PWSS	120 months
	Shushilan	Community people	550	RWHS	36 months
	World Vision	Community people	Unknown	Unknown	48 months
Ramjannagar	Shushilan	Community-institutions	345	RWHS, PSF	36 months
	World Vision	Community people	Unknown	Unknown	48 months

[80] Yet unknown
[81] By the implementing NGOs

Union	Implementing agency/NGOs	Target beneficiaries	Population covered	Technology options used	Period of programme
Kaikhali	Shushilan	Community-institutions	5,000	RWHS, PSF	36 months
	World Vision	Unknown	Unknown	Unknown	48 months
Atulia	Shushilan	Community people	3,600	RWHS, PSF	96 months
	Shushilan	Community people	500	RWHS	36 months
Padmapukur	Friendship	Community people	2,025	RO	48 months
	Shushilan	Community people	1,000	PSF	11 months
	World Vision	Community people	Unknown	Unknown	48 months
Kashimari	World Vision	Unknown	Unknown	Unknown	48 months
	Shushilan	Institution	400	DTW	12 months

5.3 Co-ordination with Current Initiatives

The O'Harijan drinking water project (implemented by LEDARS) has initiated two projects to enhance adaptive livelihood capacity and income of target beneficiaries. To reduce climate induced migration, the project is introducing integrated water resource management models through excavated mini ponds and canals in paddy land, establishing deep tube-wells, and supporting households to preserve the daily use of waste water for dry season cropping. The project also increases awareness of the beneficiaries on how to maximise use of their conserved rainwater, what varieties are growing in less water, which varieties can grow in brackish water, introduce tools and techniques for adaptive agriculture. The project will include implementation of biosand filters at the household level for improved safe drinking water supply.

USAID's Nobo Jatra project works in 40 Unions including in Kaliganj in Satkhira District and Dacope in Khulna District. The project is designed to reduce food insecurity and vulnerability for 856,116 households in 4 Unions and includes activities related to Installation of water systems and to promote livelihoods of the poor. It will establish Climate Smart Agriculture plots and engage with local producer groups. It will activate or reactivate Water, Hygiene, and Sanitation (WASH) Committees and community support groups and engage in behavioural change communication activities. The project will install 1-2 water options and 23-25 sanitation options per village. Water interventions mainly focus at the community-level whilst sanitation more at the household level. There are no water interventions around schools or growth centre/health centres. The proposed project is coordinating with both these initiatives on targeting and coverage to address supply gaps (see Section 7.4 Proposed Technology and Selection Methodology). The project also aims to coordinate with these efforts during implementation on institutional capacity building efforts to support systematic, climate-risk informed planning and implementation of these solutions.

Considering the high demand and insufficient supply of safe non-saline drinking water identified through the REEP project, GIZ is conceptualizing a new project under GCF - "Solar Powered Drinking Water Supply in Selected Coastal Areas of Bangladesh". The project would include another technology, namely Managed Aquifer Recharge (MAR), along with the mentioned three technologies and is expected to meet the water demand of approximately 0.16 million households. Discussions between the team developing this GCF proposal and GIZ have been ongoing and agreement reached that the two proposals are complimentary and that the GIZ proposal can focus on pumping and desalination technologies while this proposal addresses the need for rainwater harvesting.

6 Gaps and Challenges Constraining Climate-Resilient Drinking Water Provision

6.1 Gaps in Baseline Non-Saline Coverage

There are a number of historical and ongoing development projects and GoB investment to provide baseline water supply coverage as outlined in Section 5 Past and Ongoing Efforts. These have resulted in extensive water supply coverage as discussed in Section 4.1. There remains a clear need to address the expected additional impacts on these sectors through climate change. Many of the projects dealing with water resources involve the construction of large-scale related infrastructure and not the supply of drinking water solutions that are resilient to climate change induced salinity. The main projects dealing with water supply in the southwestern coastal areas are the ADB funded Southwest Area Integrated Water Resources Planning and Management Project, and the WB funded Rural Water Supply and Sanitation project. These projects both focus on non-drinking water aspects of water resource management and not directly on increasing the supply of safe drinking water that is resilient to the impacts of climate change induced salinity.

As stated in Section 4.1, the non-saline drinking water sources (i.e. excluding shallow tube wells etc.) that provide safe year-round supply are a subset of the data recorded in the 2011 Census. The PRA process, as cited before, was used to identify the baseline coverage for safe year-round non-saline drinking water supply and the supply gaps for the target 39 Unions of 5 Upazilas in the Khulna and Satkhira Districts. The PRA process identified functional and potential drinking water sources in the communities at household, community and institutional levels as follows:

- Functioning : provides year-round supply of non-saline drinking water
- Potential : currently does not provide year-round supply of non-saline drinking water (for example a potential pond location does not currently have a functioning water treatment system)

The process involved participatory community consultation – firstly, both at Ward level (i.e. Ward PRA on water source mapping) and Union level, with knowledgeable community members (both men and women) represented by various social groups (comprising 8-10 participants in each session), e.g. Ward members, teachers, housewives, religious leaders and social workers[82]. Table 16 and Table 17 summarise the PRA process outcomes and identify the safe non-saline drinking water supply gaps in all wards of the target 39 Unions of Khulna and Satkhira. The baseline coverage is low due to the exclusion of saline drinking water sources such as shallow tube wells. The baseline coverage is the households supplied by functioning non-saline water technologies: deep hand tube well (DHTW), rainwater harvesting (RWH), pond sand filter (PSF), RO (reverse osmosis desalination), piped water supply (PWS) and managed aquifer recharge (MAR).

Table 16: Non-saline drinking water supply gap analysis for the Khulna District (all wards in the target unions)

Upazila	Union	No. of Wards	No. of Villages	No. of HHs	HHs covered by Safe Non-Saline Water Options	Baseline Non-Saline Coverage (%)	HHs without Safe Water Options	Supply Gap (%)
Paikgacha	Deluti	9	23	3,922	544	13.87	3378	86.13
	Lata	9	23	2,651	101	3.81	2550	96.19
	Chandkhali	9	31	7,600	411	5.41	7189	94.59
	Garaikhali	9	15	4,722	300	6.35	4422	93.65
	Soladana	9	33	4,777	612	12.81	4165	87.19

[82] Community members and Ward members are different, while a UP Ward is a lowest tier of Bangladesh local government structure beyond Union Parishad (a Union consists of 9 Wards) and constituted by a number of communities/villages

Upazila	Union	No. of Wards	No. of Villages	No. of HHs	HHs covered by Safe Non-Saline Water Options	Baseline Non-Saline Coverage (%)	HHs without Safe Water Options	Supply Gap (%)
UZ Total:	5	45	125	23,672	1,968	8.31	21,704	91.69
Koyra	Amadi	9	30	8,404	441	5.25	7963	94.75
	Maheswaripur	9	23	6,356	310	4.88	6046	95.12
	Bagali	9	28	7,625	373	4.89	7252	95.11
	Koyra Sadar	9	13	7,002	2,392	34.16	4610	65.84
	Maharajpur	9	24	6,128	831	13.56	5297	86.44
	Uttar Bedkashi	9	24	3,863	1,330	34.43	2533	65.57
	Dakhin Bedkashi	9	17	3,456	2,848	82.41	608	17.59
UZ Total:	7	63	159	42,834	8,525	19.90	34,309	80.10
Dacope	Sadar	9	12	3,809	396	24.48	1221	75.52
	Bajua	9	20	4,103	755	19.82	3054	80.18
	Banishanta	9	15	3,303	701	21.22	2602	78.78
	Sutarkhali	9	13	6,286	788	12.54	5498	87.46
	Pankhali	9	11	3,569	371	10.39	3198	89.61
	Tildanga	9	12	4,294	1,217	28.34	3077	71.66
	Kamarkhol	9	19	3,183	813	25.54	2370	74.46
	Laudubi	9	34	6,226	447	7.18	5779	92.82
	Kailashganj	9	13	3,471	1,048	30.19	2423	69.81
UZ Total:	9	81	149	35,758	6,536	18.28	29,222	81.72
Dist. Total	21	189	433	102,264	17,029	16.65	85,235	83.35

Table 17: Non-saline drinking water supply gap analysis for the Satkhira District (all wards in the target unions)

Upazila	Union	No. of Ward	No. of Village	No. of HHs	HHs covered by Safe Non-Saline Water Options	Baseline Non-Saline Coverage (%)	HHs without Safe Water Options	Supply Gap (%)
Shyamnagar	Atulia	9	34	6,684	1,865	27.90	4819	72.10
	Ramjan Nagar	9	14	4,735	1,968	41.56	2767	58.44
	Kashimari	9	16	5,704	5,199	91.14	505	8.86
	Burigoalini	9	24	5,488	1,500	27.33	3988	72.67
	Gabura	9	17	6,808	1,983	29.13	4825	70.87
	Kaikhali	9	18	5,573	2,328	41.78	3245	58.22
	Padmapukur	9	12	5,563	2,371	34.95	3619	65.05
	Munshiganj	9	19	9,187	2,868	31.22	6319	68.78
UZ Total:	8	72	154	49,741	20,082	39.51	30,086	60.49
Assasuni	Anulia	9	24	5,525	346	6.26	5179	93.74
	Durgapur	9	14	3,419	502	14.68	2917	85.32
	Sreeula	9	23	5,760	1,706	29.62	4054	70.38
	Budhata	9	24	6,253	983	15.72	5270	84.28
	Barodal	9	23	5,919	1,371	23.16	4548	76.84
	Khajra	9	26	5,708	404	7.08	5304	92.92
	Kulla	9	21	5,890	1,480	25.13	4410	74.87
	Kadakati	9	24	3,181	676	21.25	2505	78.75
	Assasuni	9	25	5,418	2,823	52.11	2595	47.89

Upazila	Union	No. of Ward	No. of Village	No. of HHs	HHs covered by Safe Non-Saline Water Options	Baseline Non-Saline Coverage (%)	HHs without Safe Water Options	Supply Gap (%)
	Protap Nagar	9	18	6,191	2,468	39.86	3723	60.14
UZ Total:	10	90	222	53,264	12,759	23.95	40,505	76.05
Dist. Total:	18	162	376	103,005	32,841	31.88	70,591	68.12

6.2 Challenges to Implementing Climate Change Resilient Water Supply Technologies

6.2.1 Challenge 1: Limited knowledge of what to do about climate-induced salinity at the household level

Coastal households, currently, have a limited planning horizon to adequately consider incremental climate change impacts on fresh-water resources and identify resilient solutions for year-round, safe drinking water supply. Households may understand that their groundwater sources are becoming too saline to drink but have a limited understanding of climate change induced salinization processes and lack the knowledge on how to plan for the future.

6.2.2 Challenge 2: Limited skills and capacities for planning and implementing community drinking water solutions in light of climate-induced salinity

Provision of water to households is fairly decentralized and where access to piped water is unavailable, communities, local authorities, and NGOs often apply disparate approaches, as there is limited common understanding and technical skills to plan and implement drinking water provision with climate risks incorporated. Adaptive technologies required to deal with increased salinization of water sources, such as rainwater harvesting, PSF, Sky-Hydrants and RO, require technical skills for both operations and maintenance (including knowledge of basic carpentry and plumbing), as well as an understanding of hydrological characteristics of water sources and water treatment options. These skills are often in short supply and there is a need to develop them.

6.2.3 Challenge 3: Disproportionate burden on women

The collection of water for drinking and other household purposes are mainly women's responsibility. Rooftop and local rainwater harvesting systems would reduce this burden on women by being able to store water near their houses. However, women need to participate in the design and sustainability of solutions as they are the main-user group of the system, which is often not the case. Implementing organizations should include women during the project design phase and any system should provide easy access to the water collection point for women and people with disabilities.

The water scarcity and lack of access to clean water is disproportionately borne by the women in these communities. Access to information, skills, and technical capacity is extremely limited among the extreme poor women preventing investment in and adoption of climate-resilient technologies. By being excluded from water distribution and planning processes, women are further marginalized.

6.2.4 Challenge 4: Limited financial means of coastal households to invest in climate-resilient drinking water technology systems

Rainwater is the most dependable source of fresh drinking water in the salinity affected coastal rural areas. This climate resilient technology could be used to ameliorate the impacts of dry spells and climate related shortages, but affordability of this technology among those with low incomes is a major concern, largely because the cost of rainwater tanks is too high for them. Many households rely on collecting rainwater in tarps and storing it in earthen jars (Motka). The Motka have limited capacity (100L) and are insufficient to provide enough storage for year-round supply of drinking water. There is no specific yearly budget allocation for water supply from the government to support people living in water scarce areas, which affects extremely poor households who cannot afford to buy a large size rainwater tank.

6.2.5 Challenge 5: Limited O&M responsibility and capacity within local communities to look after drinking water technologies

Whilst 100 per cent of the population have access to some form of drinking water sources, only 61 per cent of the population have access to safe drinking water sources (not year round), and only 22 per cent of the population have access to year round safe drinking water.[83] Additionally, community involvement in water management and the design of water solutions is very limited. A screening of common practices undertaken by the proposal design team showed that water management committees and the involvement of women in them, exists on a conceptual level. However, the function of committees, the frequency of meetings, and transparency of decision making processes are not currently sufficient. This constrains involvement of the marginalized and poor, leading to a reduced sense of ownership, which in turn limits the willingness and interest to participate in required O&M activities. Clear and mandated mechanisms are required to strengthen the position of local communities and women in designing and managing drinking-water supplies.

Operational and management of drinking-water technology needs to be managed by the local community on a day to day basis. However, often there is a lack of capacity at the local level to maintain installed water options. Proper technology-management such as protection and water quality at the user-level needs to be given a higher priority by stakeholders, which should be addressed jointly by government and the private sector. Maintenance of the system has been found a major problem, especially for community-scale systems where roles and responsibilities for maintaining the system are not often clearly distributed among the beneficiaries. Inadequate training and awareness raising programs on the long-term benefits of freshwater storage technologies results in a lack of technical knowledge and neglect among the local users. Water quality control is also a challenge for stored rainwater, mainly for two reasons; a lack of awareness regarding the presence of bacteria in stored rainwater, which may be due to bird droppings in the catchment, insects inside the tank, etc.; and the absence of low-cost, easy-to-maintain and effective disinfection technology. These can be addressed through education programs and promoting low-cost disinfection systems.

In Deluti Union for example, local people pay a monthly fee (BDT 40) to a designated caretaker for maintenance of the community-based tube well and associated storage tanks, including regular water quality control. This was found to work well, but the source gives limited yields of water restricting its use. In other areas pond sand filters are used to remove turbidity and bacteria from pond water, but the removal efficiency of bacteria from pond water is often not satisfactory. Moreover, due to O&M difficulties (e.g. cleaning of filter beds, ensuring water passes through the filter chamber, lack of repair/maintenance funds) most of the pond sand filters in this area were abandoned. Those that were functional were found to be vulnerable to pollution, largely due to a lack of maintenance.

[83] Bangladesh Bureau of Statistics (BBS) 2011. Population and housing census report 2011.Bangladesh Bureau of Statistics, Ministry of Planning, Dhaka and Annex IIb

7 Proposed Climate Resilient Water Supply Technologies

7.1 Justification of Needs and Water Supply Technology Options

The primary drinking water source, throughout Bangladesh, is groundwater. Although the country has immense natural water resources, drinking water quantity and quality are greatly affected by Bangladesh's monsoonal climate (with 80% of annual rainfall occurring from June to mid-October) and a range of anthropogenic factors that have deteriorated water quality. For water quality, DPHE is addressing arsenic contamination in groundwater. This seasonal nature affects the choices people make in selecting good quality drinking sources. In the dry season, rainwater is not available for drinking and surface water sources become stagnant. During extended periods, this results in local water scarcity and degraded water quality, and necessitates the use of multiple drinking water sources to meet basic personal needs.[84]

As discussed in Section 6.2.1, high salinities occur in the shallow groundwater of coastal aquifers of Bangladesh, and the direct impacts of sea-level rise on coastal inundation and extent of storm surges is of greater concern on groundwater conditions than classical lateral intrusion. During the study, groundwater in a number of Unions was found to be unsuitable for drinking purposes due to high salinity concentration. Moreover, the tendency of salinity intrusion in this region indicates that more aquifers could be affected by salinity in future as climate change risks evolve. However, in a few unions deep fresh water aquifers are available and people were found collecting drinking water from these sources.

On the coast, most of the groundwater used for water supply is pumped from the top 150 m, but much of it is saline.[85] A study from Bangladesh Water Development Board[86] as shown in Figure 14, indicates that groundwater salinity in the selected project areas is beyond the limit for potable and irrigation use (>2500 uS/cm). Shallow coastal aquifers have high salinity and as such water supply wells must penetrate 250 metres or more to find water of acceptable quality.[87] During monsoon season aquifers are expected to be flushed and recharged ringing an abundance of fresh subsurface water. However, it has been suggested that recharge owing to the presence of intermittent and thick deposits of clays remains highly variable.

[84] Ansari et al. 2011

[85] Ravenscroft 2003; Chowdhury 2010

[86] BWDB 2012

[87] Ahmed, 2006

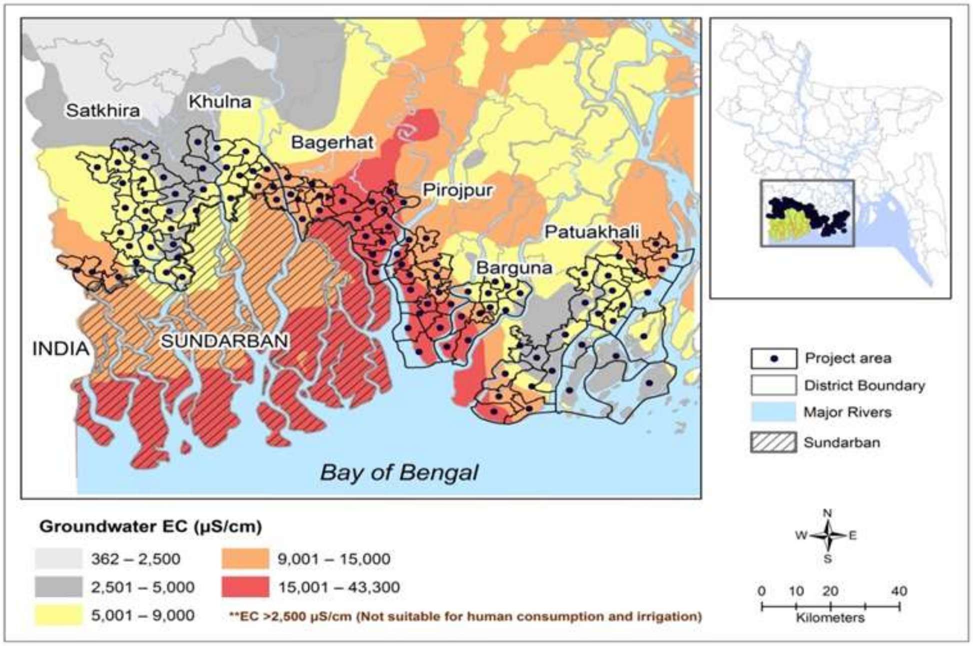

Figure 14: Groundwater Salinity in the South-west coastal zone (Data from BWDB 2012)

A long list of water supply options was developed primarily from the water supply technologies currently in use in the Satkhira and Khulna coastal communities (as identified through the Participatory Rural/Rapid Appraisal (PRA) consultation process) and from secondary sources. The long list of water supply technologies[88] is as follows:

1. Shallow Tubewell (STW)
2. Deep Hand Tubewell (DHTW)
3. Piped Water System (PWS)
4. Pond Sand Filter (PSF)
5. Rainwater Harvesting (RWH) System
6. Reverse Osmosis (RO) Plant
7. Managed Aquifer Recharge (MAR)
8. Zero discharge desalination
9. Solar distillation (for example the Carocell panels)
10. Pond treatment using Sky-Hydrant membrane technology

The first seven water supply technologies in the list were recorded as currently in use through the PRA process. The Sky-Hydrant technology was added to the list as an alternative to the PSF for treatment of pond surface water that provides full removal of microbial contamination. The Sky-Hydrant technology has been implemented by the GoB-led HYSAWA project in the Satkhira District (outside the target coastal communities).

Two additional innovative technologies were briefly considered but excluded from the long-list. Zero liquid discharge desalination was reviewed but there are no known installations in Bangladesh and this technology would rely on a local application for the salt by-products. Carocell solar purifiers (a low technology form of desalination) was also reviewed but excluded from the long-list due to no evidence of successful reliable installations in the target coastal communities.

7.2 Background to the Options Analysis

The current use of the identified water supply technologies primarily depends on the local availability of freshwater sources (surface water, groundwater and rainwater), environmental concerns, and the social acceptability of the options. The long-list of eight water supply options was assessed using a comprehensive set of evaluation criteria to identify the appropriate water supply technologies for the communities under the study districts[89] (Khulna and Satkhira):

- Climate change resilience to increased salinity
- Proven local technology (proportion of households that are presently using the options)[90]
- Availability (Reliability to meet demand year-round for water and accessibility of water source)
- Sustainability of O&M (level of technical expertise required)
- Social impact and acceptability
- Affordability: Economic aspects
- Provides safe drinking water
- Environmental impacts

The evaluation of the long-list against the above criteria is a multi-criteria assessment (MCA). The evaluation criteria are in line with the GCF investment criteria. The description of each water supply technology option and their applicability in the context of the coastal zone are discussed in the sub-sections 7.2.1 through 7.2.8 below and the MCA results are presented in sub-section 7.3.

7.2.1 Shallow Tube Well (STW)

Shallow wells are normally the means of accessing ground water of shallow depths (shallow ground water table). In this water supply system, skilled labourers dig into soft ground formations (sandy to clay) until the water table is struck. A shallow well is called “unprotected” when its top is not properly covered and a protected well with a lid. A hand-pump may also be fitted to increase the protection (see the Shallow Tubewell in Figure 15).

[89] Specifically covers 39 predetermined unions only of 5 Upazilas under Khulna (3 Upazilas i.e. Paikgacha, Koyra and Dacope) and Satkhira (2 Upazilas i.e. Shyamnagar and Assasuni) District (note: these were neither covering all unions under the upazilas nor all upazilas of the districts)

[90] Is meant to providing ‘indicative popularity’ of the systems/options as sources of drinking water (except Shallow Tubewells, that are mainly being used for the domestic purposes other than drinking during normal period, while the sources are exceptionally used for drinking purpose during the period of crisis i.e. natural disasters)

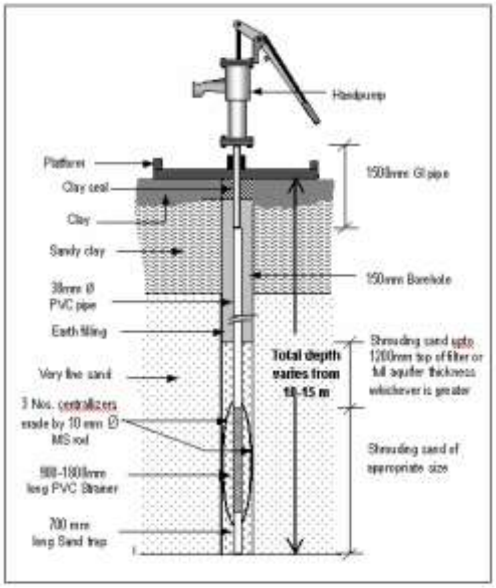

Figure 15: Schematic diagram of Shallow Tube Well

The following two technologies are often used;

- Shallow well siting
  A site to dig a shallow well is often identified by its hydrogeological setting; being along low-lying areas with thick soils and the type of vegetation favouring a shallow water table. At times, traditional divining methods are used (e.g. a small branch of a special tree which breaks at the right site). In many cases, they know from experience that the area has a shallow water-table, and even the taste of the water (e.g. areas with or without salty water).

- Shallow well digging
  a. Hand Dug Shallow wells
  Normally, a hand-dug shallow-well is about one to two metres (1 to 1.5 yards) in diameter, depending on the size of tools used. A hand-held hoe is the most common tool used. A small bucket, tied to a rope, is used to remove the dug soil from the hole. This process requires a team of two or so experts. As they dig deeper, they make notches along the walls, where they step (hence a small diameter is advantageous). At times, they use locally made wooden ladders. If they reach a hard formation (e.g. rock) before striking the water, they abandon the well. As the depth increases, oxygen decreases in the hole. At depths of over two metres, some put fresh leaves beside the digger (although they normally may not explain the technology; the leaves actually use the carbon dioxide from the digger to produce oxygen within the hole!). While five metres depth are often considered maximum, some go beyond. It takes an average of a week to finish a hand-dug shallow-well.

  b. Machine dug
  Some communities have appropriate technologies which assist them to dig the well faster in the same soft formations. Many communities use a tripod auger (also called the Vonder Rig). It goes to a depth of 15 metres. Its diameter is the borehole size. This process requires an average of ten people for two to three days. If a mechanized drilling machine is used, a maximum of one day would be required to complete a well.

7.2.1.1 Performance and Protection of Shallow Wells

Shallow wells in clay formation are good for stability of their walls, but recharge is usually slow if many people draw water from it. The result is a common long queue of people awaiting water recharge in the well. On the other hand, shallow-wells in sandy formations tend to be hazardous as they collapse easily, but their recharge is usually fast due to much higher porosity compared to the clay formations. This problem is usually managed by lining the well's walls with locally made materials such as bricks or baskets. A concrete slab is often put on top to prevent pollution. Where resources allow, a pulley system or better still, a hand-pump is installed to lift the water to the surface.

Table 18: Assessment of Shallow Tube Wells Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	The shallow groundwater source is mostly arsenic contaminated and vulnerable to salinity intrusion and thus STW water is not suitable for drinking. During the dry season, many STWs become non-functional due to a depletion of the water table and during disasters many STWs are inundated under salt water and become unusable, if platforms are not raised above flood level.
Proven local technology	In Khulna and Satkhira, 6,355 HH are using water from 593 STW (2.4% of total), out of which 2,349 HHs have own STWs. (In addition, 339 STW identified as potential). **Note:** Shallow Tubewells are mainly being used for the domestic purposes other than drinking during normal period, while the sources are exceptionally used for drinking purposes during periods of crisis i.e. natural disasters.
Reliability	The shallow groundwater layer is available in some unions of the coastal zone but except some pocket area there is high concentration of arsenic, iron and chloride in this layer. The layer is not available for extraction of water round the year as well due to dry-season depletion.
Accessibility	Access to STW is limited in many areas of the coastal district and the travel time and distance is high (>1km) for many households.
Sustainability of O&M	The STW are operated by using No.6 hand pump, which operates on suction mode. The O&M of this hand pump is simple, user-friendly and can be easily maintained by the households.
Social impact and acceptability	Where Shallow layer is available, the people install STW adjacent to their houses and they use this STW water for all domestic purposes which they perceive suitable for drinking rather than drinking pond water in case there are no other safe sources nearby.
Affordability for the users: Economic aspects	The cost of a STW ranges from BDT 8,000- 10,000, which poor people cannot afford. The water is free, however the repair and maintenance cost is very insignificant.
Provides safe drinking water	Except a few STWs in safe pocket sources, the water of most of STWs is not safe for personal, public and reproductive health (i.e. drinking and people drinking STW water are exposed to high risk of poisonous effect of arsenic and other intestinal diseases).
Environmental impacts	There are no visible adverse effects of STW water on the environment. However, STWs installed close to latrines are likely to be polluted by the short-circuiting of faecal mobility, especially during disasters or heavy rainfall.

7.2.2 Deep Hand Tube Well (DHTW)

Deep groundwater aquifers in the coastal region are currently not affected by salinity. Deep Tubewells are currently a popular option for drinking water as the system is user-friendly and needs very low maintenance, which makes it more affordable to the local communities.

Table 19: Assessment of Deep Hand Tube Wells Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	According to a study of World Bank (2010) on coastal aquifers of Bangladesh, the direct impacts of sea-level rise on coastal inundation and extent of storm surges is of greater concern on groundwater conditions than classical lateral intrusion. Moreover, the tendency of salinity intrusion in this region indicates that the aquifers could be affected by salinity in future as climate change risks evolve. However, it was learnt from PRA sessions that most of the existing DTWs are functioning well and discharging safe drinking water.
Proven local technology	2,586 DHTWs are being used by 22,522 households (8.6% of total). From these, 861 HHs have individual options (21,661 households use either community or institutional-based options) of which, 518 are functioning and 343 are identified as potential options/sources
Reliability	The deep groundwater layer is rarely available in most of the unions of the project area and hence DTW is not feasible in many unions. In a number of unions, the groundwater was not found suitable for drinking purposes due to high salinity concentrations. However, in a few unions, freshwater aquifers were available and people were found collecting drinking water from these sources.
Accessibility	Due to the limited locations of deep groundwater, access to DHTW is very limited in most areas of the coastal district and the travel time and distance is high (>1km) for many households.
Sustainability of O&M	DTWs are operated by using the No.6 hand pump,[91] which operates on suction mode. The O&M of this hand pump is simple, user-friendly and can be easily maintained by the households.
Social impact and acceptability	DTW is the most popular and socially acceptable option due to the extraction of safe drinking water, where a safe groundwater layer is available. DTW is an attractive option for the communities, due to the year-round availability of safe, free water and it needs minimal maintenance. In areas where Tubewells are unavailable, DTW water is collected from distant places directly or through vans with transportation costs.
Affordability for the users: Economic aspects	Most DTWs are public and installed by either DPHE or NGOs with a minimum 10% contribution from the user-households. The contribution amount ranges from BDT 6000- 7500, often shared by 5-10 households, which is affordable for the poor households. DTW water is free and the repair and maintenance cost is insignificant (i.e. affordable for all community segments)
Provides safe drinking water	The DTW water is arsenic and bacteriologically safe for drinking and there is no adverse health effect. DTW water also usually contains mineral items within acceptable range, which reduces mineral deficiency of the health.
Environmental impacts	Over extraction of freshwater in the saline prone area will create environmental problems through exacerbating climate change induced saline intrusion.

[91] The No. 6 Pump is a lever operated suction pump for shallow wells. Typically, No. 6 Pumps are installed in collapsible tube wells with the screen extending to the coarse sand aquifer. It is designed for family use, serving up to 100 persons. The maximum possible lift is 7 m. The No. 6 pump is a public domain pump defined by RWSN specifications. It is easy to install and has excellent potential for community based maintenance.

7.2.3 Piped Water Supply (PWS)

Table 20: Assessment of Piped Water Supply Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	The piped water system is normally resilient to disaster shocks and can continue to supply water, if the pond water source is not polluted by salt water intrusion.
Proven local technology	3,896 households in are using drinking water from 614 community based PWS (1.5% of the total).
Reliability	The deep groundwater layer is rarely available in most of the unions of the potential project area and hence groundwater based PWS is not feasible in many unions. However, in a few unions, piped water supply installed by GIZ is available and people were found collecting drinking water from specific stand points from nearby household clusters. These piped water systems either use a groundwater source or a pond water nearby. PWS that use pond water will reduce reliability of pond water for other sources because during the dry period the demand of water could exceed the capacity of the pond.
Accessibility	There are few existing PWS and the travel time and distance would be too high (significantly >1km) for most households.
Sustainability of O&M	The piped water system is required to be operated by a trained pump operator and the supply lines need to be continuously checked for leakage and uninterrupted water supply. The system is operated by either electricity or solar energy. A strong institutional arrangement is required for sustainable operation of PWS, which was found absent for most of the existing PWS. The O&M cost is required to be recovered from the users through tariffs.
Social impact and acceptability	Piped water supply is a desired option in the potential project area due to its ability to supply water at the doorstep of the households requiring zero or minimum collection effort especially by women.
Affordability for the users: Economic aspects	Due to unknown household cluster setting, topography and depth of suitable aquifer, the capital cost of a piped water system cannot be estimated. However, the community has to contribute up to 10% of the capital cost to get connected into the PWS. Besides, the user households have to pay monthly tariff at the rate of BDT 150-200, which is affordable by the users in consideration of potential benefits of PWS in terms of easy access to the PWS and convenience of water collection without any cost and effort.
Provides safe drinking water	The PWS water is typically arsenic free and bacteriologically safe for drinking, if not polluted through piped system.
Environmental impacts	There is no adverse effect of PWS water on the environment.

7.2.4 Rainwater Harvesting System (RWHS)

The coastal region of Bangladesh receives approximately 2,900 mm rainfall every year but more than 70% of this rainfall occurs during monsoon,[92] making rainwater harvesting a potential solution to fulfil the water demand in this region.

[92] Rahman and Akhter, 2011

Rainwater harvesting (RWH) is a widely used term covering all those techniques whereby rain is intercepted and used 'close' to where it first reaches earth. RWH is a solution for drinking water crises in areas where there are no possibilities of providing safe water cheaply within a reasonable distance of households, as the ground conditions are unsuitable and surface waters are polluted or absent. For example, the ground may be impermeable (rock/stony layers precluding Tubewell construction), groundwater may be over-mineralized by fluorides, iron or even heavy metals (e.g. Arsenic contamination in Bangladesh), or the aquifer may have saline zones such as in the coastal areas, the aquifer may be too deep to reach or groundwater table rapidly declining. In these situations, the harvested rainwater can be a valuable alternate water supply option. The rainwater is free from arsenic and other impurities. The physical, chemical and bacteriological characteristics of harvested rainwater usually represent a suitable and acceptable standard of potable water.

7.2.4.1 Elements of a Rainwater Harvesting System

The fundamental elements of a rainwater harvesting system include:

- **Collection/Catchment Surface:** The collection surface from where the rainfall runs off.
- **Conveyance:** Roof runoff is typically conveyed to a rainwater collection system via gutters with downspouts or roof area drains with leaders. Filtration devices are often used to remove particulate contaminants en route to storage. In some systems, a first-flush method is used to completely bypass an initial amount of roof runoff so that it cannot enter storage.
- **Storage:** Tanks or cisterns are used to store harvested rainwater, which may be placed in various locations. A number of processes automatically occur within the tank itself such as settlement, flotation and pathogen die-off. Finally, some technique of disinfection (such as chlorination, solar disinfection or use of a ceramic filter) may be employed to the water after it is drawn from the tank.
- **Distribution/delivery system:** Using harvested rainwater to fulfil designated uses normally requires filtering, treating, controlling flow to end-use, monitoring storage tank levels, and/or controlling the need for switching to backup/bypass/makeup water.

7.2.4.2 Collection/ Catchment Surface

A catchment is an exposed surface area on which precipitation falls and flows towards a draining point. The volume and rate of rainwater runoff are functions of catchment area, intensity and duration of rainfall, slope of the surface, and type of surface material. Roofs are considered as the most effective choice for catchments.

Water quality from different roof catchments is a function of the type of roof material, climatic conditions and the surrounding environment. Thin metal sheets (galvanized iron, mild steel etc.), often corrugated, are the most commonly used roofing material in rural areas. Because of the smooth texture, the rainwater collection is very efficient. Some caution must be exercised regarding roofing surface paints. Asbestos sheeting or lead-painted surfaces should be avoided by all means. Rainwater collected from roofs with copper flashings may cause discoloration of porcelain fixtures. Roofs made of clay or concrete tiles deliver rainwater which are suitable for both potable and non-potable use, but may contribute as much as a 10% loss due to rough texture, obstacles in flow, evaporation and porosity. Bacterial growth is encouraged in rough surfaces and dirt may be accumulated on the corner of the tiles. To reduce water loss and prevent growth of microorganisms, tiles are painted or coated with a sealant. In this case, special sealants should be used containing little or no toxic materials. Roofing materials made of asphalt shingles (tar-like hydrocarbon speckled with coloured small ceramic granules) are prone to leaching of toxins from coloured shingles and the harvested water may not be appropriate for direct consumption as potable water.

7.2.4.3 Rainwater Conveyance

Rainwater is typically conveyed from the collection surface (roof) to a storage tank or cistern in two ways:

1. A sloped roof typically drains to gutters and downspouts at the outer edges(s) of the structure. Scuppers, oversized gutters, and other methods are employed for overflow protection.
2. A flat or semi-flat roof may use roof area drains that connect to leaders (downspouts/ rainwater downpipes). Particularly for horizontal surfaces there shall be parapet around the surface to prevent free-fall of rainwater.

7.2.4.4 Rainwater Storage

While the tank is the largest component of storage, there are numerous supporting components that are fundamental to the functioning of this element. The components of a storage system include the following (Figure 16): (1) Tank, (2) Rainwater Inlet from Conveyance (may enter the tank from top, side), (3) Calming Inlet (minimizes disturbance of sediment at bottom of tank by reducing agitation from the incoming water), (4) Intake (usually provides extraction of water from a location below top surface), higher water quality is found below the top surface and above the very bottom of the tank, (5) Overflow (excess water flows out of tank to grade), storm water sewer, storm water control devices, or other appropriate path as per local requirements (6) Vent (provides ventilation for stored water and pressure relief from incoming water), and (9) Tank Access (should be secured to prevent unauthorized access).

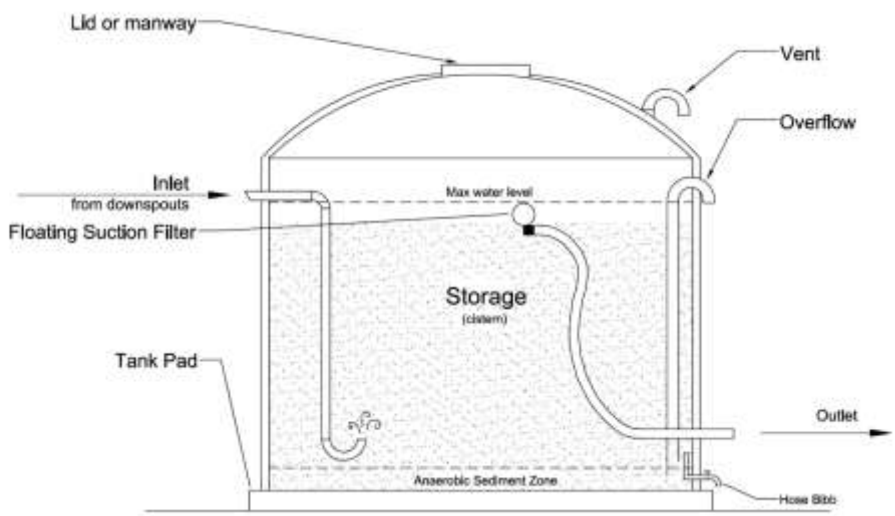

Figure 16: Different components of a rainfall cistern

7.2.4.5 Rainwater Distribution System

The distribution system is made up of the elements responsible for delivering water with the appropriate quality and pressure. All components in the distribution system need to be chosen carefully for compatibility and application purposes. Distribution is affected by factors such as location of the tank and the water supply expected from the rainwater system. In rural contexts, at the household, water can be collected and used from the storage tank directly, which may undergo a certain form of treatment/ disinfection (UV, chlorination, etc.) in a separate container.

7.2.4.6 Water Quality Management in RWHS

The potential of water quality contamination throughout a rainwater harvesting system necessitates the use of intervention options to produce water of suitable quality for potable and non-potable uses. Potential intervention options for rainwater collection systems include improved design features (positioning of inlet, altering the location of collection systems), pre-storage measures (debris screens and filters and first-flush diversion), and post-storage measures (post-storage filtration and disinfection).

7.2.4.7 Tank Maintenance

The success and overall usefulness of a RWH system will be largely determined by how a system is maintained. Downspout filters should be installed at a location easily seen and accessed by system users to facilitate frequent inspection and cleaning. Pump filters and treatment filters should be easily accessed and cleaned as well. Storage tanks should have access ways and drawdown valves should be installed to make tank cleaning and sediment removal easier.

Table 21: Assessment of Rainwater Harvesting Systems Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	Future changes in rainfall patterns need to be considered when deciding the size of storage, given that there is almost no rainfall for 4 to 6 months during dry season. Although it is predicted that rainfall levels on average could increase, the pattern may become more irregular over coming decades. This pattern of rainfall with long dry spells, makes storage of rainwater for the whole year difficult as large rainwater tanks to store water during the dry season are required. During disasters (cyclones), the roof of the user household being used as catchment area is likely to be damaged. However, the rainwater tank constructed on a raised platform remains intact and provides storage of safe drinking water. The impact of climate change on rainfall patterns is discussed under rainwater harvesting tank design.
Proven local technology	5,659 HHs are using water from RWHS, out of which 4,746 HHs have their own systems.
Reliability	The coastal region receives approximately 2,900 mm rainfall every year but more than 70% of this rainfall occurs during monsoon (June to September) every year in Bangladesh[93]. This huge amount of rainfall every year makes rainwater harvesting a potential solution to fulfil the water demand in this region. Despite rainwater being unavailable for 4 to 6 months of the year, people in most of the Unions were found heavily dependent on rainwater for drinking purposes. During the PRA, local communities reported that households get enough rainwater during the rainy period, but have to look for other options one or two months immediately after the rainy season as they cannot store enough rainwater to fulfil their demand for whole dry season. Therefore, rainwater harvesting systems with adequate storage capacities to store rainwater for the entire dry season, which also needs to be designed considering the rainfall pattern in this area, is be a good solution for people in this region. RWH can reduce exposure to waterborne pathogens by providing improved potable water quality and water for other household purposes, including hygiene, bathing and washing[94.]
Accessibility	RWH scores highly on accessibility as it can be designed to be included at the household level. RWH systems can also be located at existing community and institution buildings close to targeted households (<1km).
Sustainability of O&M	The system is based on low O&M requirements: mostly simple cleaning and basic repairs. Where not normally practised, local manufacture and supply of materials

[93] Rahman and Akhter, 2011
[94] UNICEF 2014

Factors Considered	Analysis
	may be weak or non-existent. A well-developed O&M plan, which accounts for proper maintenance over longer storage periods, and adequate testing of water quality is required to prevent contamination of stored water.
Social impact and acceptability	Widespread practice, relatively low-tech and low-cost: stored rainwater is a convenient, inexpensive water supply close to home – which can decrease the time spent fetching water or queuing at water points. It generally requires little training or capacity building, only local supply chains for storage containers and system components should be in place.
Affordability for the users: Economic aspects	The cost of the RWH system with 2000 litre plastic water tank ranges from BDT 20,000 to 25,000, which is not affordable by the poor people. But people are mostly interested to receive support for RWH systems from DPHE or NGOs with a cost contribution of 10%. The repair and maintenance cost is low. The main challenge is to provide the required water storage capacity for year-round demand at an affordable cost. The costs of high quality storage containers may still be a major investment for poor rural households. Group investments can help.
Provides safe drinking water	The RWH water is fresh water and is bacteriologically safe for drinking if the catchment, gutter system and water tank are cleaned regularly and hygienically maintained. However, water quality deteriorates after one or two month of the rain, if not preserved properly. Households need a user-friendly device for water quality testing.
Environmental impacts	There is no adverse effects of RWH water on the environment.

7.2.5 Pond Sand Filter (PSF)

PSF is a popular option of potable water supply in the coastal belt and arsenic prone areas. PSF is a simple low-cost technology with very high efficiency in turbidity and bacterial removal constructed with locally available materials and trained masons. It is a type of slow sand filter unit developed to treat surface water, usually pond water for domestic water supply. Slow sand filter is installed near or on the bank of pond, which does not dry up in the dry season. The water from the pond is pumped by a manually operated hand tube well to feed the filter bed, which is raised from the ground, and the treated water is collected through tap(s). It has been tested and found that the treated water from a PSF is usually bacteriologically safe or within tolerable limits.

7.2.5.1 Site Selection for PSF

PSF is usually constructed in areas where DHTW are not feasible for installation due to hard layer or non-availability of suitable aquifer producing acceptable quality and quantity of water. Moreover, areas where the shallow aquifer is contaminated with arsenic or existence of excessive salinity in the ground water, PSF can be used as the alternative solution. Since this technology is highly dependable on filtering surface water, special emphasis should be given on selecting ponds for this technology.

- The pond should be large enough and water should be available throughout the year.
- The pond should not be used for washing and bathing purposes.
- The pond should not be used for pisiculture and in no way any fertilizer or any chemical should be used in pond water for any purpose. But natural fish can grow by themselves without any external influence/support.
- The pond dike needs to be repaired as & when required, particularly before rainy season to protect agricultural, domestic and other waste runoff into the pond.

- The pond should be at a safe distance from latrines and cowsheds. Duck or any kind of poultry rearing in hanging shed over the pond must be prohibited.
- The salinity of the water should not exceed 600 ppm at any time of the year.

7.2.5.2 Water Quality Maintenance of PSF

PSF perform best under continuous operation and constant flow conditions. A 24-hour operation makes maximum use of the plant. Traditionally PSF connects with fresh water pond to supply raw water. In present coastal context, fresh water pond is not available and maximum existing pond water are saline. Existing fresh water ponds are re-excavated with proper bank management to protect from tidal surge and flood. These ponds are mostly rainwater fed ponds and soil protection can be done to protect leaching by using clay or other materials. New excavated pond is kept for one year after excavation for filling rainwater than PSF are constructed for supplying safe water.

Table 22: Assessment of Pond Sand Filters Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	Due to intrusion of salt water during tidal surges, especially during Aila in 2009, many fresh water ponds were damaged and have become saline. However, few fresh water ponds survived from saltwater intrusion and are currently being used during dry seasons by local people. However, these ponds are always exposed to risk of salt water inundation during cyclone and tidal surge and PSFs based on these ponds are also at risk of being non-functional due to increased salinity of the pond water. The risk of salt water inundation can be addressed through raising the pond embankment.
Proven local technology	A total of 617 PSFs are found installed, out of which 309 are presently functional and being used by 14,926 HHs (5.7% of total).
Reliability	PSF is an alternative and popular option of potable water supply in coastal problematic areas, where DTWs are not feasible. There are a number of fresh ponds either private or public in almost all unions of the coastal area. PSFs are based on these fresh ponds and filter pond water to remove turbidity and all other impurities including harmful bacteria. The PSF capacity depends on the pond size and dimension of PSF and has a wide range. A typical PSF can provide water to 30-50 households located nearby the ponds.
Accessibility	There are many available ponds in Dacope, Shyamnagar and Assasuni but only a limited number of suitable ponds in Koyra and no suitable ponds in Paikgacha. PSF scores similar to community and institution RWH on accessibility as it can be close to targeted households (<1km) where suitable ponds are available.
Sustainability of O&M	These ponds are not often perennial and dry up 4 months dry season when operation of PSFs become difficult due to inadequate water availability and high concentration of nutrients in the pond water (which leads to high requirements for cleaning filter media). But it was observed that due to operational and maintenance difficulties (cleaning of filter beds, manual lifting of water into the filter chambers, lack of repair/maintenance funds, etc.) these PSFs cease to operate and are often abandoned.
Social impact and acceptability	PSFs are also popular options and are socially acceptable community options. These are the next preferred option after RWH and are used as conjunctive or supplementary source of safe drinking water when harvested rainwater stock diminishes.

Factors Considered	Analysis
Affordability for the users: Economic aspects	The cost of a PSF typically ranges from BDT 50,000- 70,000 depending on the size of the chambers. The pond preservation and raising of embankment are necessary requirement of a PSF, which also increases cost and the users have to contribute at least 10% capital cost of PSF. The filter media is required to be cleaned after every three months and replaced as and when needed, which requires a significant costs and users are often reluctant to pay that cost.
Provides safe drinking water	If the PSF have sufficient regular maintenance then water is usually bacteriologically safe for drinking.
Environmental impacts	There is no adverse effect of PSF on the environment.

7.2.6 Managed Aquifer Recharge (MAR)

Managed Aquifer Recharge (MAR) was found to be used as a source of drinking water in few Unions where Department of Public Health Engineering (DPHE) installed these systems under an action research which is still going on. In this technology, water is collected from ponds and roofs and, after passing through a sand filter, is then injected into the shallow saline aquifer through a ring of infiltration wells, creating a lens of fresh water. After the turbidity of the infiltrated water has improved to an acceptable level, water can be abstracted using a standard hand pump yielding water of improved quality (reduced levels of turbidity, coliforms, iron and arsenic). This system remains operational during rainy season only, when rainwater is abundant.

MAR is increasingly being considered as a good option for water supply in a few countries as it provides large storage capacity to capture intermittently available excess seasonal water for use during dry season, although the system is yet to prove its effectiveness in the context of salinity affected coastal districts. The major challenge for the MAR system in coastal areas is proving its technological sustainability and solving maintenance issues. Its potential for scaling up in coastal region would largely depend on its performance, and identifying the specific conditions (e.g., salinity level, catchment characteristics, depth of water table, etc.) where MAR would be beneficial. The action research on application of MAR with options to store pond water and rainwater into shallow, brackish aquifers in 20 sites on the coastal plains of Bangladesh through recharge wells under gravity is currently being conducted in coastal areas of Satkhira, Khulna and Bagerhat (Sultana and Ahmed, 2014). The Schematic diagram of Managed Aquifer Recharge is shown in Figure 17.

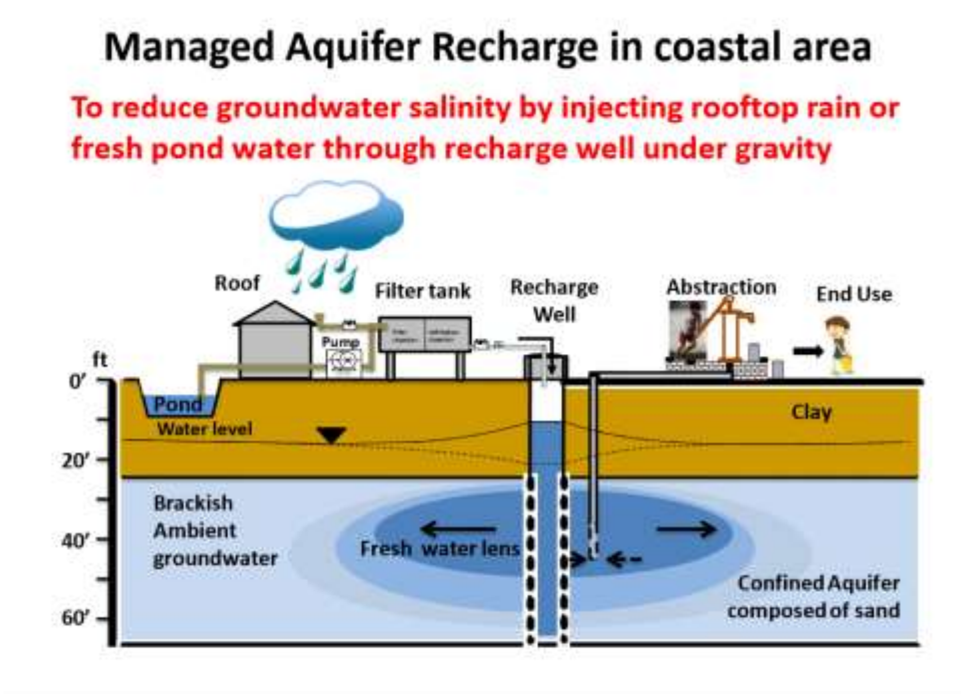

Figure 17: Schematic diagram of Managed Aquifer Recharge

Figure 18 shows a MAR system installed in Mongla upazila under Bagerhat district. This system remains operational during rainy season when rainwater is abundant. The system uses pond water, which is stored rainwater and have been used for drinking and cooking by the families living around the pond. The pond water goes through a pre-treatment process in a chamber containing filter materials, and then is allowed to pass through the recharge wells. The users collect water from this system through tube wells for drinking, though exact number of families collecting water was not registered.

Figure 18: Managed Aquifer Recharge (MAR) system in Mongla upazila under Bagerhat district

After successful construction of the MAR systems in the selected sites, their performance has not meet expectations or has failed entirely due to lack of proper management during operation. The reduction in hydraulic conductivity[95] around recharge wells is still a frequent reason for abandonment of MAR schemes. A maximum infiltration rate of 6m^3/day has been achieved at a number of sites where the average is about 3 m^3/day. This raises a concern over the possible recharge rate through MAR systems (Sultana and Ahmed, 2014). Clogging is a more significant issue for recharge well and can occur in the well screen, filter pack or aquifer and can have a physical, chemical or biological origin. Clogging issues related to aquifer material, design, drilling and construction methods have also been reported in the MAR sites (Sultana and Ahmed, 2014). Observations at few sites showed that with only rainwater infiltration, the volumes were not enough to reduce the salinity and make the water drinkable, suggesting that further research is needed for intervention in high salinity sites (Tuinhof et. al., 2012).

Table 23: Assessment of Managed Aquifer Recharge Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	The MAR system is yet to prove its effectiveness in the context of salinity affected coastal districts. From the results of the research currently being conducted in 20 sites in coastal districts, it appears that the major challenge for the MAR system in coastal areas is proving its technological sustainability and solving maintenance issues. Its potential for scaling up in coastal region would largely depend on its performance, and identifying the specific conditions (e.g., salinity level, catchment characteristics, depth of water table, etc.) of the areas to be considered for MAR implementation. Where MAR is injecting fresh rainwater into the saline aquifer and relying on dilution to provide drinking water, this initiative is not properly functioning but in saline intense areas. The risk of salt water intrusion into the pond during disasters is a potential threat for MAR operation (similar to any pond based water source).
Proven local technology	Total 370 HHs (0.01% of total) are using 5 MAR. (1 MAR identified as potential)
Reliability	Managed Aquifer Recharge (MAR) was found to be used as a source of drinking water in a few Unions where the Department of Public Health Engineering (DPHE) installed these systems under an action research which is still going on. This system remains operational during the rainy season only, when rainwater is abundant. The system uses pond water, which is stored rainwater and has been used for drinking and cooking by the families living around the pond.
Accessibility	MAR relies on pond water or RWH for the input water and scores similar to community/institution RWH and ponds for accessibility (it can be designed to be within 1km from target households if ponds or RWH are near).
Sustainability of O&M	The system is under action research in few coastal unions, results of which is yet to be captured/learnt and disseminated.
Social impact and acceptability	Comparatively new technology in the coastal zone and is yet to prove its social acceptability; however, hypothesis[96] used behind the technology suggest that stored runoff can be used for non-potable uses (e.g. garden irrigation), reducing pressure on higher quality (domestic) sources. In some regions, stored water can be used for drinking in the dry season with adequate treatment. Storage provides a good alternative when water availability is insufficient, but technical,

[95] A property of soil that describes the ease with which a fluid (usually water) can move through pore spacesor fractures.

[96] UNICEF 2014

Factors Considered	Analysis
	environmental, social or legal concerns may preclude development of reservoirs if they are too large. Social acceptability is significantly less than other technologies due to the operations and maintenance complexity.
Affordability for the users: Economic aspects	Under action research. O&M costs are not available; however, it requires potentially high costs depending on the scale of the project and location (availability of donors may help, but issues of sustainability when the project is completed).
Provides safe drinking water	MAR water is believed to be bacteriologically safe for drinking.
Environmental impacts	There is no proven adverse effect yet of MAR on the environment. However, capturing runoff can affect downstream communities, reducing their water availability. Additionally, directing excess runoff down, for example, abandoned wells to recharge aquifers can fast-track contamination.

7.2.7 Reverse Osmosis (RO) Plant

Reverse osmosis (RO) is a desalination process and can produce safe drinking water from both surface (i.e. river) water and groundwater as input water irrespective of salinity and other contaminants. This makes this technology option resilient to increasing levels of salinity in the coastal areas of Bangladesh. In this process water is made to pass from the more concentrated solution to a less concentrated one which is the principle of process of osmosis. The force necessary to accomplish this is the application of pressure greater than the osmotic pressure of the saline solution. When saline solution is in contact with semi permeable membrane which is placed under pressure being in excess of its osmotic pressure, water from the solution will flow through the membrane. Water flow will continue till the pressure created by the osmotic head equals the osmotic pressure of the salt solution.

Reverse osmosis treatment reduces the concentration of dissolved solids, including a variety of ions and metals and very fine suspended particles such as asbestos that may be found in water. RO also removes certain organic contaminants, some detergents, and specific pesticides. Although RO membranes can remove virtually all microorganisms, it is currently recommended that only microbiologically safe (i.e., coliform negative) water be fed into RO systems.

Acetate membranes have proved most successful to be used for this purpose. The salt content in the water produced can be controlled by reducing the pressure or increasing the number of filtrations. The Schematic diagram of Reverse Osmosis system is shown in Figure 19. RO technology is very good at purifying saline water but is heavily associated with higher operation and maintenance costs and high capital investment. The cost for energy and chemicals with frequent replacement of parts creates challenges for poor communities and introduces the potential for social discrimination when using this technology in vulnerable communities.

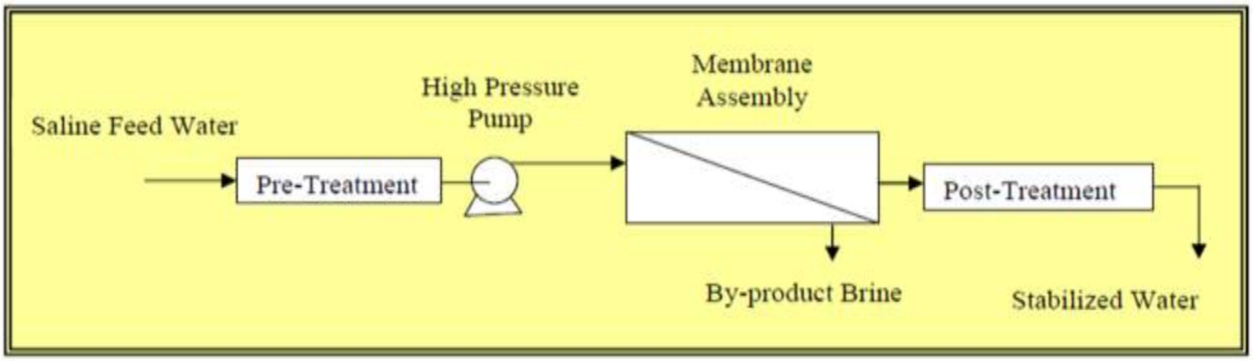

Figure 19: Schematic diagram of Reverse Osmosis system

7.2.7.1 Characteristics of RO Plant

The main attraction of this process is its low energy consumption. The energy required for operating the process increases with feed water salinity. RO process is suitable for both sea and brackish water. There are flexibility in water quantity and quality. This process requires low power consumption compared to other desalination plant. On the other hand, this process requires high quality feed water. The operational and maintenance cost is relatively higher than other desalination plant. This technology also requires higher pressure for functioning.

7.2.7.2 Maintenance of RO system

An RO system must be well maintained to ensure reliable performance. Clogged RO membranes, filters, or flow controls will decrease water flow and the system's performance. If fouling is detected in the early stages the membrane can often be cleaned and regenerated. The cleaning procedure varies depending on the type of membrane and fouling. Completely clogged or torn RO membranes must be replaced. In addition, pre- or post-filters must be replaced once a year or more often, depending on the volume of water fed through the system and the quality of the feed water. Damage to RO membranes cannot be seen easily. The treated water must be analyzed periodically to determine whether the membrane is intact and doing its job. Many systems now have a built-in continuous monitor that indicates a high Total Dissolved Solids (TDS) level, a sign that the system is not operating properly. It may also be necessary to test regularly for specific health-related contaminants such as nitrates or lead. Microorganisms, dead or alive, can clog RO membranes. To prevent bio-fouling, RO units must be disinfected periodically with chlorine or other biocides provided by the manufacturer. Continuous chlorination can be used with cellulose membranes to protect the system from biofouling and eliminate the particle trapping slime that worsens other forms of fouling such as scaling. Chlorine and other oxidizing disinfectants are harmful to thin film composite membranes. If the feed water is chlorinated, an activated carbon unit must be in place to remove the oxidizing chemicals before they reach the TFC membrane. Activated carbon (AC) prefilters should not be used on non-chlorinated water supplies because they provide a place for microorganisms to multiply and lead to increased bio-fouling of the RO membrane surface.

Table 24: Assessment of Reverse Osmosis Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	The RO technology is resilient to increasing levels of salinity in the river or ground water.
Proven local technology	2,497 households (1% of total) are using 26 functional systems, while 2 other systems are found to not functional, but potentially can be fixed.

Factors Considered	Analysis
Reliability	The RO system is based on a desalination process and can use both surface (i.e. river) water and groundwater irrespective of salinity and other pollution to produce safe drinking water. There are few rivers flowing through some unions of the study area and these rivers could be a potential source of water for RO plant implementation, especially for the areas, where no safe ground water source is available for DTW installation or fresh pond available for PSF/Sky-Hydrant implementation.
Accessibility	The accessibility of RO was scored based on river locations, i.e. generally far from most of the target households.
Sustainability of O&M	The RO plant is a Hi-tech option which requires to be operated by a skilled operator and the smooth operation of the plant requires technical back-up support from its supplier. The system is either operated by electricity and diesel generator in emergency situation. The O&M cost of RO system is comparatively higher than any other technologies due to costly treatment system and replacement of filter media. A strong institutional arrangement is required to keep RO plant operational.
Social impact and acceptability	The RO water is regarded as high-quality water and is socially acceptable. But due to cost factors, the RO is not a very popular option in the study area.
Affordability for the users: Economic aspects	The capital cost of and RO plant has been estimated at BDT 4,200,000 which can serve 200-250 households for supply of safe drinking water. The cost is high and it requires to be operated by the private sector. The RO water is currently sold in saline area at a cost of BDT 0.5-1 per litre (20-30 litres per household per day) including cost of transportation by water vendors. To make the cost affordable for the Poor and “Extreme Poor”, the cost needs to be reduced, which is possible by increasing RO water supply coverage i.e. by ensuring optimum utilisation of RO plant capacity
Provides safe drinking water	The RO water is of high quality, which is chemically and bacteriologically safe for drinking, and therefore, not harmful for either personal or public health
Environmental impacts	The brine generated from RO plants contains high salinity (60% higher than feed water). Discharge of this brine will increase salinization (over and above climate change impacts) of receiving water and have a high potential to adversely affect the health and biodiversity. In the absence of detailed river flow modelling, RO cannot be recommended due to the potential for adverse environmental impacts from the brine discharge. Zero liquid discharge desalination would likely have less adverse environmental impacts but are no known installations in Bangladesh. In addition zero liquid discharge desalination would be considerably more costly than RO and would rely on a local application for the salt by-products

7.2.8 Sky-Hydrant

Sky-Hydrant is a membrane filtration unit, which filters raw water and makes the output 100% free from coliform/bacteria, and turbidity. It has a filtration unit through which raw water passes by gravity force and produces fresh water at the output. The preferable source of raw water could be fresh surface water from ponds, rivers, and lakes. The Sky-Hydrant water purification unit produces safe drinking water without the need for power or chemicals. It is a low cost, lightweight (16 kg) portable and easy to deploy in the field. The UF membrane is robust, cleanable and has a service life of 10 years. Operating functions are simple and manual, with virtually no consumables. The units are designed to produce water for 500-1000 people as standalone unit, or can be configured for larger capacity. A single unit can produce up to 1000 litres per hour.

More information on Sky-Hydrant can be found at http://www.skyjuice.org.au/skyhydrant/. The schematic diagram of the Sky-Hydrant system is shown in Figure 20.

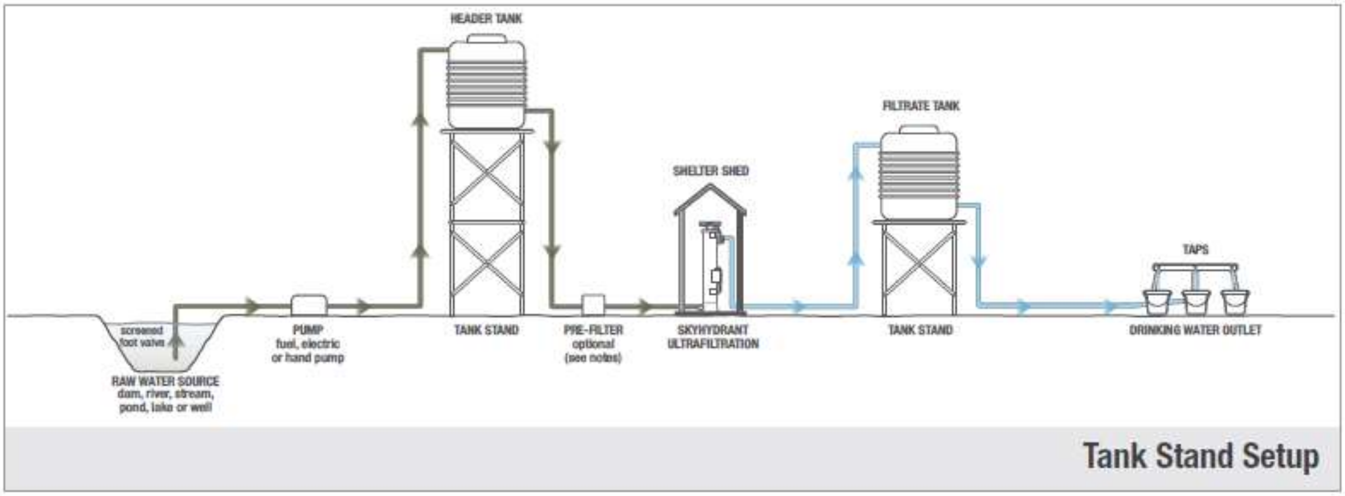

Figure 20: Schematic diagram of Sky-Hydrant system (Sky-Hydrant Setup Options Brochure)

7.2.8.1 Water Quality Maintenance of Sky-Hydrant

The Sky-Hydrant will remove biological contaminates and pathogens including bacteria, viruses, protozoa etc. making water safe to drink. The Sky-Hydrant will remove turbidity and dirt from water however the flow output and maintenance requirements depend on the incoming turbidity. The Sky-Hydrant will not remove salt, dissolved chemicals and minerals from water, therefore non-saline ponds need to be selected for this technology to provide suitable drinking water.

Table 25: Assessment of Sky-Hydrant Against the Evaluation Criteria

Factors Considered	Analysis
Climate change resilience to increased salinity	The Sky-Hydrant modules are installed in a well-protected superstructure, which are resilient to disaster shocks. In some areas of the coastal region, Sky-Hydrants have been used for 3 years. However, protection of the pond water sources from tidal surges during cyclones is required for climate change resilience (this protection can be provided by raising pond embankments to above highest storm surge level).
Proven local technology	New system is being implemented by GOB-led HYSAWA project in Satkhira District (but outside the target unions for this project).
Reliability	Sky-Hydrant is a membrane filtration unit, which filters raw water and make the output 100% free from coliform/bacteria, and turbidity. It has a filtration unit through which raw water passes by gravity force and produces fresh water as output. All fresh ponds, rivers and lakes are potential sources of water for the Sky-Hydrant technology.
Accessibility	There are many available ponds in Dacope, Shyamnagar and Assasuni but only a limited number of suitable ponds in Koyra and no suitable ponds in Paikgacha. Sky-hydrant was given the same score as PSF for accessibility as it can be close to targeted households (<1km) where suitable ponds are available.
Sustainability of O&M	A pump is also required (eather electrical or solar) and can be easily maintained by a trained caretaker. The sustainable O&M requires some institutional arrangement to recover O&M cost through tariff.

Factors Considered	Analysis
Social impact and acceptability	This is a new water technology, but in use for last 3 years in the coastal areas. Although many coastal people are not familiar with this technology, this is a well-accepted technology where it has been implemented due to its smooth functioning, minimum maintenance and wide coverage.
Affordability for the users: Economic aspects	The cost of a Sky-Hydrant is around BDT 1,000,000 including cost of superstructure. The users in current installations have had to contribute at least 10% capital cost of Sky-Hydrant, which is shared by 150-200 households. The Sky-Hydrant water is not free. The tariff for current installations has been estimated at BDT 100 per month for collection of 30 litre water per day (2 Pitcher). The tariff has also been fixed on piecemeal basis i.e. BDT 2.00 per pitcher as evidenced in HYSAWA area, which is affordable by the users.
Provides safe drinking water	The Sky-Hydrant water is bacteriologically safe for drinking.
Environmental impacts	There are no anticipated adverse environmental impacts from Sky-Hydrants as long as maintenance requirements are followed.

7.3 Option Analysis Results

Figure 21 shows the graphical results of the MCA for the qualitative criteria for each of the water source options. Piped water supply is not shown in the graph as it is not a distinct source of water (i.e. the source of water for piped water supplies will be PSF, DHTW etc.)

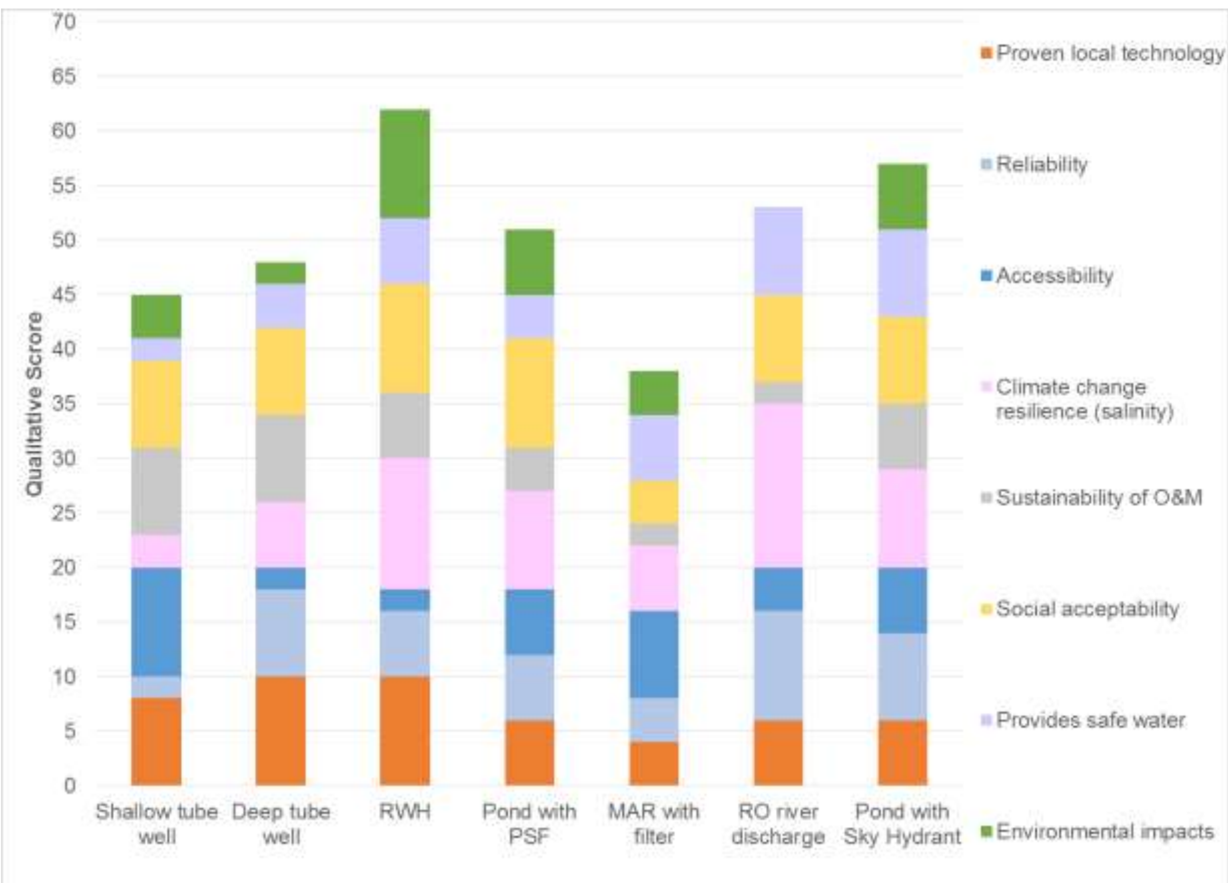

Figure 21: Multi-Criteria Analysis Graphical Results for Qualitative Criteria

The ranking of options from the above multi-criteria analysis is as follows:

1. Rainwater harvesting
2. Pond treatment with Sky-Hydrant
3. RO river discharge (however without robust river modelling to determine minimum environmental impacts, RO can be ruled out as an option)
4. Pond with pond sand filter (the MCA score of this option can be increased with an improved PSF design)
5. Deep tube well (in non-saline areas)
6. Shallow tube well
7. MAR with filter

Table 26 presents a summary of the options analysis for each of the short-listed water supply technologies.

Table 26 Summary of Options Analysis Results

Water supply technology options	Summary of options analysis results
Shallow Tube Well	STWs are not considered as a safe drinking water source due to climate change induced salinity and the DPHE does not promote STW implementation programmes.
Deep Hand Tube Well	DTWs are recognised as existing safe sources of drinking water and hence included as improved water source in JMP. All groundwater is considered to be at risk of climate change induced salinity over the long term. The availability of deep groundwater aquifers is also limited in the target wards and therefore new DTWs were not proposed as part of this project.
Piped Water Supply	A piped water system would rely on a significant water source such as deep groundwater aquifer which are rare in the target communities. The community-based viable institutional arrangement has not been experienced in the study areas. This is why community based piped water supply system is not proposed.
Rainwater Harvesting System	Due to an abundance of rain water in the coastal area, along with local traditional practice, familiarity with and fascination for the RWH, this option has been proposed as the main technological option. The community expressed a high desire for RWH.
Pond Sand Filter	Due to widely-observed maintenance difficulties and test results showing microbiological contamination, PSFs are not proposed for safe drinking water coverage. The community proposed the installation of some PSFs where fresh ponds were available, however these have been replaced with Sky-Hydrant technology.
Sky-Hydrant	Due to simple maintenance and full removal of microbiological contamination, Sky-Hydrants are becoming popular in the coastal areas and are replacing PSFs. Hence, Sky-Hydrants have been proposed as an improved alternative treatment technology to treat pond water in the study area.
Managed Aquifer Recharge (MAR)	Since the potential of MAR and its applicability in the salinity affected coastal region is yet to be proven sustainable over the long term, it was not considered as proposed technology option for the study area. MAR relies on either rainwater or pond water for its raw water input, therefore is a more expensive water supply technology than either rainwater or pond water treatment (capital and operations and maintenance costs).

Water supply technology options	Summary of options analysis results
Reverse Osmosis (RO)	Due to the negative environmental impacts and the potential for RO to increase salinity in the receiving environment, this technological option has not been proposed for increasing safe drinking water coverage in the study area.

In summary, rainwater harvesting is the preferred option from the MCA analysis due to its resilience to climate changed induced salinity, capacity to provide safe drinking water year-round and lack of adverse environmental impacts. The next preferred water source option is pond treatment with Sky-Hydrant.

7.4 Proposed Technology and Selection Methodology for each Ward

Rainwater harvesting is the preferred option from the MCA analysis due to its resilience to climate changed induced salinity, capacity to provide safe drinking water year-round and lack of adverse environmental impacts. The next preferred water source option is pond treatment with Sky-Hydrant.

Rainwater harvesting at existing community and institution buildings will have the highest cost efficiency due to economies of scale. However existing community and institution buildings are often far from the target households and to improve accessibility (travel distance and travel time to obtain water), household level RWH also need to be included in the proposed solutions.

Household level RWH can supply people with no access to community or institution based RWH or pond treatment systems, especially people living far away from these systems (at least 1km distance), women and adolescent girl headed households, people with disabilities and minority groups. Household level RWH is the most expensive of the preferred water solutions, more than twice as expensive per household supplied than the larger community-scale and institution-scale RWH systems. Despite the higher unit cost, a minimum number of household level RWH per ward is essential to ensure accessibility as outlined above.

The water supply gap in the target wards (for year-round, safe non-saline drinking water) is too large to address solely through installing RWH systems at existing community and institution buildings. The supply gap can be met through installing household level RWH however a more cost effective option (another community-scale water source) is also required. The next preferred water source option is pond treatment.

The existing surface water ponds are an alternative and popular option of potable water supply in the coastal belt and arsenic prone areas. Ponds typically do not dry up during the dry season and can provide a viable additional safe water source after treatment. The existing Pond Sand Filters (PSFs) are a simple low-cost technology using slow sand filtration, but most existing PSFs have been unable to fully remove microbiological contamination. In addition, inadequate O&M arrangements and inundation of the ponds during high storm surges and damage to filters have left many PSFs in the area unusable. To improve climate-resiliency and prevent saltwater intrusion during intense cyclonic events, selected fresh water ponds (not in the vicinity of / exposed to shrimp farming or other aquaculture), will be supported by raised embankments. The pond selection will also focus on existing ponds that are not saline and can provide year-round water availability. Table 27 provides a comparison of an improved pond sand filter design against the Sky-Hydrant Technology.

Table 27 Comparison of Improved Pond Sand Filter Against the Sky-Hydrant Technology

Issue	Sky-hydrant	PSF
Treatment and disinfection	Membrane filtration for removal of suspended solids and chlorination for disinfection.	No disinfection. PSF does not provide bacteria free water. Difficulty to add a disinfection system to the PSF that will sustain e.g. UV disinfection has been trialled but due to assembling/working modality etc. it did not sustain (reference: DPHE, ITN-BUET, WaterAid, OXFAM)
Sustainability	System installed in HYSAWA project have been running for more than 6 years.	There are many articles indicating PSFs don't sustain. Lower capital cost than Sky-Hydrant but shorter life expectancy.
O&M	The cost of maintenance is higher, but this includes maintenance of pumps, filter and disinfection system which are absent in PSF.	Lower O&M cost than Sky-Hydrant.

The preferred pond treatment technology is the Sky-hydrant system which provides filtration and ensures water quality. The Sky-hydrant modules have filtration units that rely on gravity force to pump fresh water out (a small solar pump is used to pump from the pond up to a raised tank to provide the head requirement for the filtration unit) and these modules are also installed in a well-protected superstructure, which are resilient to disaster shocks. The cost of water for the Sky-hydrant system per household supplied is higher than the larger community-scale and institution-scale RWH systems but less than the household RWH systems. Sky-hydrant systems will supply at the community-scale.

The following water supply options are proposed to fulfil the demand of drinking water in 39 Unions in 5 Upazilas of Satkhira and Khulna District:

- Household based rainwater harvesting system
- Community based rainwater harvesting system
- Institution based rainwater harvesting system
- Community based Sky-Hydrant system for treatment of water from fresh water ponds, where available

These water supply options and scales have been endorsed by DPHE.

After selecting the target wards (based on salinity, elevation and poverty as discussed in Section 3.8 Targeting of beneficiaries), the remaining steps to calculate the target households per ward and the appropriate water solutions to cover the target households were as follows:

1. For each ward, subtract the baseline coverage of the households with existing functioning safe non-saline drinking water supply from the total ward population (e.g. functioning deep Tubewells were included as a non-saline water source but shallow tubewells were excluded from the baseline due to salinity). The baseline does not include water sources that are being used but are saline. Current baseline is 13,122 HHs (13,122 * 4.4 = 57,737) in the target wards out of a total of 56,298 households as measured through the PRA process. This is equivalent to 23% of the households in the target wards.

2. Multiply the remaining households without access to functioning non-saline water supply in each ward by the zone factor where the zone factor is based on whether there are other proposed water supply improvement programmes in that sub-district. The known water supply improvement programmes in the Khulna and Satkhira Districts are the World Vision Nobo Jatra Project and the

O'Horizon programme targeting marginalised households as discussed in Section 5.3. The zone factors for each sub-district are as follows:

a) The factor for Zone 1 is 50% on the following basis: Zone 1 includes wards in the sub-districts of Shyamnagar, Dacope, Koyra. The combined programmes from World Vision and O'Horizon will implement drinking water solutions targeting 50% of the demand-supply gap in these sub-districts. World Vision's Nobo Jatra Project is proposing to install community level water solutions in 30% of the households. O'Horizon is targeting 20% of the households and is proposing to install household level water solutions.

b) The factor for Zone 2 is 100% on the following basis: Zone 2 includes wards in the sub-districts of Assasuni and Paikgacha. Neither World Vision nor O'Horizon are planning to implement drinking water improvements in these sub-districts.

The proposed drinking water supply solutions were then prioritised for the target households based on the following list in descending order of cost effectiveness:

- Community level water treatment of pond water using Sky-Hydrant (and including raising embankments to protect the pond water from saline intrusion during storm surge)
- Institution-scale RWH with large storage tanks (supplying 75 households) and very large storage tanks (supplying 100 households) at existing institutional buildings with large roof catchments (schools and colleges)
- Community-scale RWH with small storage tanks (supplying 25 households) and medium storage tanks (supplying 50 households) at existing community buildings (primarily at community buildings such as mosques, temples, cyclone centres, community clinics and other private owned buildings used for community purposes) and existing institutional buildings with smaller roof catchments (primarily in institutions such as schools, colleges, Union Councils and other government institutions)
- Household level RWH for people with no access to community or institution based RWHS, especially people living far away from these systems, people with disabilities and ethnic minority groups. At least 20% of total target households in each ward will be covered by household based systems.

In a number of wards in the Zone 1 sub-districts, there are higher household figures being targeted for climate resilient livelihoods than for water supply improvements, due to the existing safe water supplies and the proposed water supply improvements by World Vision. The households being supported with livelihood interventions will have water security, whether through the project or otherwise. Household level RWH will also be installed at households living far from the water sources and/or those who have accessibility issues (elderly people, person with disabilities, bad access roads, etc.).

In Upazilas with positive population growth forecast, the community-scale and institution-scale water options were sized considering the forecast 10-year population where possible. Surplus capacity was only built into the community-scale and institution-scale water options if there were no more than 20% of the households covered by HH-RWHS in that ward.

7.5 Rainwater Harvesting System Design

7.5.1 Rainwater Tank Sizing Methodology

Three modeling approaches were considered for sizing the proposed rainwater tanks. These are described below:

Dry period method. This method provides a rough estimate of the required tank size. The tank is designed to accommodate the necessary water demand throughout the longest dry period. For example, if the daily water demand is 100 liters and the dry season lasts for 120 days, a tank with a capacity of at least 12,000 liters would be required. The longest dry period needs to be defined.

Singular Tabular Method. This method uses monthly data over a one year rainfall period (e.g. the worst recorded year). A table is created to tabulate the monthly supply versus demand. For each month the excess water (not used by demand) from the previous month is factored into the existing tank volume (no allowance is made for overflow from the tanks during high daily rainfall events). Over the year the cumulative volume captured minus the cumulative demand over the year will determine the necessary tank size. The volume captured in a month is calculated by multiplying the available roof area equipped with gutters (A, m^2) by an appropriate runoff coefficient based on the type of roof surface (Cr) and the monthly rainfall (R, mm).

Daily mass balance model. This is the most sophisticated of the three methods considered. The daily mass balance model is based on treating the RWH system as a closed system with a single input (rainfall depth), a single output (demand), storage (with overflow when the tank is full), and losses (inefficiencies in the gutter-downspout system and the percentage of the roof area with guttering attached). The daily mass balance model calculates the volume of water stored in the tank at the end of each day and establishes a more realistic estimate of the portion of rainwater volume delivered from the roof to the storage tank. This method provides the most accurate assessment of the required tank size out of the three methods considered.

7.5.2 Analysis of Historical Rainfall and Climate Change Impacts

As discussed in Section 4, climate change predictions are for the peak monsoon months (June, July and August) to become warmer and wetter and the dry winter months (December, January, February) to become warmer and drier. Specifically a 5% decrease in rainfall is forecast for the dry winter months by 2050 (see Table 7). The predicted impact of climate change on long term average monthly rainfall for the dry winter months and peak monsoon months is shown graphically in Figure 22 and Figure 23 (the pre-monsoon and post-monsoon months are shown with 0% change).

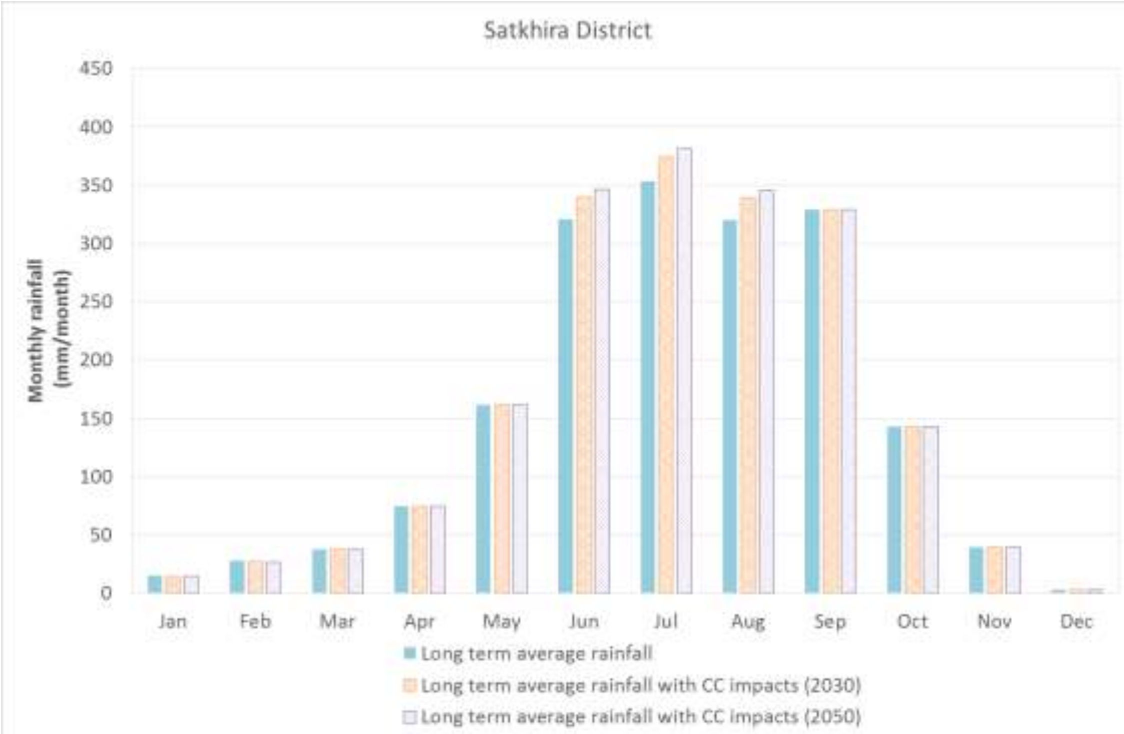

Figure 22: Impact of Climate Change on Satkhira District Monthly Rainfall for 2030 and 2050 (precipitation scenarios used in GoB documents as per Table 7)

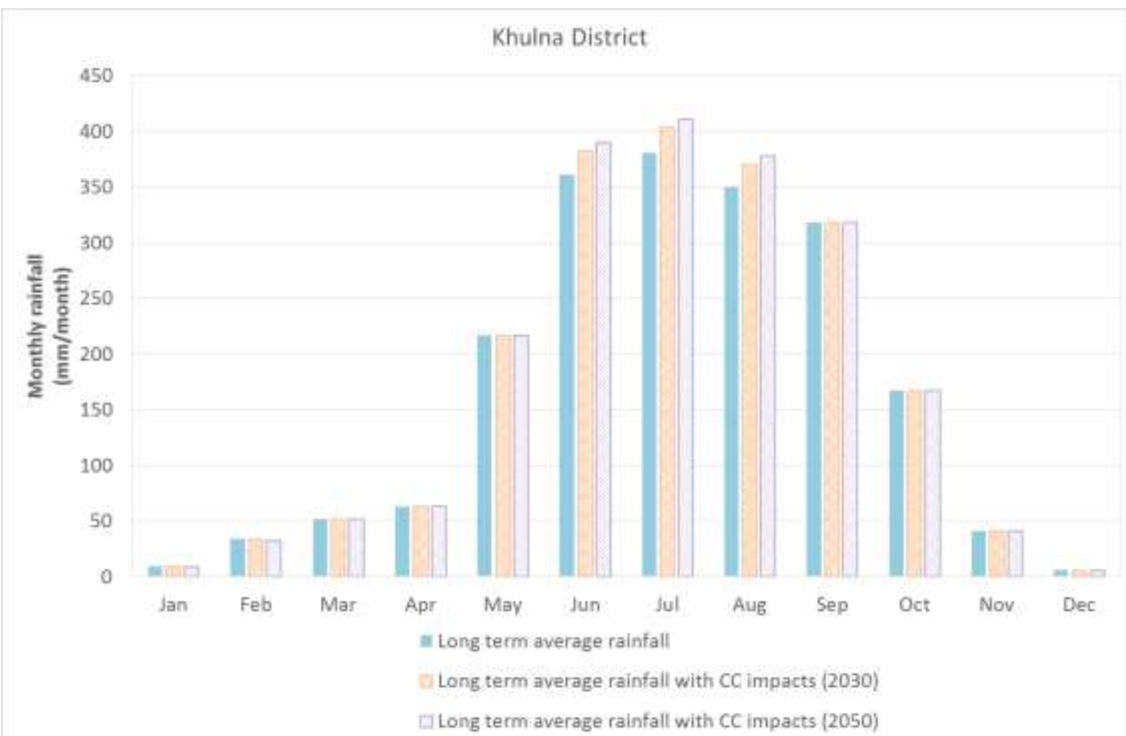

Figure 23: Impact of Climate Change on Khulna District Monthly Rainfall for 2030 and 2050 (precipitation scenarios used in GoB documents as per Table 7)

Figure 22 shows a decrease in the Satkhira winter rainfall from a long term average of 46mm to 44mm. Figure 23 shows a decrease in the Khulna winter rainfall from a long term average of 49mm to 47mm. The Singular Tabular Method for rainwater tank sizing would be combined with these monthly rainfall predictions to assess the tank size.

The Singular Tabular Method with climate change predictions was compared against the Dry Period Method using historical data to assess which is the worst case. Available climate data provided 31 years of daily rainfall data from two weather stations, one in Satkhira District and one in Khulna District. These climate records were analysed and the worst case scenario was found to be 180 consecutive days of dry period with no rainfall. The Dry Period Method result of 180 days of no rainfall is clearly the worst case when compared to a Singular Tabular Method using long term monthly rainfall with climate change predictions.

The Dry Period Method was adopted for the sizing the RWH storage tank capacity (180 days multiplied by the average daily demand).

The tanks have been sized to provide sufficient storage for 180 days (almost 6 months) of zero rainfall. The long term average rainfall for the six driest months (to correspond with the 180 day design period) is 197mm in Satkhira and 142mm in Khulna. Clearly the design drought of 180 days with zero rainfall is more conservative than the climate change prediction for a 5% decrease in rainfall during the dry months.

7.5.3 Rainwater Tank Sizing Design

The water security target was set at a minimum of 2 litres of drinking water person per day for the worst case six month dry period based on other drinking water projects implemented in rural areas of Bangladesh (i.e. this is a minimum for an extended drought situation. During normal years and under climate change predictions, the dry period is only 3 months. The water allocation of 2 litres of drinking water per person per day for six months is equivalent to over 5 litres of drinking water per person per day for three month dry period.

The average household occupancy was estimated to be 4.4 based on the demographic data for the target wards. The daily demand per household was calculated from these two parameters. For the institutions there was no additional water allowed for students, their allocation of water would be included under their household allocation of a minimum of 2 litres of drinking water person per day.

The minimum required roof catchment area to capture sufficient rainfall to fill the tanks to meet the dry period demand was estimated using rainwater capture formula and the singular tabular method of monthly rainfall. This was then checked using a daily mass balance model. The formula for rainfall capture is Area X depth of rainfall X catchment efficiency.

- Area is the effective rooftop catchment area (area projected from bird's eye view and enclosed by gutters) [L^2]
- Depth of rainfall per day [L/day]
- Catchment efficiency of the gutter-downspout system was assumed to be 85% (i.e. average spillage and loss of 15% based on the typical cast iron household roof and concrete community and institution building roofs)

For the household RWH systems, the required tank capacity is 2,000L based on the 180 day drought period and a conservative 5 people per household. The minimum roof area for a household RWH system is 5.6m².

The construction cost estimate allows for a new cast iron roof sheet for household RWH systems as many of the poorest households have only thatched roofs.

Existing community and institution buildings with potential for RWH installation were identified and defined through a building database developed by UNDP in 2016 for the target districts. The key parameters recorded included the location name, roof area (measured from satellite photos) and the condition of the building and roof structure (assessed through site visits). The 2016 building database was used to identify four sizes of RWH storage tanks based on the roof catchment area.

1. Small community-scale tank volume of 45m³ requiring a roof area of at least 75m²
2. Medium community-scale tank volume of 90m³ requiring a roof area of at least 150m²
3. Large institution-scale tank volume of 135m³ requiring a roof area of at least 225m²
4. Very large institution-scale tank volume of 180m³ requiring a roof area of at least 300m²

The capacity of these tank sizes to provide the required water supply was verified through a daily rainwater tank volume analysis over the historical climate record using the input parameters above and two example results are shown in the example graphs below. The orange line shows the % full for the tank after taking into account the daily demand for water and the daily rainfall capture. The blue lines show the daily rainfall. Drier years are evident on the graph by the low points in the tank % full line.

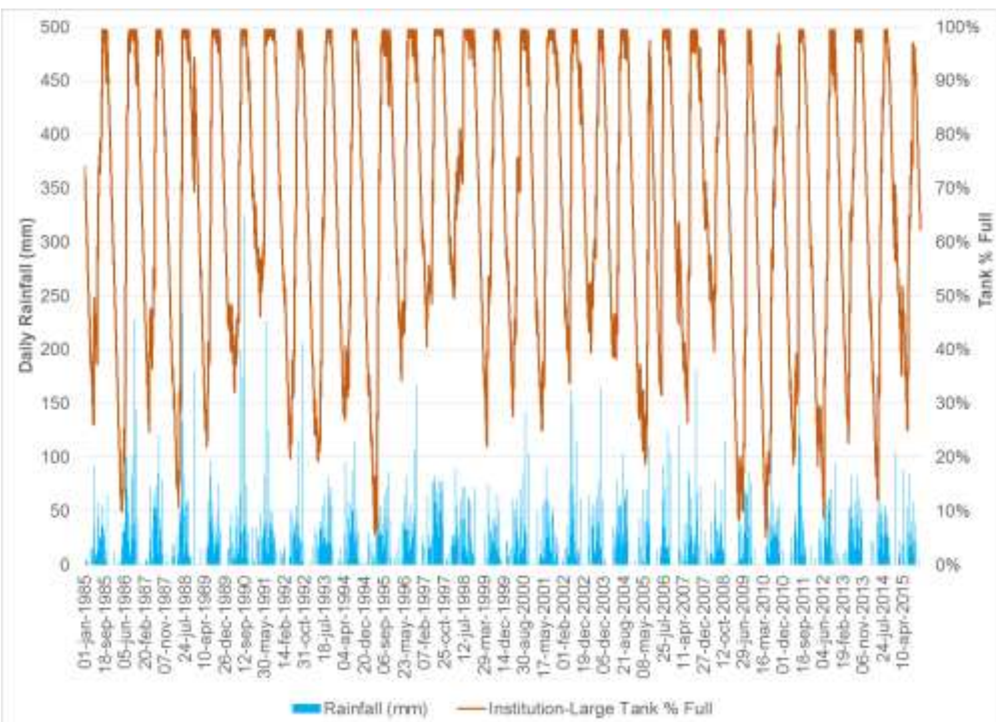

Figure 24: Modelled rainwater tank percent full over the climate record (large institution-scale tank in Satkhira District)

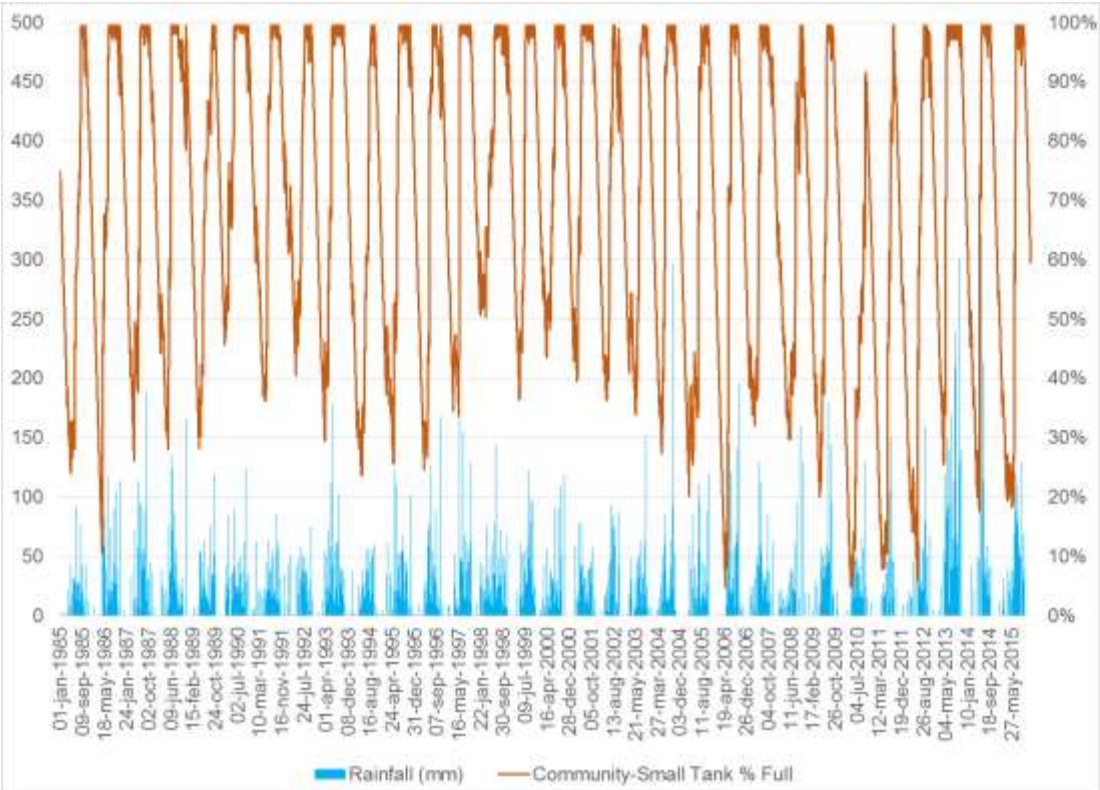

Figure 25: Modelled rainwater tank percent full over the climate record (small community-scale tank in Khulna District)

The long term average rainfall in the Satkhira District during the three wettest months from June to September is 10.8 mm per day. The long term average rainfall in the Khulna District during the three wettest months from June to September is 11.6 mm per day. The maximum rainfall required to fill each tank and the estimated number of days to fill the tank during the average rainy season are shown below (the maximum rainfall figures are conservative as they are based on the smallest roof size for each community and institution tank).

- A household tank will require 422mm of rainfall to fill. During the average rainy season in Satkhira this is equivalent to 39 rain days and in Khulna this is equivalent to 36 rain days.
- The community and institution tanks will require a maximum of 706mm of rainfall to fill. During the average rainy season in Satkhira this is equivalent to 65 rain days and in Khulna this is equivalent to 61 rain days (all of the community and institution tanks have been scaled proportionally.)

7.5.4 Selection of Community and Institutional Buildings for Rainwater Harvesting

The 2016 building database developed by UNDP was used to select target locations for the large and very large institution-scale tanks and for prototype example community-scale tanks. These target locations were surveyed through field site visits by RainForum and Aosed. Detailed survey reports were prepared for the 19 institution-scale tanks are included in Annex 4. A summary of all site survey information is provided in Annex 2. See the 5 union reports in Annex 3 and the remaining union reports in Annex IId for the locations of all proposed institution-scale and community-scale RWH systems in each union.

In the building database and site survey reports there were three condition ratings applied for the building and roof structure of the community and institutional buildings:

- Good (minimal repairs required)

- Moderate (moderate repairs required)
- Bad (major repairs required)

All buildings in good condition in the target wards were prioritised for rainwater harvesting with the appropriate sized tank according to their roof catchment area (roof areas smaller than 75 m^2 were considered too small for community-scale rainwater harvesting tanks).

The buildings in moderate condition in the target wards were only selected for rainwater harvesting if the need was great enough (i.e. after subtracting from the target households the households to be supplied by pond Sky-Hydrants and community and institution-scale rainwater harvesting at buildings in good condition).

The 2016 building database is not a complete inventory of all community and institution buildings in each ward (for example one ward in Assasuni has a population of over 4,000 people but had only one recorded building in the 2016 building database). The extent of the data gap was tested by site consultations with the UP staff on the actual number of available community and institution buildings in selected wards. There were three wards selected from the Assasuni upazila, one ward in the Koyra upazila and two wards in the Paikgacha upazilla. The site consultations found at least two additional buildings in each ward that were suitable for rainwater harvesting. Based on this, a maximum of two additional buildings were assumed in each ward that had insufficient buildings recorded in the 2016 building database. A conservative assumption was adopted that these would typically have a roof area of approximately 150m^2 in moderate condition and would be suitable for a medium size RWH tank.

Site surveys were undertaken at each of the institution buildings targeted for the installation of large and very large rainwater tanks (supplying 75 to 100 households). The site surveys included preparation of a site map and data collection on key design parameters including the building dimensions, condition assessment, roof materials, site boundaries, % of roof with existing guttering, roof shape, roof slope, number of households within 1km of the building, area of land available for construction of tanks, soil types, site elevation above mean sea level, existing power supply accessibility and availability and preliminary consultation undertaken with stakeholders on installation of RWH.

The minimum site area required for the RWH storage tanks is as follows (based on a 3m high tank):

- Community-scale small tank of 45m^3 will have a minimum site area requirement of 15m^2
- Community-scale medium tank of 90m^3 will have a minimum site area requirement of 30m^2
- Institution-scale large tank of 135m^3 will have a minimum site area requirement of 45m^2
- Institution-scale very large tank of 180m^3 will have a minimum site area requirement of 60m^2

The site specific data for the institution-scale rainwater harvesting locations are presented in the site survey reports in Annex 4. Annex 3 contains a summary of the institution-scale tank site data. For some of the institution-scale tank sites, more than one roof area will need to be diverted to the tank to provide the required minimum roof catchment area for the tank. The rainwater harvesting system technical design diagrams are shown in Section 10.1 and the bill of quantities for the investment costs are shown in Section 10.2. For the buildings in moderate condition the construction cost estimates include an additional allowance for roof catchment preparation/repairs.

7.6 Pond Treatment System Design

The ponds that are currently used by villagers, but do not have a functional PSF installed, were considered as the potential source for Sky-Hydrants. These ponds were selected because the water is non-saline and there are no man-made causes of salinity nearby. Saline water based aquaculture (e.g., shrimp farming) around the pond area should be currently absent and prohibited for the future.

Ponds are exposed to the risk of salt water inundation during cyclone and tidal surge. The risk of salt water inundation will be addressed through raising the pond embankment. The embankment height will be designed above the water level (predicted by local people and verified by DPHE) during tidal surges and this height should be maintained

The suspended solids and turbidity in these ponds is expected to be very low based on the preference of the villagers for these ponds as a potential drinking water source. The ponds for installing Sky-Hydrants will be confirmed after testing water quality of pond water in laboratory. Key water parameters that are likely to be tested include pH, Total Dissolved Solids, Total Suspended Solids, Electrical Conductivity, Total Coliform, Faecal Coliform Colour, Turbidity, Ammonia and Phosphate. The proposed Sky-Hydrant technology is sized for 200 households and 2 litres of drinking water per person per day. The Sky-Hydrant technical design diagram is shown in Section 10.1 and the bill of quantities for the investment costs are shown in Section 10.2.

8 Upazila Profiles and Proposed Water Technologies

8.1 Introduction to Upazila Profiles

From analyses of the information collected during PRA process, existing non-saline drinking water supply options of each upazilla were identified for each of the 39 targeted unions. The sub-sections below present the five upazila profiles which includes a summary of the upazila geography and demographics as well as the results of the PRA process summarised at a union level (including all wards in each union, not just the targeted wards). The union reports in Annex IId and Annex 3 (5 sample unions, one for each upazila) provide details for each of the targeted 101 wards.

As discussed in Section 6.1, each existing drinking water source was classified as either functioning or potential.

8.2 Upazila: Shyamnagar

8.2.1 Background (geography, socio-economic)

Shyamnagar Upazila of Shatkhira district is situated in the southern part of Satkhira District adjacent to World famous mangrove forest 'Sundarbans'. The total area of the union is 1968 sq.km. The union is situated 78 km away from District HQ. The union is surrounded by Kaliganj in the North, the Sunderbans in the South, Kapatakha and Kholpetua River in the East and Raimangal River in the West. Besides, Jamuna, Chuna, Malancha and Madar Rivers are flowing through Shaymnagar. The important rivers flowing through this union are Kholpetia, Chuna and Kadamtala. There are 15 public fresh water bodies in the union. As per estimate in the PRA sessions, the population of Shaymnagar was estimated at **216,124** (M: 105,638 F: 110,486) and household at **49,741**. The union wise population is presented in Table 28.

Map of Shaymnagar Upazila

Table 28: Demographic information of Shyamnagar Upazila

Union	Total number of Ward	Total Number of village	Total Number of HH	Population		
				Female	Male	Total
Atulia	9	34	6,684	15,484	14,929	30,413
Ramjannagar	9	14	4,735	11,886	10,046	21,932
Kashimari	9	16	5,704	13,471	13,186	26,657
Burigoalini	9	24	5,488	12,011	12,903	24,914
Gabura	9	17	6,808	16,450	14,665	31,115
Kaikhali	9	18	5,573	12,330	12,278	24,608
Padmapukur	9	12	5,563	12,469	12,185	24,654
Munshiganj	9	19	9,187	16,385	15,447	31,832
Total:	72	154	49,741	110,486	105,638	216,124

8.2.2 Drinking Water Sources, Supply, and Access

There are a total 1,577 household based RWHS in Shaymnagar Upazila which covers only 2.7% households of the Upazila.

In 5 Unions, there is a source of fresh groundwater that provides drinking water to the community by extraction through deep hand Tubewell (DHTW). A total of 382 household based functional DHTWS and 791 community based functional DHTW in Shaymnagar Upazila cover 9634 households (17.05%). These DHTW provide water round the water and reduces the collection time and effort of the woman substantially in those 5 unions. However, salinity intrusion in the deep layer is perceived to be the main threat of climate change in these areas. There are 22 piped water supply schemes based on ground supply in 4 unions of Shaymnagar Upazila, which provide drinking water supply to 1680 households (2.86%). Piped water supply provides water supply at the door step of the households and substantially reduces collection effort of the women. But water quality of these piped water schemes is not up to the mark and water supply is not also regular.

In areas where fresh water ponds are available, people depend on pond water, especially during dry season when rainwater is not available. But fresh water ponds are very scarce in Shaymnagar Union and people, especially women, are seen to collect pond water from a distance of 2 to 3 kilometres. There are 118 functional pond sand filters (PSF) based on these fresh ponds, which provides drinking water to 5,715 households (9.73%) of Shaymnagar. It was reported by the local communities in Shaymnagar that a large number of PSFs installed in the Union are currently non-functional (54%).

There are 9 Reverse Osmosis (RO) plants in 4 unions of Shaymnagar Upazila which provides water supply to 862 households (1.47%). These RO plants are operated by different NGOs on business models for extreme salinity affected areas. But these RO plants fail to attract poor users to purchase water at a high price (0.5-1.0 BDT per litre) and hence these are not operated at their optimal capacity. There is one MAR in Gabura Union, which was installed by DPHE and is operating on pilot basis.

All the above technological options provide year-round safe drinking water supply to 20,082 households and the supply coverage from these non-saline sources is 34.2%. There is a supply gap of 65.8% in Shaymnagar Upazila. Existing water supply technologies, coverage and supply gaps of Shaymnagar Upazila are shown in Table 29. The households covered by each of the non-saline year-round drinking water sources are shown in the columns with yellow highlights.

Table 29: Existing water supply technologies, coverage and supply gap of Shyamnagar Upazila

Union	Total number of ward	Total # of village	Total Number of HH	Existing Household based drinking water technology					Existing Community based drinking water technology																					Total HH covered (HH & Community)	Non-saline Coverage (%)	Uncovered HH	Supply gap (%)
				DHTW		RWH		Total	Deep set Hand Tube well (DHTW)			Pond Sand Filter (PSF)			Rain Water Harvesting (RWH)			Reverse Osmosis (RO)			Piped Water Supply (PWS)			Others (MAR)			Total P options	Total P options	Total HH covered				
				Functional	Potential	Functional	Potential		Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered							
Atulia	9	34	6,684	32	70	469	5	501	47	11	550	9	16	275	15	0	64	1	0	25	1	0	450	0	0	0	73	27	1364	1865	27.90	4819	72.10
Ramjan Nagar	9	14	4,735	0	0	128	1	128	39	4	450	13	22	1,375	3	0	15	0	0	0	0	0	0	0	0	0	55	26	1840	1968	41.56	2767	58.44
Kashimari	9	16	5,704	234	0	29	0	263	387	17	3811	11	3	425	0	0	0	0	0	0	10	0	700	0	0	0	408	20	4936	5199	91.14	505	8.86
Burigoalini	9	24	5,488	0	0	395	0	395	0	0	0	15	24	690	7	0	35	5	1	380	0	1	0	0	0	0	27	26	1105	1500	27.33	3988	72.67
Gabura	9	17	6,808	62	0	264	14	326	69	4	745	7	17	140	4	5	20	2	0	422	1	0	280	1	0	50	84	26	1657	1983	29.13	4825	70.87
Kaikhali	9	18	5,573	0	0	98	0	98	39	0	446	42	23	1760	2	3	24	0	0	0	0	0	0	0	0	0	83	26	2230	2328	41.78	3245	58.22
Padmapukur	9	12	5,563	4	5	55	0	59	144	11	1685	1	7	50	0	0	0	0	0	0	6	0	150	0	0	0	151	18	1885	1944	34.95	3619	65.05
Munshiganj	9	19	9,187	50	40	139	0	189	66	0	1520	20	26	1000	6	0	24	1	0	35	4	0	100	0	0	0	97	26	2679	2868	31.22	6319	68.78
Total	72	154	49,741	382	115	1577	20	1959	791	47	9207	118	138	5715	37	8	182	9	1	862	22	1	1680	1	0	50	978	195	17696	19655	39.51	30086	60.49

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8.2.3 Proposed Water Technologies

The proposed water technologies for the Shyamnagar Upazila are given in Table 30.

Table 30: Proposed water technologies in Shyamnagar Upazila

Union	Ward No.	Number of HH	Baseline Coverage for Non-Saline Drinking Water	Target Beneficiary Households (50%)	Proposed Technology									
					HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
						in buildings with "good" roof condition		in buildings with "moderate" roof		in buildings with "good" roof condition		in buildings with "moderate" roof		
						Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Atulia	4	829	125	352	227	1	-	-	2	-	-	-	-	-
Atulia	5	550	45	253	53	-	-	-	-	-	-	-	-	1
Atulia	7	356	167	95	19	-	-	-	-	-	-	-	-	1
Atulia	8	650	114	268	54	1	-	-	-	-	-	-	-	1
		2,385	451	968	353	2	-	-	2	-	-	-	-	3
Ramjan Nagar	4	604	200	202	41	-	-	-	-	-	-	-	-	1
Ramjan Nagar	9	559	400	80	30	-	-	-	1	-	-	-	-	-
		1,163	600	282	71	-	-	-	1	-	-	-	-	1
Kashimari	6	447	413	17	4	1	-	-	-	-	-	-	-	-
Kashimari	9	413	321	46	10	-	-	-	1	-	-	-	-	-
		860	734	63	14	1	-	-	1	-	-	-	-	-
Burigoalini	1	662	142	260	60	-	-	-	-	-	-	-	-	1
Burigoalini	4	427	334	47	10	-	-	-	-	-	-	-	-	1
Burigoalini	7	756	130	313	63	-	-	-	1	-	-	-	-	1
		1,845	606	620	133	-	-	-	1	-	-	-	-	3
Gabura	4	653	330	162	37	1	-	-	2	-	-	-	-	-
Gabura	5	936	479	229	46	-	-	-	-	-	-	-	-	1
Gabura	7	664	8	328	66	-	-	-	-	-	-	-	-	2
		2,253	817	719	149	1	-	-	2	-	-	-	-	3
Kaikhali	6	855	498	179	36	-	-	-	-	-	-	-	-	1
Kaikhali	8	395	274	61	13	-	-	-	-	-	-	-	-	1
		1,250	772	240	49	-	-	-	-	-	-	-	-	2
Padmapukur	3	783	375	204	41	-	-	-	-	-	-	1	1	-
Padmapukur	4	621	170	226	46	-	-	-	-	-	-	-	-	1
Padmapukur	7	618	50	284	57	-	-	-	1	-	-	-	-	1
		2,022	595	714	144	-	-	-	1	-	-	1	1	2
Munshiganj	6	1,130	307	412	83	2	4	2	1	-	-	-	-	-
Munshiganj	9	933	144	395	295	-	-	-	2	-	-	-	-	-
		2,063	451	807	378	2	4	2	3	-	-	-	-	-
	Total	**13,841**	**5,026**	**4,413**	**1,291**	**6**	**4**	**2**	**11**	**-**	**-**	**1**	**1**	**14**

8.3 Upazila: Assasuni

8.3.1 Background (geography, socio-economic)

Assasuni Upazila of Satkhira District is situated to the south east of Satkhira District with geographical location 22.5500°N 89.1681°E. The upazilla has 11 UPs of which 10 unions are covered under this study. The total area of the Assasuni is 367 sq.km. The upazilla is situated 27 km away from District HQ. The Upazilla is surrounded by Tala and Satkhira Sadar in the North, Assasuni in the South, Paikgacha and Koyra of Khulna District in the East and Kaliganj and Debhata in the West. Four rivers namely Maricchap, Khelna, Khelpetua and Kapotakkha are flowing through Assasuni. As per estimate in the PRA sessions at the union level, the population of Assasuni was estimated at **242,056 (M: 134,521 F: 120,967)** and household at **53,264**. The union wise population is presented in Table 31.

Table 31: Demographic information of Assasuni Upazila

Union	Total number of ward	Total Number of village	Total Number of HH	Population		
				Female	Male	Total
Anulia	9	24	5,525	12365	12345	24,710
Durgapur	9	14	3,419	7871	8329.5	16201
Sreeula	9	23	5,760	12967	12995	25962
Budhata	9	24	6,253	14,553	28,420	29,540
Barodal	9	23	5,919	14,357	13,681	28,038
Khajra	9	26	5,708	13,331	12,716	26,047
Kulla	9	21	5,890	12,068	12,494	24,562
Kadakati	9	24	3,181	6,849	7,272	14,121
Assasuni	9	25	5,418	11,468	12,157	23,625
Protap Nagar	9	18	6,191	15,138	14,113	29,251
	72	222	53,264	120,967	134,521	242,056

8.3.2 Drinking Water Sources, Supply, and Access

From analyses on the information collected during PRA process and expert judgment by the technical team, current drinking water supply options of Assasuni upazila were identified. There were three major sources of drinking water in the Union which are rainwater, groundwater from a shallow aquifer, and pond water. There are a total 779 household based RWHS in Assasuni Upazila which covers only 1.06% households of the Upazila.

In 8 Union, there is a source of fresh groundwater that provides drinking water to the community by extraction through deep hand Tubewell (DHTW). A total of 323 household based functional DHTWs and 394 community based functional DHTW in Assasuni Upazila cover 4,944 households (6.75%). These DHTW provide water round the water and reduces the collection time and effort of the woman substantially in those 8 unions. However, salinity intrusion in the deep layer is perceived to be the main threat of climate change in these areas. There are 3 piped water supply schemes based on ground supply in 2 unions of Assasuni Upazila, which provide drinking water supply to 1295 households (1.77%). Piped water supply provides water supply at the door step of the households and substantially reduces collection effort of the women. But water quality of these piped water schemes is not up to the mark and water supply is not also regular.

Fresh water ponds are very scarce in Assasuni Union and people, especially women, are seen to collect pond water from a distance of 3 to 5 kilometre s. Due to a lack of adequate maintenance, these ponds are found vulnerable to pollution. But absence of any other sources makes a large number of households dependent on this unsafe source for drinking water. In some households, alum is used in pond water which fastens precipitation of suspended particles, though it does not effectively remove bacteriological contamination from water. For treatment of pond water, pond sand filters (PSFs) are often proposed in coastal areas. There are 69 functional pond sand filters (PSF) based on these fresh ponds, which provides drinking water to 4,182 households (5.71%) of Assasuni. But it was observed in the study area that due to operational and maintenance difficulties (cleaning of filter beds, lifting of water into the filter chambers, lack of repair/maintenance funds, etc.) these PSFs did not last over time. It was also reported by the local communities in Assasuni that a large number of PSFs installed in the Union are currently non-functional (45%).

There are 13 Reverse Osmosis (RO) plants in 5 unions of Assasuni upazila which provides water supply to 1375 households (1.88%). These RO plants are operated by different NGOs on business model in extreme salinity affected areas. But these RO plants fail to attract poor users to purchase water at a high price (0.5-1.0 per litre) and hence these are not operated at their optimal capacity.

All the above technological options provide year-round safe drinking water supply to 12,759 households and the supply coverage from these non-saline is 17.6%. Still there is supply gap of 82.4% in Assasuni upazila. Existing water supply technologies, coverage and supply gap of Assasuni Upazila is shown in Table 32. The households covered by each of the non-saline year-round drinking water sources are shown in the columns with yellow highlights.

Table 32: Existing water supply technologies, coverage and supply gap of Assasuni Upazila

Union	Total number of ward	Total Number of village	Total Number of HH	Existing Household based drinking water technology					Existing Community based drinking water technology																						Total HH covered (HH & Community)	Non-saline Coverage (%)	Uncovered HH	Supply gap (%)
				DHTW		RWH		Total	Deep set Hand Tube well (DHTW)			Pond Sand Filter (PSF)			Rain Water Harvesting (RWH)			Reverse Osmosis (RO)			Piped Water Supply (PWS)			Others (MAR)			Total P options	Total P options	Total HH covered				
				Functional	Potential	Functional	Potential		Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered							
Anulia	9	24	5,525	1	0	17	0	18	28	0	280	0	1	0	1	0	48	0	0	0	0	0	0	0	0	0	29	1	328	346	6.26	5179	93.74
Durgapur	9	14	3,419	2	0	95	0	97	0	0	0	3	5	135	4	0	20	3	1	250	0	0	0	0	0	0	10	6	405	502	14.68	2917	85.32
Sreeula	9	23	5,760	105	0	41	0	146	82	135	1460	2	2	100	0	0	0	0	0	0	0	0	0	0	0	0	84	137	1560	1706	29.62	4054	70.38
Budhata	9	24	6,253	0	0	87	0	87	2	1	40	10	5	500	4	0	16	5	0	290	1	0	50	0	0	0	22	6	896	983	15.72	5270	84.28
Barodal	9	23	5,919	6	0	105	0	111	0	0	0	23	21	1180	16	0	80	0	0	0	0	0	0	0	0	0	39	21	1260	1371	23.16	4548	76.84
Khajra	9	26	5,708	0	0	104	0	104	0	0	0	6	2	300	0	0	0	0	0	0	0	0	0	0	0	0	6	2	300	404	7.08	5304	92.92
Kulla	9	21	5,890	142	0	43	0	185	1	0	50	14	4	765	0	0	0	2	0	480	0	0	0	0	0	0	17	4	1295	1480	25.13	4410	74.87
Kadakati	9	24	3,181	2	0	147	0	149	1	0	25	7	12	327	1	2	20	2	0	155	0	0	0	0	0	0	11	14	527	676	21.25	2505	78.75
Assasuni		25	5,418	16	0	101	5	117	42	2	386	4	4	875	0	0	0	1	0	200	582	0	1245	0	0	0	629	6	2706	2823	52.11	2595	47.89
Protap Nagar		18	6,191	49	0	39	0	88	238	3	2380	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	238	4	2380	2468	39.86	3723	60.14
Total	72	222	53,264	323	0	779	5	1102	394	141	4621	69	57	4182	26	2	184	13	1	1375	583	0	1295	0	0	0	1085	201	11657	12759	23.95	40505.1	76.05

8.3.3 Proposed Water Technologies

The proposed water technologies for Assasuni upazilla are given in Table 33.

Table 33: Proposed water technologies in Assasuni Upazila

Union	Ward No.	Number of HH	Baseline Coverage for Non-Saline Drinking Water	Target Beneficiary Households (100%)	Proposed Technology									
					HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
						in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
						Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Anulia	2	387	4	383	208	-	-	1	3	-	-	-	-	-
Anulia	4	494	0	494	294	-	2	-	2	-	-	-	-	-
Anulia	7	1,302	22	1,280	1,230	2	-	-	-	-	-	-	-	-
Anulia	9	453	261	192	39	-	-	1	3	-	-	-	-	-
		2,636	287	2,349	1,771	2	2	2	8	-	-	-	-	-
Durgapur	4	382	159	223	45	-	-	-	-	-	-	-	-	1
Durgapur	6	541	78	463	93	1	2	-	2	-	-	-	-	1
Durgapur	9	320	49	271	121	-	1	-	2	-	-	-	-	-
		1,243	286	957	259	1	3	-	4	-	-	-	-	2
Sreeula	1	652	15	637	487	-	1	-	2	-	-	-	-	-
Sreeula	2	417	9	408	258	1	-	1	2	-	-	-	-	-
Sreeula	4	735	297	438	88	-	-	1	-	-	-	-	-	2
		1,804	321	1,483	833	1	1	2	4	-	-	-	-	2
Budhata	1	550	175	375	75	-	-	-	-	-	-	-	-	2
Budhata	2	469	15	454	129	2	2	-	2	-	-	1	-	-
Budhata	8	739	103	636	128	2	3	-	3	-	-	-	-	1
		1,758	293	1,465	332	4	5	-	5	-	-	1	-	3
Bardal	1	336	151	185	85	-	-	-	2	-	-	-	-	-
Bardal	4	1,060	20	1,040	390	1	2	1	-	-	1	-	-	2
Bardal	7	788	162	626	126	-	2	1	1	-	1	-	1	1
		2,184	333	1,851	601	1	4	2	3	-	2	-	1	3
Khajra	2	720	22	698	498	-	2	-	2	-	-	-	-	-
Khajra	3	653	116	537	387	-	1	-	2	-	-	-	-	-
Khajra	9	748	109	639	264	1	1	-	2	-	-	-	2	-
		2,121	247	1,874	1,149	1	4	-	6	-	-	-	2	-
Kulla	5	603	350	253	103	-	1	-	2	-	-	-	-	-
Kulla	6	566	66	500	125	1	1	-	2	-	-	-	-	1
Kulla	9	468	38	430	86	-	2	-	2	1	1	-	-	-
		1,637	454	1,183	314	1	4	-	6	1	1	-	-	1
Kadakati	2	287	92	195	39	-	-	-	-	-	-	-	-	1
Kadakati	3	301	45	256	106	1	-	1	2	-	-	-	-	-
Kadakati	5	216	91	125	25	-	-	-	-	-	-	-	-	1
		804	228	576	170	1	-	1	2	-	-	-	-	2
Assasuni	2	376	366	10	2	-	1	-	-	-	-	-	-	-
Assasuni	9	441	45	396	246	-	-	-	3	-	-	-	-	-
		817	411	406	248	-	1	-	3	-	-	-	-	-
Protapnagar	6	518	400	118	24	-	-	-	-	-	-	-	-	1
Protapnagar	7	662	255	407	232	1	3	-	-	-	-	-	-	-
Protapnagar	8	511	173	338	163	1	1	-	2	-	-	-	-	-
		1,691	828	863	419	2	4	-	2	-	-	-	-	1
	Total	**16,695**	**3688**	**13,007**	**6,096**	**14**	**28**	**7**	**43**	**1**	**3**	**1**	**3**	**14**

8.4 Upazila: Paikgacha

8.4.1 Background (geography, socio-economic)

Paikgacha Upazila is situated between 22°28' and 22°43' north latitudes and in between 89°14' and 89°28' east longitudes. It is bounded by Tala and Dumuria Upazilas on the north, Koyra Upazila on the south, Batiaghata and Dacope Upazilas on the east, Tala and Assasuni upazilas on the west. The upazilla is 65 km away from Khulna District. Total population of Paikgacha Upazila is **109,258; male 57,722, female 51,536**; Main rivers of Paikgacha Upazila are Kobadak, Shibsa, Marichap, Haria, Shengrail, Mora Bhadar Gang.

Main sources of income are agriculture 53.14%, non-agricultural labour 5.48%, industry 1.50%, commerce 22.93%, transport and communication 2.82%, service 4.11%, construction 1.16%, religious service 0.21%, rent and remittance 0.12% and others 8.53%.

Table 34: Demographic information of Paikgacha Upazila

Union	Total Number of village	Total # of Households	Population		
			Female	Male	Total
Deluti	23	3,922	6815	8739.5	15555
Lata	23	2,651	5,506	5,350	10,856
Chandkhali	31	7,600	17,655	20,080	37,735
Garaikhali	15	4,722	11,667	11,139	22,806
Soladana	33	4,777	9,893	12,414	22,307
	125	23,672	51,536	57,722	109,258

8.4.2 Drinking Water Sources, Supply, and Access

From analyses on the information collected during PRA process and expert judgment by the technical team, current drinking water supply options of Paikgacha Upazila were identified. There were three major sources of drinking water in the Union which are rainwater, groundwater from a shallow aquifer, and pond water.
There are a total 427 household based functional RWHS and 28 community based functional RWHS in Paikgacha Upazila which covers 567 households (1.91%).

In 2 Unions, there is a source of fresh groundwater that provides drinking water to the community by extraction through deep hand Tubewell (DHTW). A total of 33 household based functional DHTWs and 2 community based functional DHTW in Paikgacha Upazila cover only 193 households (0.65%). These DHTW provide water round the water and reduces the collection time and effort of the woman substantially in

the above 2 unions. However, salinity intrusion in the deep layer is perceived to be the main threat of climate change in these areas. There are 6 piped water supply schemes based on ground supply in 2 unions of Paikgacha Upazila, which provide drinking water supply to 521 households (1.76%). Piped water supply provides water supply at the door step of the households and substantially reduces collection effort of the women. But water quality of these piped water schemes does not meet water quality standards.
Fresh water ponds are very scarce in Paikgacha Union and people, especially women, are seen to collect pond water from a distance of 2 to 3 kilometres. There are 7 functional pond sand filters (PSF) based on these fresh ponds, which provides drinking water to 427 households (1.44%) of Paikgacha. But it was observed in the study area that due to operational and maintenance difficulties (cleaning of filter beds, lifting of water into the filter chambers, lack of repair/maintenance funds, etc.) these PSFs do not sustain. It was also reported by the local communities in Paikgacha that a large number of PSFs installed in the Union are currently non-functional (62%).

There is 3 MAR in Paikgacha, which was installed by DPHE and is operating on pilot basis which covers 260 households (0.88%).

All the above technological options provides year-round safe drinking water supply to 27,669 households and the supply coverage from these non-saline sources is only 7.06%. Still there is a huge supply gap of 92.94% in Paikgacha Upazila. Existing water supply technologies, coverage and supply gap of Paikgacha Upazila is shown in Table 35. The households covered by each of the non-saline year-round drinking water sources are shown in the columns with yellow highlights.

Table 35: Existing water supply technologies, coverage and supply gap of Paikgacha Upazila

Union	Total number of ward	Total Number of village	Total Number of HH	Existing Household based drinking water technology					Existing Community based drinking water technology																						Total HH covered (HH & Community)	Non-saline Coverage (%)	Uncovered HH	Supply gap (%)
				DHTW		RWH			Deep set Hand Tube well (DHTW)			Pond Sand Filter (PSF)			Rain Water Harvesting (RWH)			Reverse Osmosis (RO)			Piped Water Supply (PWS)			Others (MAR)			Total P options	Total P options	Total HH covered				
				Functional	Potential	Functional	Potential	Total	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered							
Deluti	9	23	23	0	0	36	0	36	0	0	0	2	8	57	1	0	30	0	0	0	1	0	321	1	1	100	5	9	508	544	13.87	3378	86.13
Lata	9	23	23	0	0	81	1	81	0	0	0	1	0	20	0	0	0	0	0	0	0	0	0	0	0	0	1	0	20	101	3.81	2550	96.19
Chandkhali	9	31	31	1	0	10	0	11	1	0	100	2	3	200	0	0	0	0	0	0	0	0	0	1	0	100	4	3	400	411	5.41	7189	94.59
Garaikhali	9	15	15	0	0	230	0	230	0	0	0	0	0	0	2	0	10	0	0	0	0	0	0	1	0	60	3	0	70	300	6.35	4422	93.65
Soladana	9	33	33	32	0	70	0	102	1	0	60	2	2	150	25	0	100	0	0	0	5	0	200	0	0	0	33	2	510	612	12.81	4165.1	87.19
Total	**45**	**125**	**125**	**33**	**0**	**427**	**1**	**460**	**2**	**0**	**160**	**7**	**13**	**427**	**28**	**0**	**140**	**0**	**0**	**0**	**6**	**0**	**521**	**3**	**1**	**260**	**46**	**14**	**1508**	**1968**	**8.31**	**21704.1**	**91.69**

8.4.3 Proposed Water Technologies

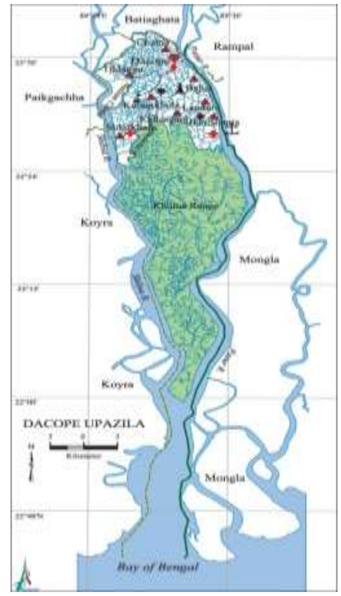
The proposed water technologies for Paikgacha upazilla are given in Table 36.

Table 36: Proposed water technologies in Paikgacha Upazila

Union	Ward No.	Number of HH	Number of HH after 10 Years	Baseline Coverage for Non-Saline Drinking Water	Target Beneficiary Households (100%)	Proposed Technology									
						HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
							in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
							Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Deluti	1	425	425	31	394	219	-	-	-	2	-	-	1	-	-
Deluti	5	678	678	303	375	275	-	-	-	2	-	-	-	-	-
Deluti	6	500	500	26	474	149	-	-	-	1	-	2	1	-	-
		1,603	1,603	360	1,243	643	-	-	-	5	-	2	2	-	-
Lata	3	208	208	7	201	51	-	1	-	2	-	-	-	-	-
Lata	4	313	313	5	308	158	-	1	-	2	-	-	-	-	-
		521	521	12	509	209	-	2	-	4	-	-	-	-	-
Chandkhali	1	928	928	1	927	577	2	4	-	2	-	-	-	-	-
Chandkhali	2	853	853	-	853	453	1	5	1	2	-	-	-	-	-
Chandkhali	3	411	411	5	406	231	3	-	-	2	-	-	-	-	-
		2,192	2,192	6	2,186	1,261	6	9	1	6	-	-	-	-	-
Garaikhali	3	706	706	12	694	544	-	2	-	1	-	-	-	-	-
Garaikhali	7	459	459	14	445	245	-	1	-	3	-	-	-	-	-
		1,165	1,165	26	1,139	789	-	3	-	4	-	-	-	-	-
Soladana	3	544	544	236	308	158	2	-	-	2	-	-	-	-	-
Soladana	6	302	302	-	302	152	-	1	-	2	-	-	-	-	-
		846	846	236	610	310	2	1	-	4	-	-	-	-	-
Total	**Total**	**6,327**	**6,327**	**640**	**5,687**	**3,212**	**8**	**15**	**1**	**23**	**-**	**2**	**2**	**-**	**-**

8.5 Upazila: Dacope

8.5.1 Background (geography, socio-economic)



Dacope Upazila (Khulna District) area 991.57 sq km, located in between 22°24' and 22°40' North latitudes and in between 89°24' and 89°35' east longitudes. It is bounded by Batiaghata upazila on the North, Pasur river on the South, Rampal and Mongla upazilas on the East, Paikgachha and Koyra Upazilas on the West. Water bodies Main rivers: Pasur, shibsa, Manki, bhadra; Palashbari, Churia, Nalian and Jugra canals are notable. Total population of Dacope Upazila is **137,681**; male **787,336** and female **73,065**.

Main sources of income are agriculture 66.07%, non-agricultural laborer 4.85%, commerce 12.86%, transport and communication 1.72%, service 4.10%, construction 0.93%, religious service 0.24%, rent and remittance 0.05% and others 9.18%.

Table 37: Demographic information of Dacope Upazila

Union	Total Number of village	Total # of Households	Population		
			Female	Male	Total
Dacope Sadar	12	1,617	3,453	3,595	7,048
Bajua	20	3,809	7,583	8,171	15,754
Bani Shanta	15	3,303	7,147	7,460	14,607
Suterkhali	13	6,286	14,675	15,385	30,060
Pankhali	11	3,569	7,613	7,957	15,570
Til Danga	12	4,294	8,176	8,830	17,006
Kamarkhol	19	3,183	5,936	6,458	13,897
Lawdob	34	6,226	11,415	13,031	9,223
Kailashganj	13	3,471	7,067	7,450	14,517
9	149	35,758	73,065	78,336	137,681

8.5.2 Drinking Water Sources, Supply, and Access (Upazila specific)

From analyses on the information collected during PRA process and expert judgment by the technical team, current drinking water supply options of Dacope Upazila were identified. There were three major sources of drinking water in the Union which are rainwater, groundwater from a shallow aquifer, and pond water. There are a total 1523 household based functional RWHS and 47 community based functional RWHS in Dacope Upazila which covers 1733 households (4.72%).

In 5 Union, there is a source of fresh groundwater that provides drinking water to the community by extraction through deep hand Tubewell (DHTW). A total of 2 household based functional DHTWS and 31 community based functional DHTW in Dacope Upazila covering 526 households (1.43%). These DHTW provide water round the water and reduces the collection time and effort of the woman substantially in those 5 unions. However, salinity intrusion in the deep layer is perceived to be the main threat of climate change in these areas. There are 2 piped water supply schemes based on ground supply in 2 unions of Dacope Upazila, which provide drinking water supply to 200 households (0.54%). Piped water supply provides water supply at the door step of the households and substantially reduces collection effort of the women. But water quality of these piped water schemes does not meet water quality standards.

Fresh water ponds are very scarce in Dacope Union and people, especially women, are seen to collect pond water from a distance of 2 to 3 kilometres. There are 94 functional pond sand filters (PSF) based on these fresh ponds, which provides drinking water to 3867 households (10.53%) of Dacope. It was reported by the local communities in Dacope that a large number of PSFs installed in the Union are currently non-functional (48%).

There are 2 Reverse Osmosis (RO) plants in 2 unions of Dacope Upazila which provides water supply to 150 households (0.41%). These RO plants are operated by different NGOs on business model in extreme salinity affected areas. But these RO plants fail to attract poor users to purchase water at a high price (0.5-1.0 per litre) and hence these are not operated at their optimal capacity. There is 1 MAR in Tildanga union, which was installed by DPHE and is operating on pilot basis which covers 60 households (0.16%).

All the above technological options provide year-round safe drinking water supply to 6,536 households and the supply coverage from these non-saline sources is 18.78%. Still there is supply gap of 81.22% in Dacope Upazila.

Existing water supply technologies, coverage and supply gap of Dacope Upazila are shown in Table 38. The households covered by each of the non-saline year-round drinking water sources are shown in the columns with yellow highlights.

Table 38: Existing water supply technologies, coverage and supply gap of Dacope Upazila

Union	Total number of ward	Total Number of village	Total Number of HH	Existing Household based drinking water technology					Existing Community based drinking water technology																					Total HH covered (HH & Community)	Non-saline Coverage (%)	Uncovered HH	Supply gap (%)
				DHTW		RWH		Total	Deep set Hand Tube well (DHTW)			Pond Sand Filter (PSF)			Rain Water Harvesting (RWH)			Reverse Osmosis (RO)			Piped Water Supply (PWS)			Others (MAR)			Total P options	Total P options	Total HH covered				
				Functional	Potential	Functional	Potential		Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered							
Sadar	9	12	1,617	1	0	165	0	166	0	0	0	5	14	180	0	0	0	0	0	0	1	0	50	0	0	0	6	14	230	396	24.48	1221	75.5
Bajua	9	20	3,809	0	0	37	0	37	1	0	60	10	13	510	12	0	48	0	0	0	1	0	100	0	0	0	24	13	718	755	19.82	3054	80.2
Bani Shanta	9	15	3,303	0	0	291	0	291	2	0	50	8	12	285	5	0	25	0	0	0	0	1	50	0	0	0	15	13	410	701	21.22	2602	78.8
Sutarkhali	9	13	6,286	0	0	76	0	76	0	0	0	21	18	700	3	0	12	0	0	0	0	0	0	0	0	0	24	18	712	788	12.54	5498	87.5
Pankhali	9	11	3,569	1	0	50	0	51	0	0	0	6	0	310	2	0	10	0	0	0	0	0	0	0	0	0	8	0	320	371	10.39	3198	89.6
Tildanga	9	12	4,294	0	0	695	0	695	28	0	414	1	7	38	1	0	10	0	0	0	0	0	0	1	0	60	31	7	522	1217	28.34	3077	71.7
Kamarkhol	9	19	3,183	0	0	63	0	63	0	0	0	13	2	580	5	0	20	2	0	150	0	0	0	0	0	0	20	2	750	813	25.54	2370	74.5
Laudubi	9	34	6,226	0	0	70	0	70	0	0	0	9	2	304	16	0	73	0	0	0	0	0	0	0	0	0	25	2	377	447	7.18	5779	92.8
Kailashganj	9	13	3,471	0	0	76	0	76	0	0	0	21	18	960	3	0	12	0	0	0	0	0	0	0	0	0	24	18	972	1048	30.19	2423	69.8
Total (Dacope)	81	149	35,758	2	0	1523	0	1525	31	0	524	94	86	3867	47	0	210	2	0	150	2	1	200	1	0	60	177	87	5011	6536	18.28	29222	81.7

8.5.3 Proposed Water Technologies

The proposed water technologies for Dacope upazila are given in Table 39.

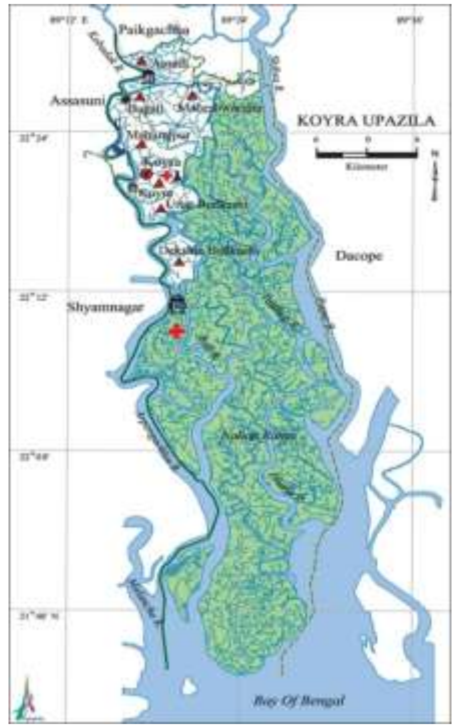
Table 39: Proposed water technologies in Dacope Upazila

Union	Ward No.	Number of HH	Baseline Coverage for Non-Saline Drinking Water	Target Beneficiary Households (50%)	Proposed Technology									
					HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
						in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
						Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Dacope Sadar	1	231	49	91	19	-	-	-	-	-	-	-	-	1
Dacope Sadar	2	250	18	116	24	-	-	-	-	-	-	-	-	1
Dacope Sadar	6	238	70	84	17	-	-	-	-	-	-	-	-	1
		719	137	291	60	-	-	-	-	-	-	-	-	3
Bajua	8	382	162	110	22	-	-	-	-	-	1	-	-	-
Bajua	9	405	74	166	34	-	-	-	-	-	-	-	-	1
		787	236	276	56	-	-	-	-	-	1	-	-	1
Banishanta	2	398	74	162	33	-	-	-	-	-	-	-	-	1
Banishanta	8	301	80	111	23	-	2	-	-	-	-	-	-	-
		699	154	273	56	-	2	-	-	-	-	-	-	1
Sutarkhali	1	736	129	304	79	-	-	1	-	-	-	-	-	1
Sutarkhali	2	840	84	378	76	-	-	-	-	-	-	-	-	2
Sutarkhali	4	610	91	260	60	-	-	-	-	-	-	-	-	1
		2,186	304	942	215	-	-	1	-	-	-	-	-	4
Pankhali	4	494	7	244	49	-	2	-	2	-	-	-	-	-
		494	7	244	49	-	2	-	2	-	-	-	-	-
Tildanga	1	775	110	333	208	1	-	-	2	-	-	-	-	-
Tildanga	3	482	170	156	32	-	1	1	1	-	-	-	-	-
		1,257	280	489	240	1	1	1	3	-	-	-	-	-
Kamarkhola	6	547	57	245	49	-	2	-	2	-	-	-	-	-
Kamarkhola	8	309	20	145	45	-	-	-	2	-	-	-	-	-
Kamarkhola	9	395	50	173	35	-	-	-	-	-	-	-	-	1
		1,251	127	563	129	-	2	-	4	-	-	-	-	1
Laudubi	1	229	88	71	21	-	1	-	-	-	-	-	-	-
Laudubi	3	234	60	87	37	-	-	-	1	-	-	-	-	-
Laudubi	9	170	16	77	27	-	1	-	-	-	-	-	-	-
		633	164	235	85	-	2	-	1	-	-	-	-	-
Kailashganj	5	380	127	127	27	-	-	-	-	-	1	-	-	-
Kailashganj	6	456	82	187	38	-	-	-	-	-	-	-	-	1
Kailashganj	7	304	55	125	25	-	-	-	-	-	-	-	-	1
		1,140	264	439	90	-	-	-	-	-	1	-	-	2
	Total	**9,166**	**1,673**	**3,752**	**980**	**1**	**9**	**2**	**10**	**-**	**2**	**-**	**-**	**12**

8.6 Upazila: Koyra

8.6.1 Background (geography, socio-economic)

Koyra Upazila (Khulna District) area 1775.41 sq km, located in between 22°12' and 22°31' north latitudes and in between 89°15' and 89°26' east longitudes. It is bounded by Paikgacha Upazila on the north, the Bay of Bengal and Sundarbans on the south, Dacope Upazila on the east, Assasuni and Shyamnagar upazila on the west.



Total population of this upazila is **193,934** where female is **95,000** and male is **98,934**. Koyra Upazila surrounded by the Kapataksa, Sakabariya and Koyra rivers.

Water bodies Main rivers: Dharla, Pasur, Arpangachhia, Taldhup, Malancha, kobadak, ball; Koyra canal is notable.
Main sources of income Agriculture 66.64%, non-agricultural laborer 7.12%, industry 0.51%, commerce 12.66%, transport and communication 1.85%, service 3.54%, construction 1.31%, religious service 0.31%, rent and remittance 0.09% and others 5.97%.

Table 40: Demographic information of Koyra Upazila

Union	Total Number of village	Total No. of Households	Population		
			Female	Male	Total
Amadi	30	8,404	15,117	18,067	33,184
Maheshareepur	23	6,356	14,021	15,972	29,993
Bagali	28	7,625	16,913	17,565	34,478
Sadar	13	7,002	16,961	16,270	33,231
Maharajpur	24	6,128	15,714	15,355	31,069
Uttar Bedkashi	24	3,863	7,788	7,437	15,225
Dakhsin Bedkashi	17	3,456	8,486	8,270	16,756
7	159	42,834	95,000	98,934	193,934

8.6.2 Drinking Water Sources, Supply, and Access

From analyses on the information collected during PRA process and expert judgment by the technical team, current drinking water supply options of Koyra Upazila were identified. There were three major sources of drinking water in the Union which are rainwater, groundwater from a shallow aquifer, and pond water.

There are a total 440 household based functional RWHS and 197 community based functional RWHS in Koyra Upazila which covers 637 households (1.00%).

In all 7 union, there is a source of fresh groundwater that provides drinking water to the community by extraction through deep hand Tubewell (DHTW). A total of 121 household based functional DHTWS and 507 community based functional DHTW in Koyra Upazila covering 6843 households (10.71%). These DHTW provide water round the water and reduces the collection time and effort of the woman substantially in those 7 unions. However, salinity intrusion in the deep layer is perceived to be the main threat of climate change in these areas. There are 1 piped water supply scheme based on ground supply in 1 union of Koyra Upazila, which provide drinking water supply to 200 households (0.31%). Piped water supply provides water supply at the door step of the households and substantially reduces collection effort of the women. But water quality of these piped water schemes is not up to the mark and water supply is not also regular.

Fresh water ponds are very scarce in Koyra Union and people, especially women, are seen to collect pond water from a distance of 2 to 3 kilometres. There are 21 functional pond sand filters (PSF) based on these fresh ponds, which provides drinking water to 735 households (1.15%) of Koyra. It was reported by the local communities in Koyra that a large number of PSFs installed in the Union are currently non-functional (40%).

There are 2 Reverse Osmosis (RO) plants in 2 unions of Koyra Upazila which provides water supply to 110 households (0.17%). These RO plants are operated by different NGOs on business model in extreme salinity affected areas. But these RO plants fail to attract poor users to purchase water at a high price (0.5-1.0 per litre) and hence these are not operated at their optimal capacity.

All the above technological options provide year-round safe drinking water supply to 8,525 households and the supply coverage from these non-saline sources is 17%. Still there is supply gap of 83% in Koyra Upazila. Existing water supply technologies, coverage and supply gaps of Koyra Upazila are shown in Table 41. The households covered by each of the non-saline year-round drinking water sources are shown in the columns with yellow highlights.

Table 41: Existing water supply technologies, coverage and supply gaps of Koyra Upazila

Union	Total number of ward	Total Number of village	Total Number of HH	Existing Household based drinking water technology					Existing Community based drinking water technology																					Total HH covered (HH & Community)	Non-saline Coverage (%)	Uncovered HH	Supply gap (%)
				DHTW		RWH		Total	Deep set Hand Tube well (DHTW)			Pond Sand Filter (PSF)			Rain Water Harvesting (RWH)			Reverse Osmosis (RO)			Piped Water Supply (PWS)			Others (MAR)			Total P options	Total P options	Total HH covered				
				Functional	Potential	Functional	Potential		Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered	Functional	Potential	HH covered							
Amadi	9	30	8,404	0	0	51	0	51	1	0	20	12	6	370	0	0	0	0	0	0	0	0	0	0	0	0	13	6	390	441	5.25	7963	94.8
Maheswaripur	9	23	6,356	0	0	170	0	170	3	0	90	1	3	50	0	0	0	0	0	0	0	0	0	0	0	0	4	3	140	310	4.88	6046	95.1
Bagali	9	28	7,625	0	0	73	0	73	8	0	176	1	2	50	1	0	4	1	0	70	0	0	0	0	0	0	11	2	300	373	4.89	7252	95.1
Sadar	9	13	7,002	9	0	15	0	24	117	15	2030	4	0	190	27	0	108	1	0	40	0	0	0	0	0	0	149	15	2368	2392	34.16	4610	65.8
Maharajpur	9	24	6,128	50	0	88	0	138	59	7	693	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	59	9	693	831	13.56	5297	86.4
Uttar Bedkashi	9	24	3,863	37	1	43	0	80	68	3	890	3	1	75	16	0	85	0	0	0	1	0	200	0	0	0	88	4	1250	1330	34.43	2533	65.6
Dakhsin Bedkashi	9	17	3,456	25	0	0	0	25	251	14	2823	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	251	14	2823	2848	82.41	608	17.6
Total (Koyra)	63	159	42,834	121	1	440	0	561	507	39	6722	21	14	735	44	0	197	2	0	110	1	0	200	0	0	0	575	53	7964	8525	19.90	34308.6	80.1

8.6.3 Proposed Water Technologies

The proposed water technologies for Koyra Upazila are given in Table 42.

Table 42: Proposed water technologies in Koyra Upazila

Union	Ward No.	Number of HH	Baseline Coverage for Non-Saline Drinking Water	Target Beneficiary Households (50%)	Proposed Technology									
					HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
						in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
						Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Amadi	6	827	-	414	314	-	-	-	2	-	-	-	-	-
Amadi	7	996	20	488	363	-	-	1	2	-	-	-	-	-
		1,823	20	902	677	-	-	1	4	-	-	-	-	-
Maheswaripur	1	657	30	314	64	-	3	-	2	-	-	-	-	-
Maheswaripur	8	598	28	285	60	-	1	-	-	-	-	1	1	-
Maheswaripur	9	648	30	309	134	-	-	-	2	-	-	1	-	-
		1,903	88	908	258	-	4	-	4	-	-	2	1	-
Bagali	2	909	138	386	211	1	1	-	2	-	-	-	-	-
		909	138	386	211	1	1	-	2	-	-	-	-	-
Koyra Sadar	2	980	285	348	73	-	3	1	2	-	-	-	-	-
Koyra Sadar	4	761	540	111	23	-	2	-	-	-	-	-	-	-
		1,741	825	459	96	-	5	1	2	-	-	-	-	-
Maharajpur	2	739	164	288	63	1	-	-	-	-	-	-	-	1
Maharajpur	7	624	211	207	42	1	1	2	1	-	-	-	-	-
Maharajpur	8	582	120	231	56	1	3	-	-	-	-	-	-	-
		1,945	495	726	161	3	4	2	1	-	-	-	-	1
Uttar Bedkashi	1	671	10	331	231	-	-	-	2	-	-	-	-	-
Uttar Bedkashi	7	368	294	37	12	1	-	-	-	-	-	-	-	-
Uttar Bedkashi	9	310	15	148	30	1	-	-	2	-	-	-	-	-
		1,349	319	516	273	2	-	-	4	-	-	-	-	-
Daskhin Bedkashi	3	293	10	142	42	-	-	-	2	-	-	-	-	-
Daskhin Bedkashi	8	272	200	36	11	1	-	-	-	-	-	-	-	-
		565	210	178	53	1	-	-	2	-	-	-	-	-
	Total	**10,235**	**2,095**	**4,075**	**1,729**	**7**	**14**	**4**	**19**	**-**	**-**	**2**	**1**	**1**

9 Site/Beneficiary Selection and Group Formation, Water Management Committee Formation, Implementation and Operation and Maintenance

9.1 Site/Beneficiary Selection

The beneficiary households in the targeted 101 wards of 39 Unions under 5 Upazilas under Khulna and Satkhira Districts will be provided with safe water options through the following systems:

1. Household based rainwater harvesting systems
2. Community and Institution-scale rainwater harvesting systems
3. Community based pond water treatment system (Sky-Hydrant)

The beneficiaries for community/institution based systems will be selected by the implementing organizations. Since safe distance for water collection has been assumed as 1 Km for the users based on preferences of targeted women beneficiaries and their households, the location of the households of beneficiaries for all of the community/institution based systems designed for 25 (medium size rainwater tank), 50 (large size rainwater tank) or 200 households (pond water treatment system using Sky-Hydrant) will be within 1 Km of water point.

Households that would not be covered by community/institution-based systems will be provided with household rainwater tanks. Priority for selection of beneficiaries for household based systems will be given to people in a manner that is sensitive to marginalization and possible selection bias, by ensuring that the final selection reflects the demographic situation of the districts. That is household selection should be done in a manner that religious minorities also have access to community and household interventions (the target districts have an approximate Hindu minority population of 30%), as well as to female-headed households and those with disabilities. Furthermore, ethnic minorities in the area (Indigenous people, known locally as adivasi) who also might not have access to the community water options will all receive coverage, and overall to those people who live outside 1 Km radius of the water points.

The selection of sites for community/institution-based systems will be based on the proposed number of systems for each ward. The total number of proposed tanks at community buildings and institutional buildings is provided in the union reports (see Annex IId and Annex 3 (5 sample unions, one for each upazila) Annex 3: Union profiles). Site survey reports for the institution-scale tanks are in Annex 4: Site survey reports.

Site visits need to be carried out to the remaining community buildings and institutional buildings to confirm that the buildings are suitable for installation of rainwater tanks. The ponds for installing Sky-Hydrants will be selected after testing water quality of pond water in laboratory.

The final selection of sites and beneficiary households will be carried out by the implementing organization, which will be supported by local government officials (Union Council Chairman, Members, etc.), and the Department of Public Health Engineering (DPHE).

9.2 Best Practices for Water Supply Management Structures

Existing practices for water supply management structures were introduced earlier in Section 4.1. Additional examples and best practices are discussed below.

In 2014, DFID funded a community-based RWH system where local people contributed five per cent of the total installation cost[97]. Typically the beneficiaries pay BDT 25 every month to the caretaker of a system, which can be used to pay the caretaker a salary and pay for any maintenance or repairs, which may be required. The temple authority said that they collect money for maintenance and other causes once in a year now. The system is then managed by a committee consisting of the members of the local temple authority. Some of the members of the committee are also beneficiaries of the system while others have their own rainwater harvesting system.

In another community scale RWH system, installed on a school premises in Dacope Union of Dacope Upazila under Khulna District, 116 school students and 5 school teachers are the beneficiaries (see Figure 33). Before installation, the school authority had to buy water every week. In 2016, Rupantor (a local NGO) with support from Water Aid installed the system which collects rainwater runoff from the rooftop and stores the runoff in three tanks, each of which has 5,000 L capacity. During the installation of the system, the school committee contributed five per cent of the total cost of the system. People's perception and acceptance of different RWH systems in the coastal areas in Bangladesh has been found to be very favourable to scaling up of the technology, as rainwater is the main source of drinking and cooking water. Many people also mentioned rainwater as their first choice of water sources.

With regard to operations and maintenance, the involvement of the community has proven to be key. Most of the RWH systems are running very well due to high community participation in O&M, and social acceptance of RWH systems is very high in the coastal area. However, people were found more willing to have household rainwater harvesting systems than community based systems as management of community based systems is often reported to have negative impacts on sustainability of the system[98]. Where communities were not found very willing to manage the systems, these often failed or became the personal property of the land owner, which many development organizations think is a problem for up scaling of community based systems.

Regularly raising funds can be a big issue for operation and maintenance. In particular, during the rainy season in normal rainfall years, people harvest rainwater and are reluctant to pay. Precise agreement and consensus is essential among the user groups for regular funding before installation of water facilities.

The WaterAid approach has been to have regular maintenance supervised by a Management Committee (Tier 1 equivalent to the proposed WUG) with oversight and strategic decisions regarding the water point provided by the Ward Development Management Committee (Tier 2 equivalent to the proposed WMC). In 2016, WaterAid conducted a study to analyze the sustainability of the water interventions including those built in Satkhira and Khulna. The Tier 1 Management Committees have played a pivotal role in ensuring proper maintenance, by regularly raising funds from local beneficiaries. The members of management committees have identified increasing awareness among beneficiaries, lack of access to alternate drinking water sources and saline intrusion as the main reasons behind beneficiaries regularly paying for maintenance.

[97] Research: Potential of 3R techniques to enhance fresh water availability in Bangladesh Wash Alliance/Rain. Retrieved from Potential-of-3R-techniques-to-enhance-fresh-water-availability.pdf
[98] Respondents of the Water Aid study conducted for this Report, 2017. Unpublished.

In order to ensure smooth implementation of the proposed water supply technologies under this project, the participation of user groups as well as officials from local government and DPHE is critical. These committees/groups should be formulated to promote equality and considering the local political economy; two types of groups/committees are envisaged:

- Water user groups at the household level;
- Water management committees at the ward level.

Additionally, these groups/committees will need to communicate and coordinate with the LGI at the Union level.

The formulation of Water User Groups (WUGs) and Water Management Committees (WMCs), as described in the sections below, will enable sustained planning and management of the proposed water solutions.

9.3 Water User Group Formation

Water User Groups (WUGs) will be formed during the first year of implementation comprising members from each of the targeted households (with women as a priority) and will be clustered based on their access to the identified drinking water solution sites. It is expected that the average size of a WUG will be 50 households. For WUGs covering institution RWH systems, the WUGs will include beneficiary households and members of school management committees. There will be at least one WUG for every ward and the number of WUGs per ward depends on the number of target households.

The WUGs' responsibilities will include:

- attending meetings every three months to discuss the supply of water in their households and any water related issues
- daily and/or monthly monitoring of the water supply systems
- minor maintenance tasks
- acting the entry point for capacity building including on climate risks awareness for example targeted 'Adaptive Learning' activities with a focus on young girls and boys in targeted coastal areas.

The operations and maintenance responsibilities of the WUGs are described in Section 9.5.1.

9.4 Water Management Committee Formation

In each of the 101 targeted wards in 39 Unions, one Water Management Committee (WMC) will be formed during the first year of implementation whose main responsibility will be to look after the water technology solutions provided to ensure proper management of the systems. The members of the management committees will comprise of:

- Local government representatives (Ward Councillor and representative from the Watsan standing committee)
- Representative from DPHE
- Representatives from associated WUGs
- Owners/representatives (at least 2) from the institutional/community buildings/facilities
- Technician/caretaker representatives for the cluster of water solutions.

The responsibilities of the water management committees in each of the targeted wards include:

1. Adaptive water distribution planning

2. Planning of adaptive operation and maintenance of water options, including water quality monitoring
3. Development of fee-based model and financial management system
4. Addressing the problems/issues raised by user groups
5. Monitoring of caretakers' performance to operate the community/institution based water options
6. Contacting the suppliers and taking necessary steps for system troubleshooting, any repair or maintenance works
7. Re-organization of the committee as per requirement

The operations and maintenance responsibilities of the WMCs are further described in Section 9.5.2. The role of local government is outlined in Section 9.5.3.

9.5 Proposed Operation and Maintenance Approach

The project proposes a three-tiered operations and maintenance (O&M) system (based on community consultations as well as discussions with LGIs and DPHE) endorsed by DPHE.

Tier 1: Beneficiary households and Water User Groups (WUGs)
Tier 2: Union Parishad and ward level Water Management Committees (WMCs)
Tier 3: DPHE

In order to ensure smooth implementation of the project, participation of user groups as well as officials from local government and DPHE will be critical. The WUGs and WMCs will be formed at the beginning of the project prior to installation and commissioning of the water technologies. The regular planned O&M (i.e. excluding major repairs/replacements) will be led by the WUGs and the WMCs (Tiers 1 and 2), apart from the third party contract for the Sky-Hydrant pond water treatment technology, which will be the responsibility of DPHE (Tier 3).

The three-tiered O&M management system has been endorsed through discussions in the field conducted in 2017 through the PRA process as well as targeted consultations undertaken with households, Union Parishads and institutional stakeholders. The three-tiered O&M management system is further explained below.

9.5.1 Tier 1 Water User Groups

The WUGs (Tier 1) will be formed as discussed in Section 9.3.

The WUGs will gather every three months to discuss the supply of water in their households and any water related issues (e.g., water quality, availability of water year-round, hygiene practices, etc.). The implementing NGO will facilitate the user group meetings and will be responsible for providing support to address the problems discussed in user group meetings.

WUGs will need to be responsible for daily and/or monthly monitoring of the water supply systems, in particular, the household level RWH (HH RWH), community-scale RWH systems and the daily operations of the pond treatment systems. The WUGs together with the school management committees will be responsible for the institution-scale RWH systems. The WUG responsibility includes minor maintenance tasks as well as distribution of water to the households from the community-scale and institution-scale RWH systems and pond treatment systems. The project will establish a nominal fee per household. The household fee will cover the materials for regular minor maintenance as well as a contribution towards the caretaker's salary. The beneficiary households of the HH RWH will need to undertake the minor maintenance with support from the caretakers as required. The fee paid by households with HH RWH will cover the cost of a water tap, adhesives and thread tape for repairing minor leaks in the joints (elbow and T joints) as required. The fee paid by households with HH RWH does not include the cost of materials for cleaning their HH RWH roof catchment/tank/filter materials, which will be the responsibility of the households.

For RWH systems located at educational institutions, Tier 1 includes co-management by WMC and the school management committee. The school management committee will assist with operations and maintenance of the school based RWHs.

9.5.2 Tier 2 Water Management Committees

The WMCs (Tier 2) will be formed as discussed in Section 9.4.
The specific operations and maintenance responsibilities of the water management committees in each of the targeted wards include:

1. Planning of adaptive operation and maintenance of water options, including water quality monitoring
2. Development of fee-based model and financial management system
3. Addressing the problems/issues raised by user groups
4. Monitoring of caretakers' performance to operate the community/institution based water options
5. Contacting the suppliers and taking necessary steps for system troubleshooting, any repair or maintenance works

WMCs (at the ward level) will staff a technician/caretaker for each ward. The WMC have backstopping support from the Watsan Standing Committee (WSC) at the Union Level. Each caretaker will be responsible for providing maintenance support to the household RWH systems and to the WUGs leading the operations and maintenance for the community and institution-scale water supply points. The caretaker will need to be responsible for an associated cluster of WUGs including WUGs for nearby household RWH systems. Co-financed by the WUG (through the nominal fees collected from every beneficiary household), and the Union Parishad contributions, this resource would be available to support daily operations and minor repairs including maintenance of pond treatment systems (excluding the annual third party module maintenance which is under Tier 3) and maintenance of RWH systems including roof catchment cleaning, tank cleaning and minor repairs of taps, joints, gutters and pipes.

The water management committees will be responsible for arranging the quarterly meetings once in each quarter of the year after its formation.

9.5.3 Tier 3 DPHE

LGI can and should play a vital role in maintenance of water facilities. All water points need to register with LGI and have to pay a regular tax for this. LGI will appoint skill people for maintenance and repair as per demand.

DPHE co-financing will phase in to backstop and cover the O&M costs related to replacement/major repairs of community and institution system infrastructure (e.g. conveyance systems including gutters and downpipes which have an expected life of 5 years), and potentially full system rehabilitation in case of unanticipated cyclonic shocks. For the pond-based Sky-Hydrant treatment systems, installation with warranty would be procured to ensure robust technical support for long-term viability of these solutions. DPHE will also be responsible for the third party contract for the Sky-Hydrant treatment systems including the annual Sky-Hydrant module maintenance cost (change of membrane and filter materials). The Sky-Hydrant third-party contract will need to include a fixed rate for the supply of replacement parts over the full lifecycle of the membranes. Post-project O&M would continue to be supported through community and DPHE financing and the commitment letter indicates the O&M and replacement/major repair costs to be covered by DPHE beyond the project lifetime.

In case of major rehabilitation or infrastructure replacement, DPHE will rebuild or repair the community-scale and institution-scale systems and contribute to partial replacement of household level RWH (Tier 3). In this case, DPHE will include these costs in their regular development programme and ensure the maintenance is carried out. To ensure regular O&M, the Union Parishad will use their WATSAN allocation (up to 500,000 BDT or US$6,230 per year) to contribute towards the annual O&M costs including the caretaker salary and water quality reagents. They will undertake small repair schemes under their Test Relief/Food For Work/ADP allocation/ LGSP allocation/ 80 days work schemes. In each programme, the WATSAN committees have provision for such maintenance work.

9.6 Implementation Modalities

The proposed intervention under this climate resilience program, increasing safe drinking water coverage with the proposed water technologies will be implemented by DPHE, the designated government agency in partnership with national and local NGOs, and in collaboration with the Local Government (UP). Under this modality, UP will provide support for site selection for installation of the proposed community based technological options and selection of poor and extreme poor households, based on set criteria, for distribution of the household based RWH units.

The NGOs are expected to play role in community mobilization and demand creation for improved water supply services, identify potential WASH entrepreneurs and build their capacity to take up operation and maintenance of the community options, which have a strong potential to run on a business model. The WUGs will gather every three months to discuss the supply of water in their households and any water related issues (e.g., water quality, availability of water year-round, hygiene practices, etc.). The implementing NGO will facilitate the user group meetings and will be responsible for providing support to address the problems discussed in user group meetings. The water management committees will be responsible for arranging the quarterly meetings once in each quarter of the year after its formation.

9.7 Sustainability and Exit strategy

The proposed options will be implemented by a national government agency, the DPHE, in collaboration with the local government (Upazila) and private sector with direct involvement of community or institution based committees. The household based RWH option will be implemented in collaboration with the Upazila. The Upazilas will identify the extreme poor, poor, women-headed households, who fit the prioritized beneficiary selection criteria, to have this facility in their houses. The community options, like RWH and Sky-Hydrants, will be implemented directly by the implementing agency with involvement of CBO committee formed by Upazila.

The institution-based RWH will be implemented in collaboration with the Upazilas, with direct involvement of institution based management committee. After successful implementation of the water provision infrastructure, the implementing agency will hand over the installed facilities to the Upazilas, the respective committees and the households selected, and will withdraw from the intervention process. However, in this regard, the following exit strategies will be followed:

- Develop technological option based O&M guideline including Water Safety Plans (WSP) for the households, water user groups, water management committees and third party service providers and provide necessary training and orientation to the UPs, water management committee members, plant operators and caretakers;
- Provide on-the-job support to the above committees, private entrepreneurs and plant operators enabling them to ensure smooth O&M of the options;
- Provide support for developing local level functional mechanism for O&M in each option including O&M fund development;
- Establish link between the committee/ private entrepreneur and technical organization/private O&M service providers for ensuring continued technical back-up support.

To ensure sustainability, a range of different strategies need to be followed and mechanisms established, including:

- gender responsive decision-making processes;
- developing the organisational structures of community groups and stakeholder engagement;
- building capacity for financial management and economic sustainability;
- introducing new adaptive technologies and interventions;
- improving environmental management.

The project will build all stakeholder capacities (including LGI and DPHE) to develop and implement O&M plans and sustain, continuous adaptive planning in light of evolving climate risks. The sustainability of the water supply technologies will be ensured through the support that the project provides for capacity building for all the stakeholders in participatory, community-based water access, distribution, and delivery planning and implementation to ensure gender-targeted, inclusive, and equitable access to safe, year-round drinking water. DPHE capacities will also be strengthened to provide backstopping and major O&M support as outlined in the O&M plan.

At the household level, the WUGs will be facilitated to meet, discuss, and plan for water supply for their households, including continuous monitoring of water availability and quality as well as peer-to-peer learning on safe health practices. The provision of and access to water will be anchored in a fee-based model (based on existing practices) that will engender ownership and commitment to securing drinking water for the targeted households. The fee would be based on affordability considerations and financing available and will go towards the operations and maintenance costs including the cost of one caretaker per ward. In addition to the fee, households with household level RWH will also be encouraged to set-aside funds to cover the household contribution to the major repairs/replacements for the short life assets of household roof catchment and gutters etc.

Additionally, the introduction of new approaches to integrating climate change and developing the adaptive capacity of vulnerable women will have multiple benefits, which extend beyond the lifetime of this project.

The project will strengthen DPHE capacities for climate-risk informed innovation and management of drinking water solutions across the target areas. This will include investment in technical capacities for DPHE and LGIs to integrate climate change risks and projected impacts on the freshwater resources and water supply infrastructure of the coastal communities into planning and implementation support. DPHE will be capacitated to assess climate risks and model drinking water needs in light of climate change. A regional database would be established, co-financed, by GoB to map water supply sources and infrastructure to support effective coordination across various implementation efforts and investments. Technical capacity of the Research & Development (R&D) wing of DPHE will be strengthened through training and field based work (in coordination with engineering institutes and ongoing efforts such as UNICEF's support to research on MAR and other climate-resilient technologies) to support technical excellence, innovation, and implementation of solutions for climate-resilient water supply. This would include supporting a shift to climate-resilient solutions (e.g. PSF, Managed Aquifer Recharge (MAR), RO, etc.) for year-round, safe drinking water for coastal populations in light of projected climate change impacts on salinity.

For the exit strategy and in case of major rehabilitation or infrastructure replacement, DPHE will rebuild or repair the community-scale and institution-scale systems and contribute to partial replacement of household level RWH. In this case, DPHE will include these costs in their regular development programme and ensure the maintenance is carried out. To ensure regular O&M, the Union Parishad will use their WATSAN allocation to contribute towards the annual O&M costs including the caretaker salary.

9.8 Operation and Maintenance of the Water Technologies

9.8.1 Planned Maintenance for Rainwater Harvesting Systems

Table 43 outlines the required regular planned maintenance tasks for RWH systems and the recommended frequency. The beneficiary households will be responsible for carrying out the regular planned maintenance tasks for the household RWH, with support from the ward level caretaker.

The WUGs will be responsible for carrying out the regular planned maintenance tasks for the community-scale RWH with support from the ward level caretaker. The WUGs and school management committees will be responsible for carrying out the regular planned maintenance tasks for the institution-scale RWH systems with support from the ward level caretaker.

Repairs (both minor and major) are unplanned maintenance tasks and will be additional to the regular planned maintenance tasks. Repairs will be carried out on an as needed basis.

Table 43: Planned Maintenance Tasks for RWH Systems and Recommended Frequency (from WaterAid 2017, adapted for rural conditions)

Task	Description/Details	Frequency
Clean roof surface and gutters	Manually clean rooftops, gutters and downspouts by hand, with hand tools, brooms and rakes. If using water to flush rooftops, gutters, or downspouts, be sure to divert this debris-laden water so that it does not flow into downspouts, filters or the tank. Inspect gutters for leaks and holes; repair as needed. This is especially important after leaf fall.	A minimum of once per month. For sites with over hanging vegetation, after each significant rainfall event.
Inspect and clean debris filter(s) and first-flush diverter(s)	Disassemble, clean and replace screens on all inlet filters as needed. Disassemble and clean as needed. Inspect all downspouts, clean any obstructions, inspect	After each significant rainfall event

Task	Description/Details	Frequency
	all inlets and overflow pipe assemblies to ensure they are unobstructed and working properly. Check screens for holes/tears and repair as needed. Disassemble and clean as needed. Disassemble and clean the first-flush diverter; ensure the weep hole is open and unclogged.	
Check all piping and valves for leaks; inspect all openings in storage tank	Check all piping and valve for cracks, holes or leaks. Repair as needed. Inspect all openings in the storage tanks for leaks and gaps	Annually
Clean media in sand filtration units	Clean media in sand filtration units.	Annually or as needed
Replace media in sand filtration units	Replace media in sand filtration units.	Annually or as needed
Remove tank sediments	Remove sediments that have accumulated in the bottom of the tank. Be sure that all safety regulations are followed with respect to confined space entry. Dispose of sediment in the manner deemed appropriate by the local regulating authority.	Annually or as needed
Record operations and maintenance tasks	It is good practice to keep a daily operational log-sheet to record drinking water production flow rates and when cleaning procedures were undertaken.	Daily

9.8.2 Planned Maintenance for the Sky-Hydrant Systems

To operate the Sky-Hydrant system, a trained caretaker with good knowledge of the system will be required. Therefore, one caretaker will be trained on operational maintenance of the system at each site, and will be responsible for maintenance of the system. The caretaker will also be responsible for regular communication with the suppliers of the materials that will be needed on a regular basis to keep the system functional. The best management practices to ensure the quality of the pond water is maintained include:

- The embankment height should be designed above the water level (predicted by local people) during tidal surges and this height should be maintained
- All types of washing/cleaning activities should be prohibited in the ponds
- Fencing around the ponds should be maintained round the year to prevent intrusion of animals/livestock into the ponds
- Any practice of saline water based aquaculture (e.g., shrimp farming) around the pond area should be prohibited

In this system, the freshwater from sweet pond is sent to raw water tank of the Sky-Hydrant by solar pump. The pump has a sensor that will start the pump once water inside the raw water tank goes below a certain level. For rainy days and emergency situations, when the pump cannot be run, a hand pump is provided with the system.

The regular planned operations and maintenance tasks required for the pond treatment using sky-hydrant are shown in Table 44. The Sky-Hydrant should function for the design life of 10 years without replacement of the internal filter module provided that the regular maintenance is undertaken (particularly the manual cleaning procedure). The daily maintenance tasks will be undertaken by the WUGs with support from the ward level caretaker. The caretaker will be responsible for the monthly and annual tasks.

Table 44: Planned Maintenance Tasks for Pond Treatment Systems and Recommended Frequency (Sky-Hydrant maintenance from the User Guide)

Task	Description/Details	Frequency
Manual cleaning of the Sky-Hydrant and backwash	Manual cleaning involves agitating the cleaning handles quickly back and forth for about one minute to clean the filter module inside the unit followed by backwash of dirty water. This manual cleaning procedure is essential to maintain the correct flow of drinking water and prevent the filtration module from clogging. See the Sky-Hydrant User Guide for more details on the manual cleaning procedure. Note that the Sky-Hydrant does not need to be opened or accessed internally for cleaning or maintenance.	At least daily and preferably more often depending on site conditions.
Solution cleaning of the Sky-Hydrant	Solution cleaning removes accumulated organic matter and other contaminates from the Sky-Hydrant not removed by the regular manual cleaning. A diluted chlorine solution would be used to remove deposits of organic matter form inside the filtration unit. See the Sky-Hydrant User Guide for more details on the solution cleaning procedure.	Weekly or monthly
Check operations of solar pump	The solar pump will have a sensor that will start the pump once water inside the raw water tank goes below a certain level. Check that this is working properly	Twice daily at the beginning and end of operations.
Check hand pump works	Use the hand pump and ensure that it can pump water up to the header tank. A hand pump is provided with the system to be used as a backup for rainy days and emergency situations, when the solar pump cannot be run.	Weekly
Check flow rate of the Sky-Hydrant	On a regular basis repeat this procedure. If the flow rate decreases it may indicate more frequent cleaning of the ultrafiltration unit should be undertaken.	Weekly or monthly
Record of tasks	It is good practice to keep a daily operational log-sheet to record drinking water production flow rates and when cleaning procedures were undertaken.	Daily
Clean the ponds	Pond should be cleaned at least once a year to remove plants and nuisance species from the ponds	At least once per year prior to the rainy season
Remove tank sediments	Remove sediments that have accumulated in the bottom of the header tank. Dispose of sediment in the manner deemed appropriate by the local regulating authority.	Annually or as needed

9.8.3 Major Repairs/Replacements

The major repairs/partial replacements of infrastructure have been programmed based on the design lives of each infrastructure type. Table 45 provides the design assumptions for the replacement frequency for the water supply infrastructure types.

Table 45: Design Assumptions for Water Supply Infrastructure Replacement Frequency

Infrastructure type	Expected useful life
Household roof catchment	5 years
Household concrete platform	5 years
All gutters and downspout pipes	5 years
Community and Institution building roof catchment	20 years
Filter materials	5 years
Rainwater tanks	40 years
Sky-Hydrant unit	10 years
Sky-Hydrant disaster resilient housing and accessories (Solar Panel, battery, pumps, pipes, raw water and fresh water reservoirs, etc.)	10 years
Pond embankment	10 years

Table 45 shows that regular replacements (every five years) are expected for household level RWH roof catchments, concrete platforms, filter materials, gutters and downspout pipes (but the largest cost item of the tanks are expected to last 40 years). Similarly, regular replacements (every five years) are expected for community-scale and institution-scale RWH filter materials, gutters and downspout pipes. The Sky-Hydrant replacements are expected every 10 years based on information from the supplier.

9.9 Training for Users and Caretakers

The caretakers of community water systems and users of the water technologies will be trained on proper way of operation and management of the systems. The user training will be conducted once every year for the users of household based systems and the user groups of community systems. The training will focus on hygienic practice of water storage, collection, transportation and use. The water quality management of drinking water will be discussed in the training sessions. The caretaker will also be monitored by the safeguards staff to ensure that there are no issues with inequitable distribution of water, particularly to marginalized groups.

The caretaker training will be done once every year where the caretakers of different community systems (rainwater harvesting and pond water treatment) will be trained on operation, maintenance and management of the water systems. For the caretakers of Sky-Hydrant systems, the suppliers will train the caretakers. The caretakers will also be trained on water quality testing using the toolkits. One set of water quality test kits will be provided to each of the Unions which can be used to test pH, Turbidity, Total Dissolved Solids, Electrical Conductivity and Fecal Coliform. The caretakers will be responsible for performing water quality tests of their systems and water quality test reagents will be provided.

9.10 Water Quality Management

The water quality provided by RWH systems is ensured through following the best practice RWH maintenance tasks. Simple sand filters will also be provided to all the rainwater systems, and the Sky-Hydrant systems have membrane filtration. There is a possibility of water getting contaminated during transportation of water and storage in house. Therefore, in the training sessions, water quality management of stored rainwater and the importance of disinfection by boiling before drinking water will be discussed. Two disinfection techniques could be given priority considering the local context: boiling and simple solar disinfection. During the training sessions, the trainers will discuss methods of disinfection and will encourage the users to disinfect water before drinking. LGI can play a role for regular testing of water quality considering the type of technology. It can also promote income generation opportunities.

A simple solar disinfection method is to fill clear PET bottles with the water and set out in the sun for 6 hours[99]. The UV-A rays in sunlight kill germs such as viruses, bacteria and parasites (giardia and cryptosporidium). The method also works when air and water temperatures are low.

People can use the simple solar disinfection method to treat their drinking water themselves. The method is very simple and its application is safe. It is particularly suitable for treating relatively small quantities of drinking water.

10 Portfolio of Climate Resilient Water Technologies

10.1 Technical Design and Diagrams

The schematic diagrams and technical drawings of the water technologies are provided in this section.

10.1.1 Household Rainwater Harvesting Systems

Figure 26 shows an example layout for a household rainwater harvesting system (not to scale). The design includes a simple sand filter for improved water quality and plastic rainwater tanks located on a concrete platform (for resilience to cyclones and tidal surges).

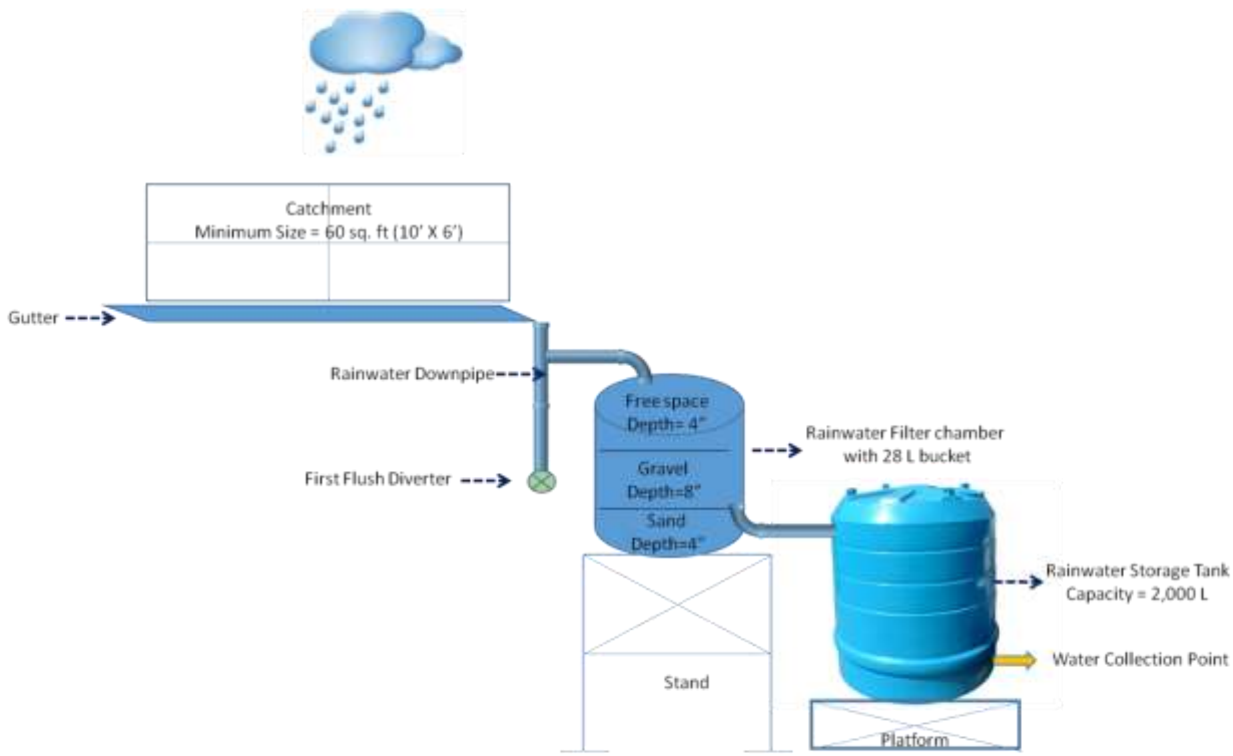


Figure 26: Schematic diagram of household rainwater harvesting system

99 http://www.sodis.ch/methode/index_EN

10.1.2 Community-scale Rainwater Harvesting Systems

Figure 27 shows an example layout for a Community-scale rainwater harvesting system. Figure 28 shows an example elevation view for a Community-scale rainwater harvesting system. These are followed by design diagrams for each size of the community-scale rainwater harvesting systems (small: 25 households and large: 50 households):

- Plan views of the storage tanks
- Cross sectional view of the storage tanks
- Beam and column sections
- Cross-section design of the filter

The community-scale rainwater tanks have been designed with concrete rainwater storage tanks located above ground (to provide more resilience to the risk of tidal surge than below ground tanks).

Figure 27: Example layout for a Community-scale rainwater harvesting system

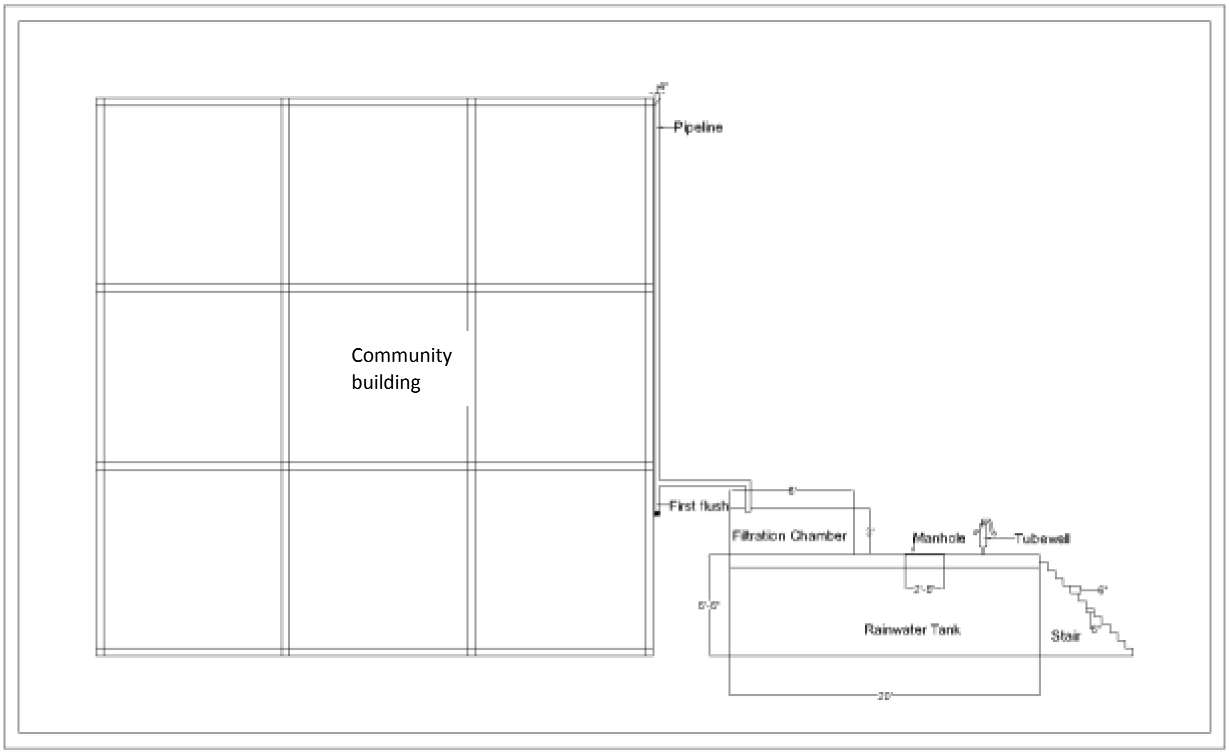


Figure 28: Elevation of an example Community-scale rainwater harvesting system

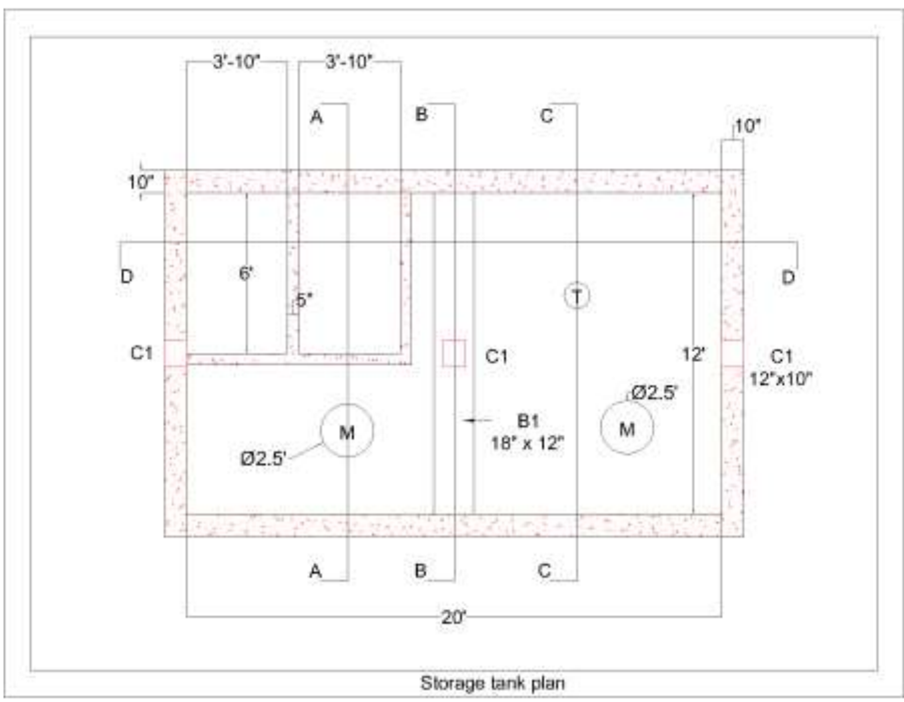


Figure 29: Storage tank plan view for small community-scale tank for 25 households

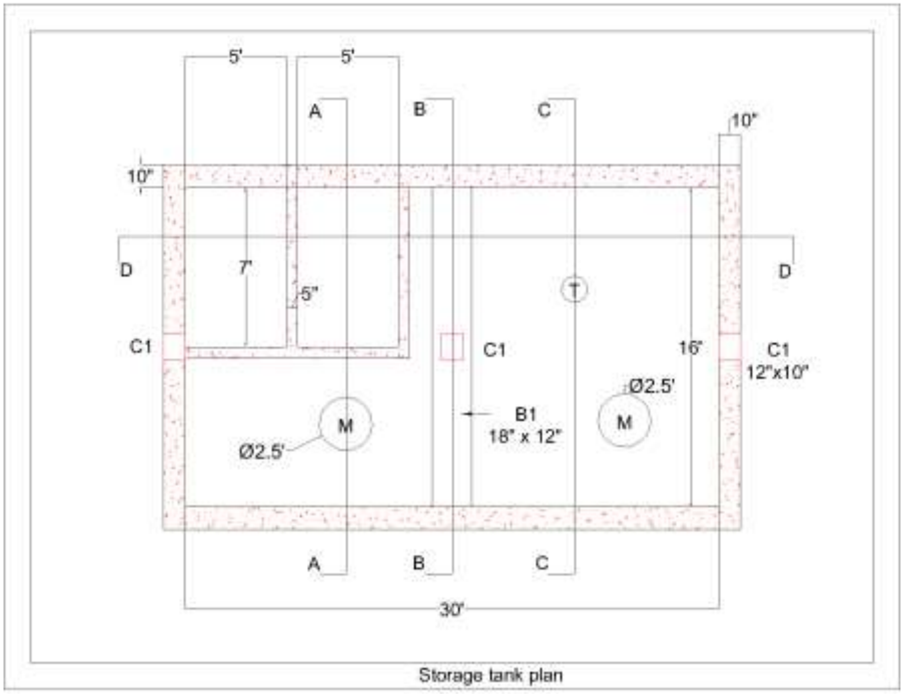


Figure 30: Storage tank plan for medium Community-scale tank for 50 households

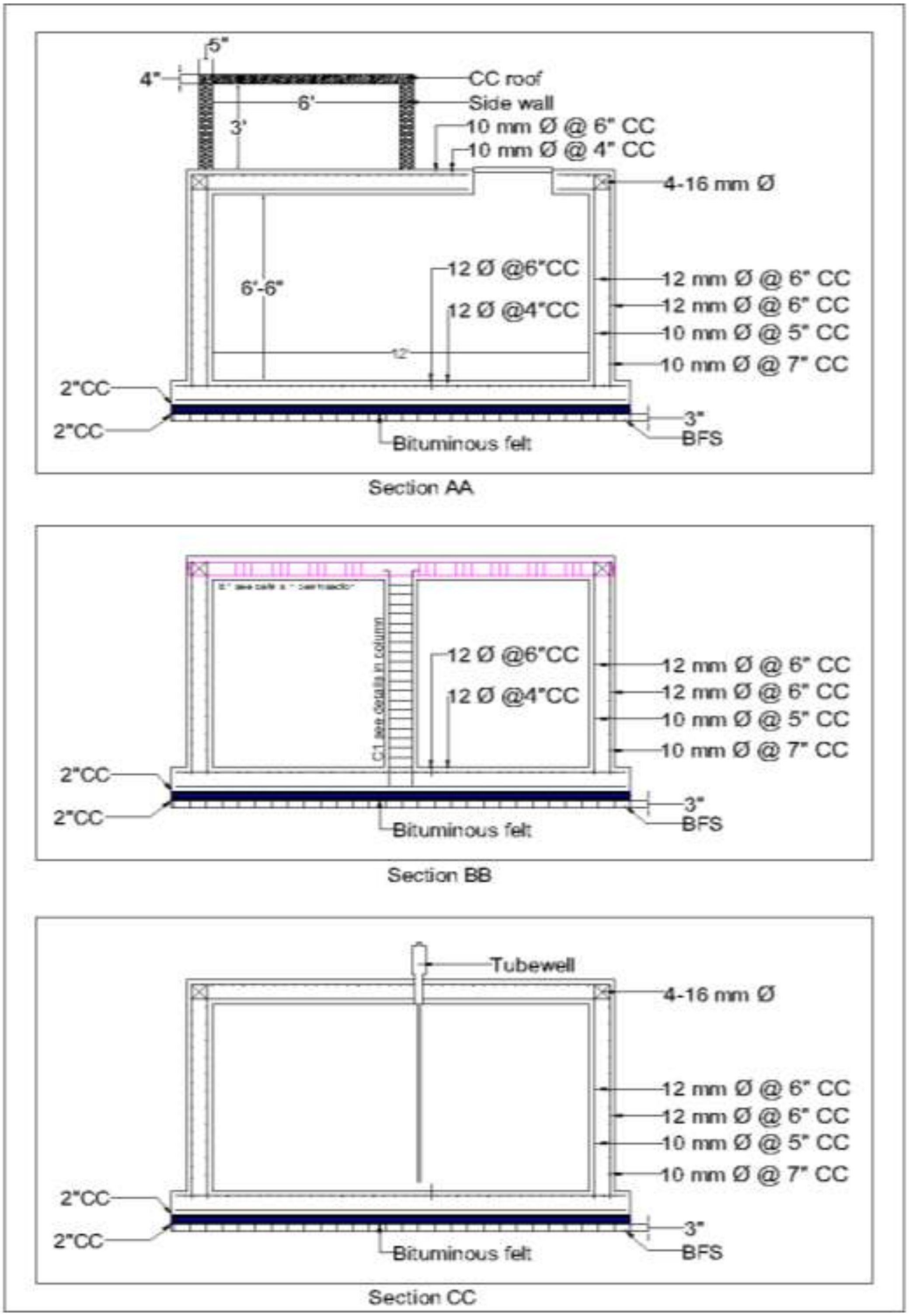


Figure 31: Cross sections for small community-scale tank for 25 households

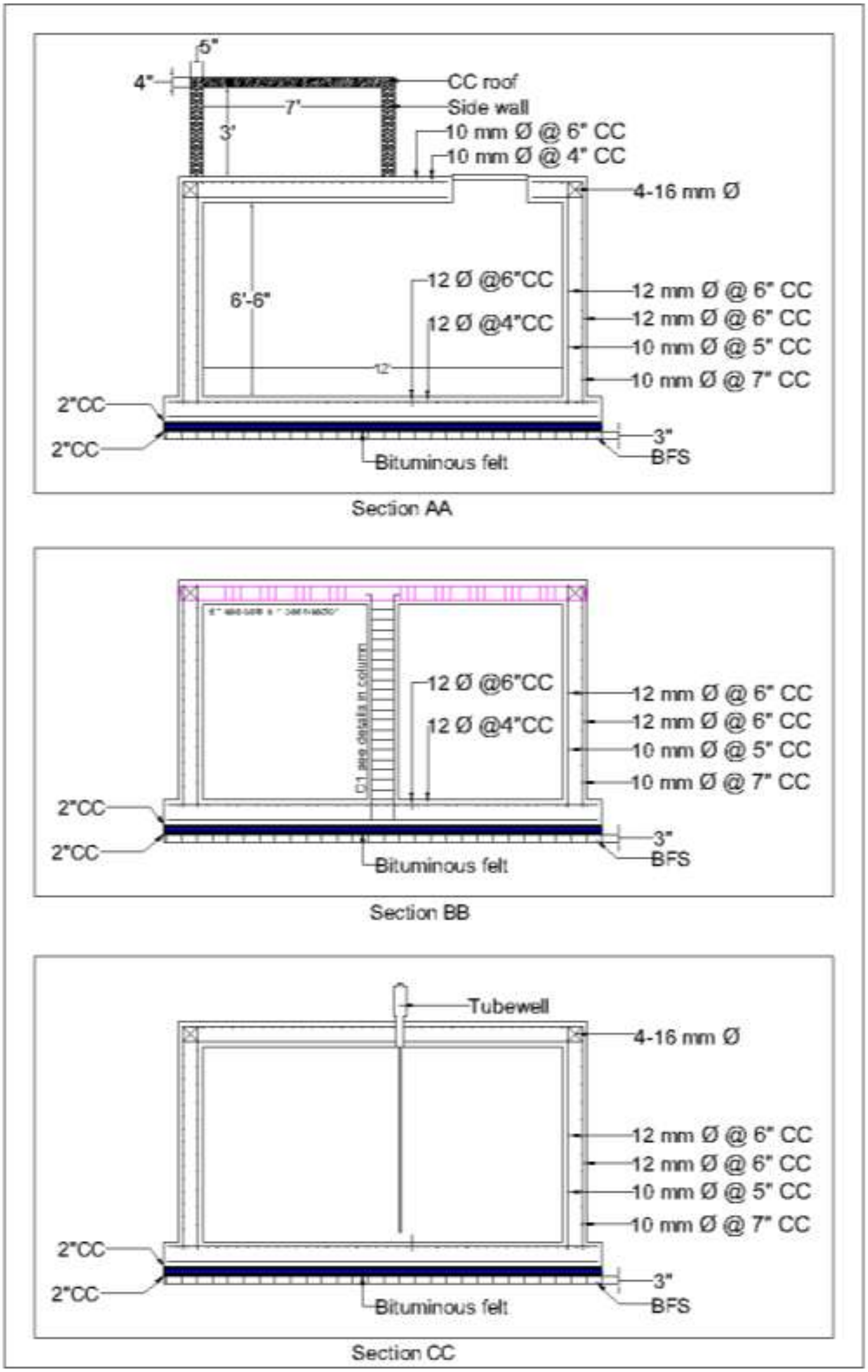


Figure 32: Cross sections of the storage tank for medium Community-scale tank for 50 households

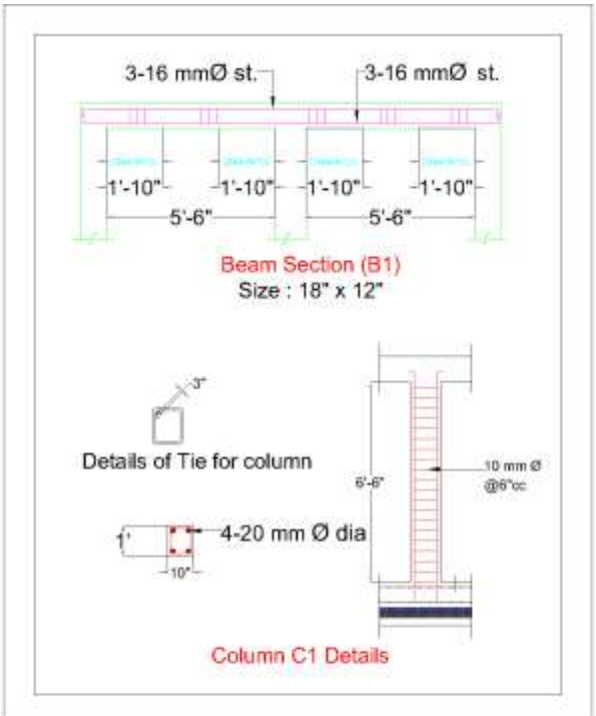


Figure 33: Beam and column sections for small community-scale tank for 25 households

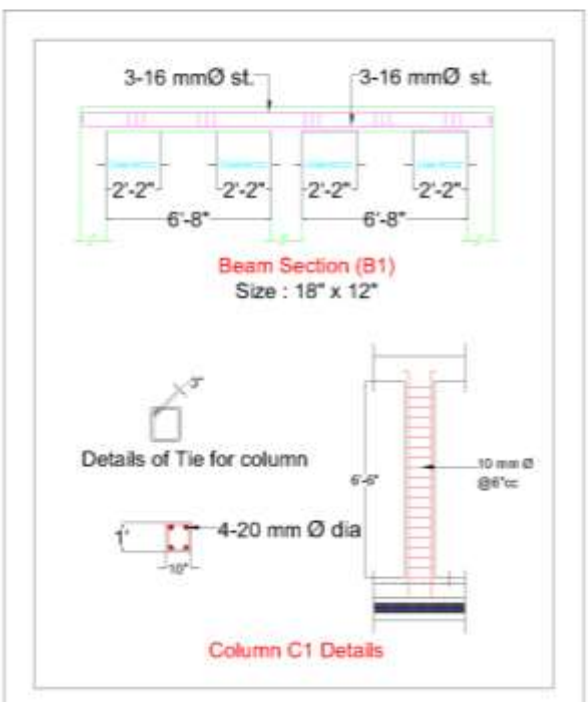


Figure 34: Beam and column sections for medium Community-scale tank for 50 households

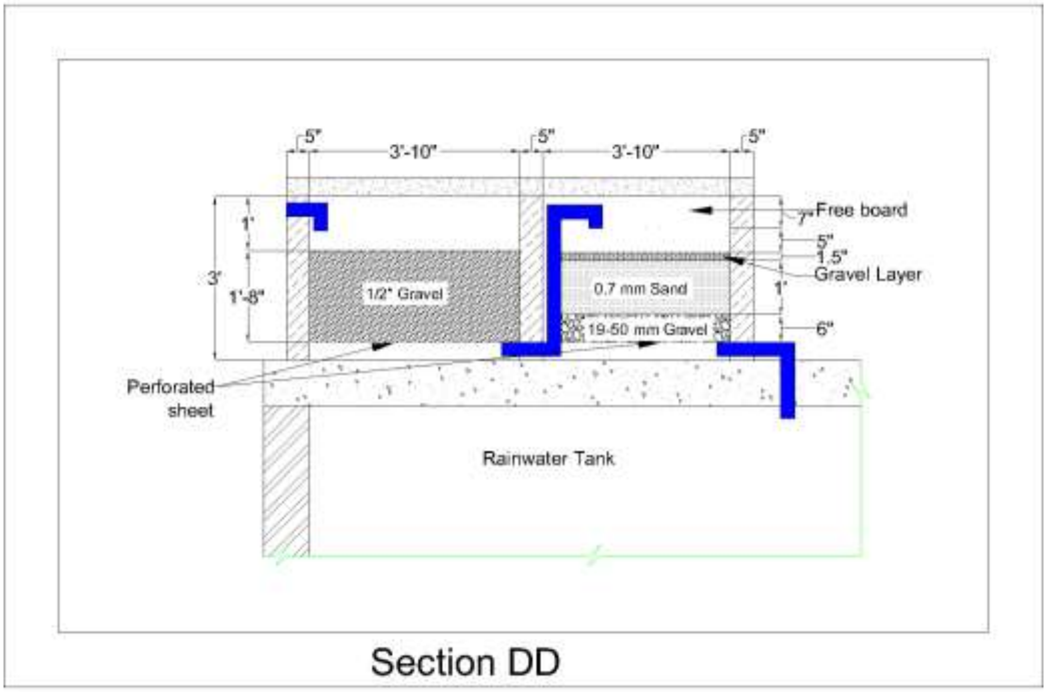


Figure 35: Filter cross-section for the rainwater harvesting system for small community-scale tank for 25 households

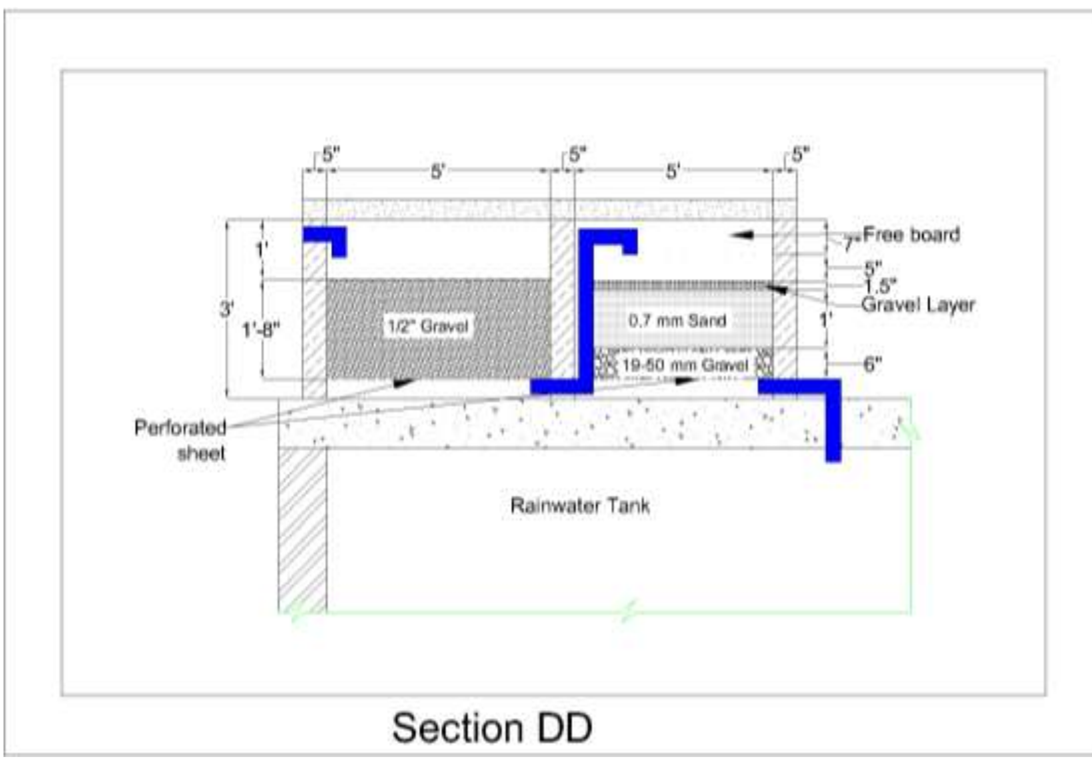


Figure 36: Filter cross-section for the rainwater harvesting system for medium Community-scale tank for 50 households

10.1.3 Institution-scale Rainwater Harvesting Systems

Figure 37 shows an example layout for an Institution-scale rainwater harvesting system. Figure 38 shows an example elevation view for an Institution-scale rainwater harvesting system. These are followed by design diagrams for each size of the Institution-scale rainwater harvesting systems (large: 75 households and very large: 100 households):

- Plan views of the storage tanks
- Cross sectional view of the storage tanks
- Beam and column sections
- Cross-section design of the filter

As per the community-scale rainwater tanks, the institution-scale rainwater systems have been designed with concrete rainwater storage tanks located above ground (to provide more resilience to the risk of tidal surge than below ground tanks).

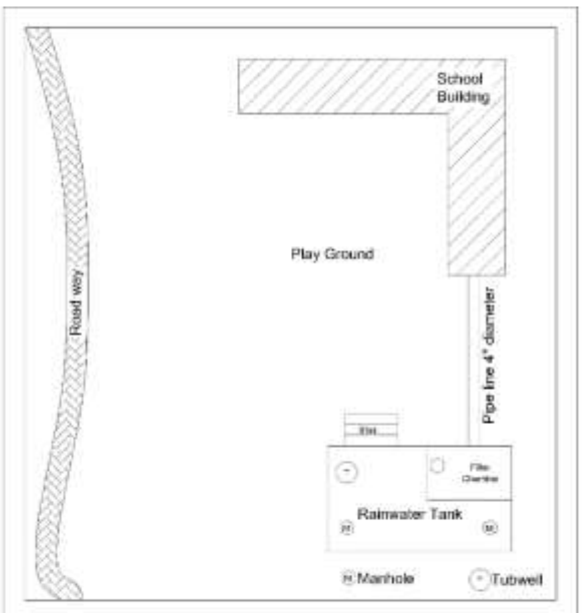


Figure 37: Example layout for an Institution-scale rainwater harvesting system

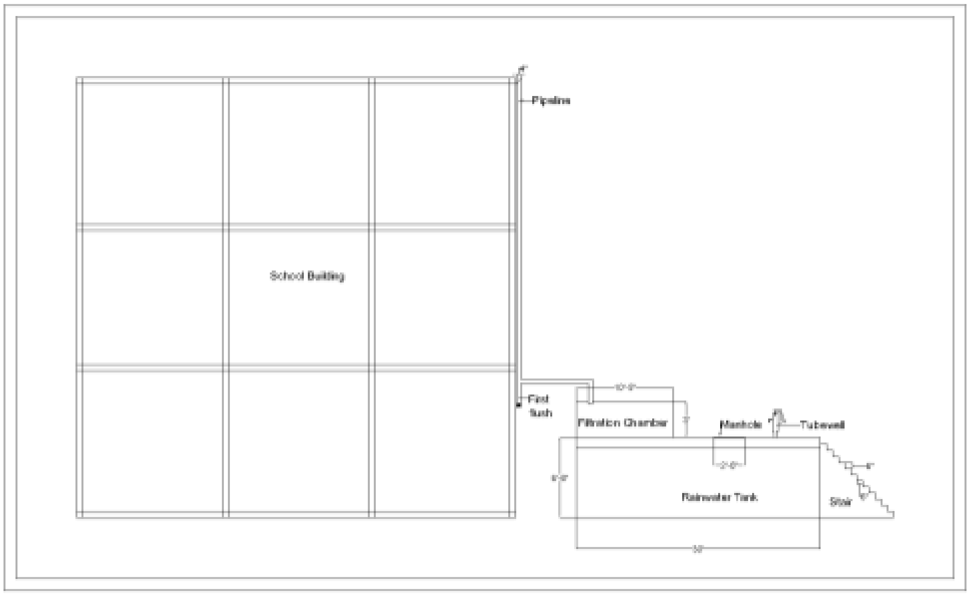


Figure 38: Cross-section view of an example Institution-scale rainwater harvesting system

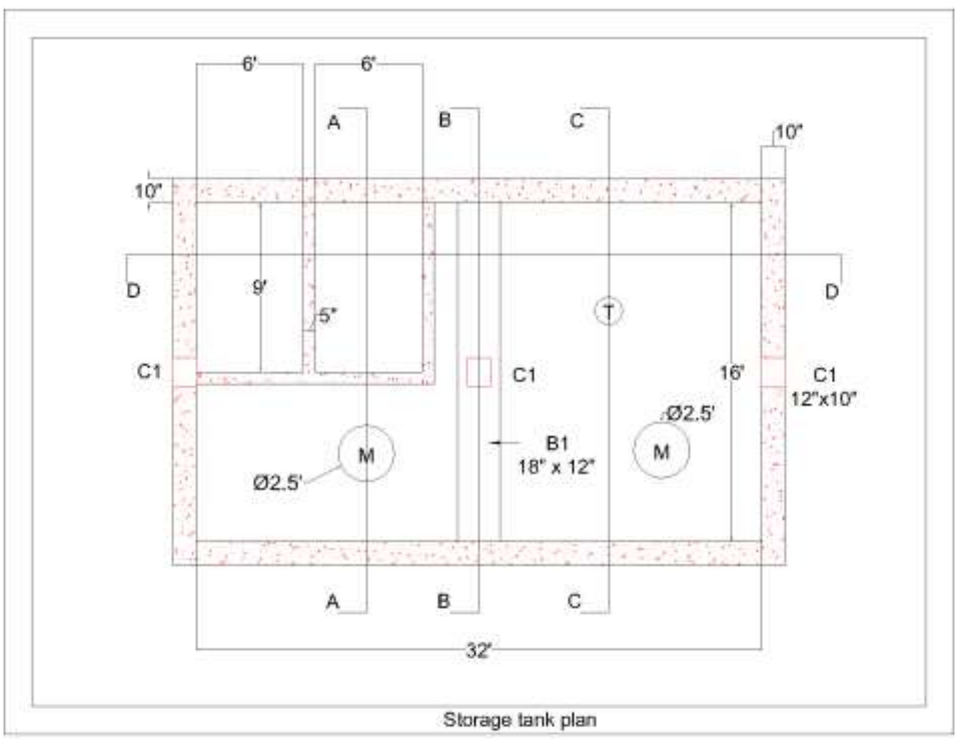


Figure 39: Storage tank plan view for large Institution -scale tank for 75 households

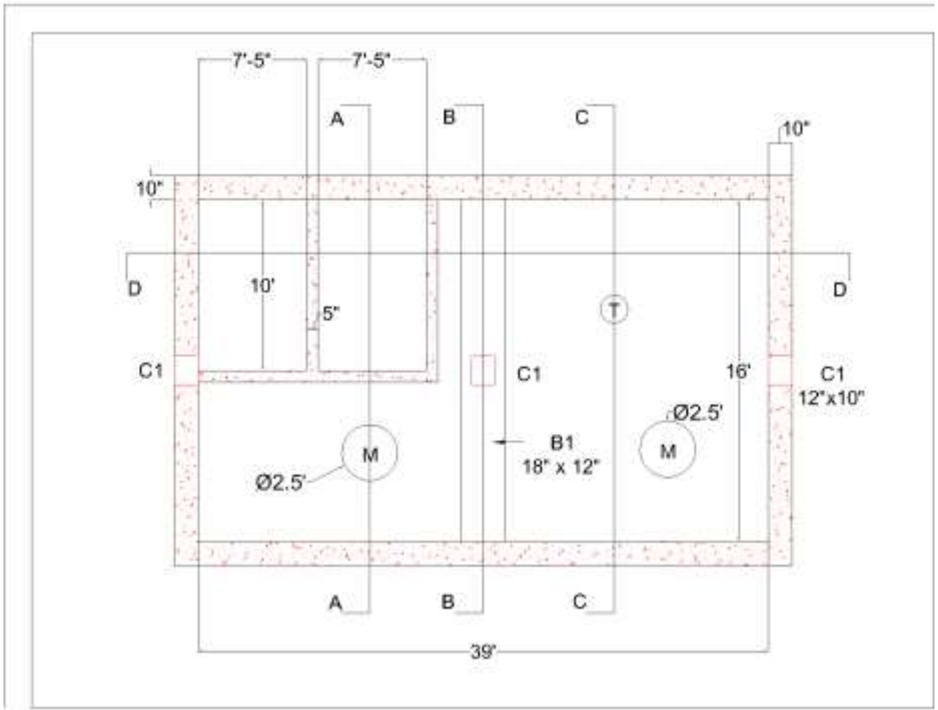


Figure 40: Storage tank plan for very large Institution-scale tank for 100 households

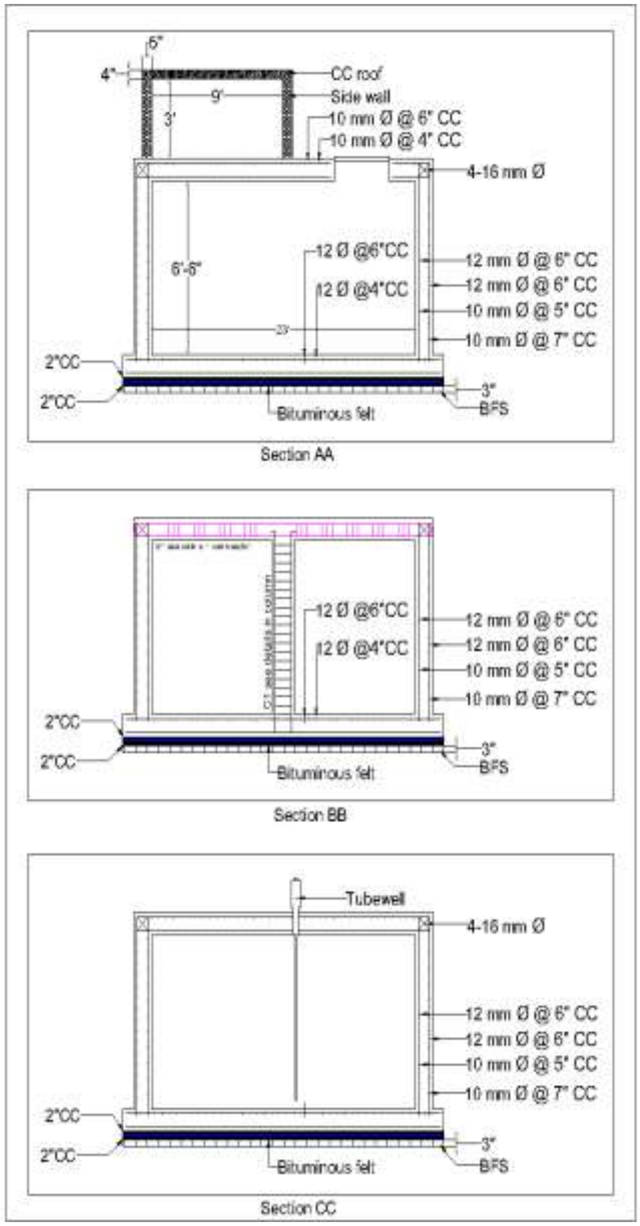


Figure 41: Cross sections for large Institution -scale tank for 75 households

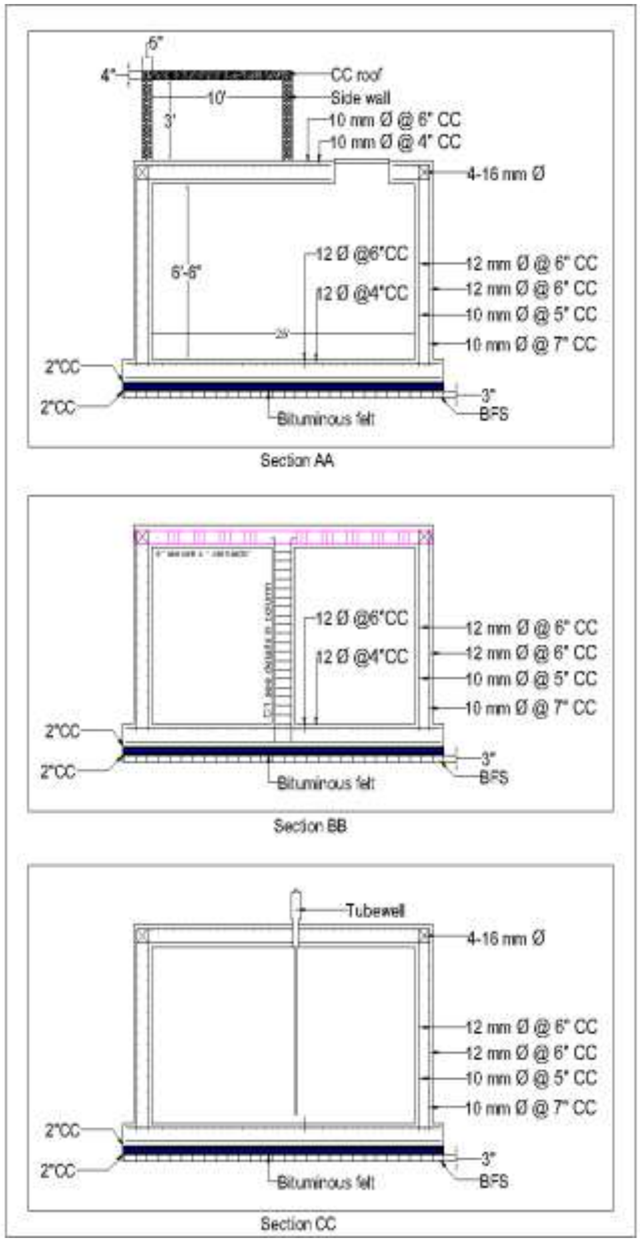


Figure 42: Cross sections for very large Institution-scale tank for 100 households

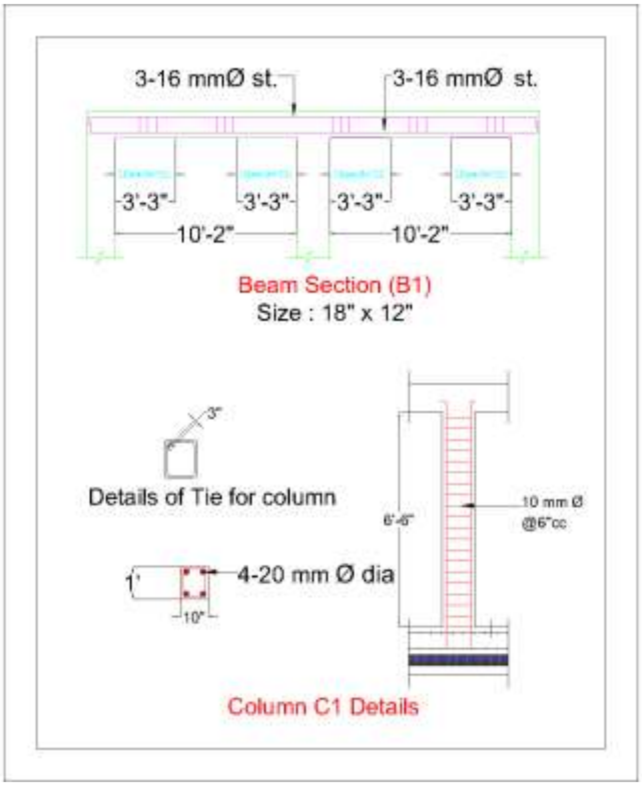


Figure 43: Beam and column sections for large Institution -scale tank for 75 households

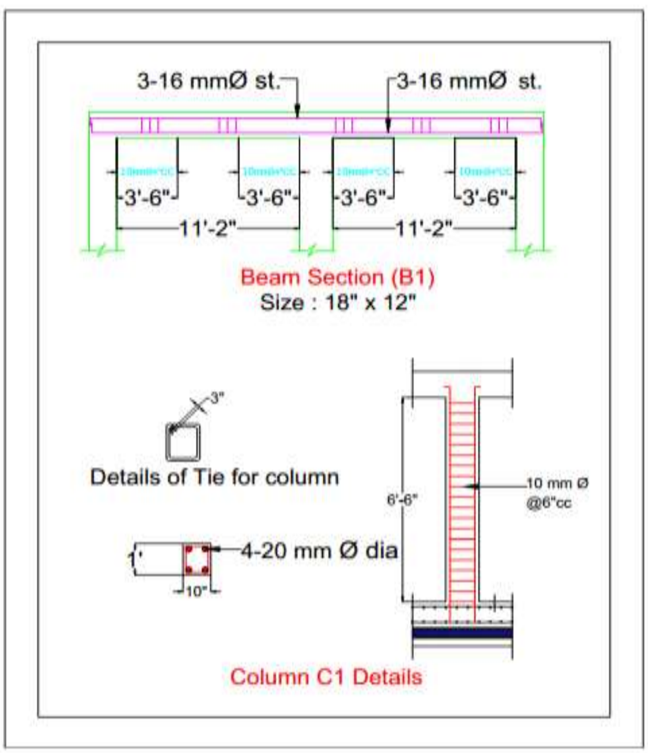


Figure 44: Beam and column sections for very large Institution-scale tank for 100 households

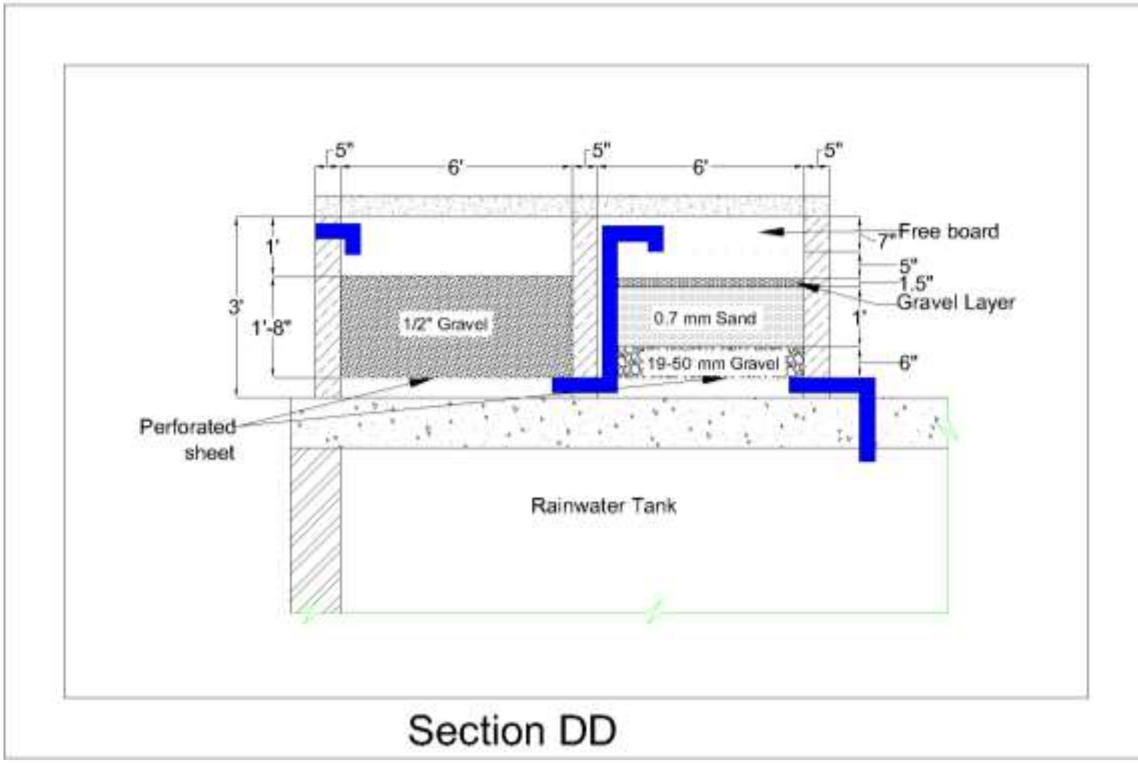


Figure 45: Filter cross-section for the large Institution -scale rainwater harvesting system for 75 households

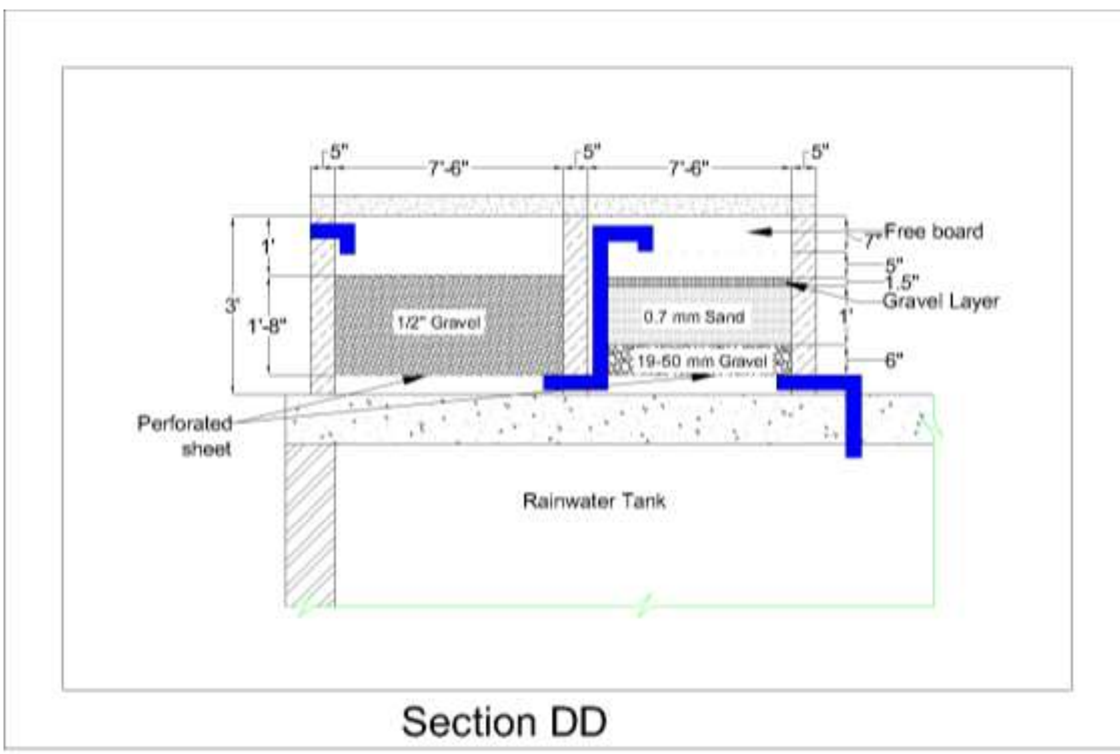


Figure 46: Filter cross-section for the very large Institution-scale rainwater harvesting system for 100 households

10.1.4 Community based Pond Water Treatment System (Sky-Hydrant)

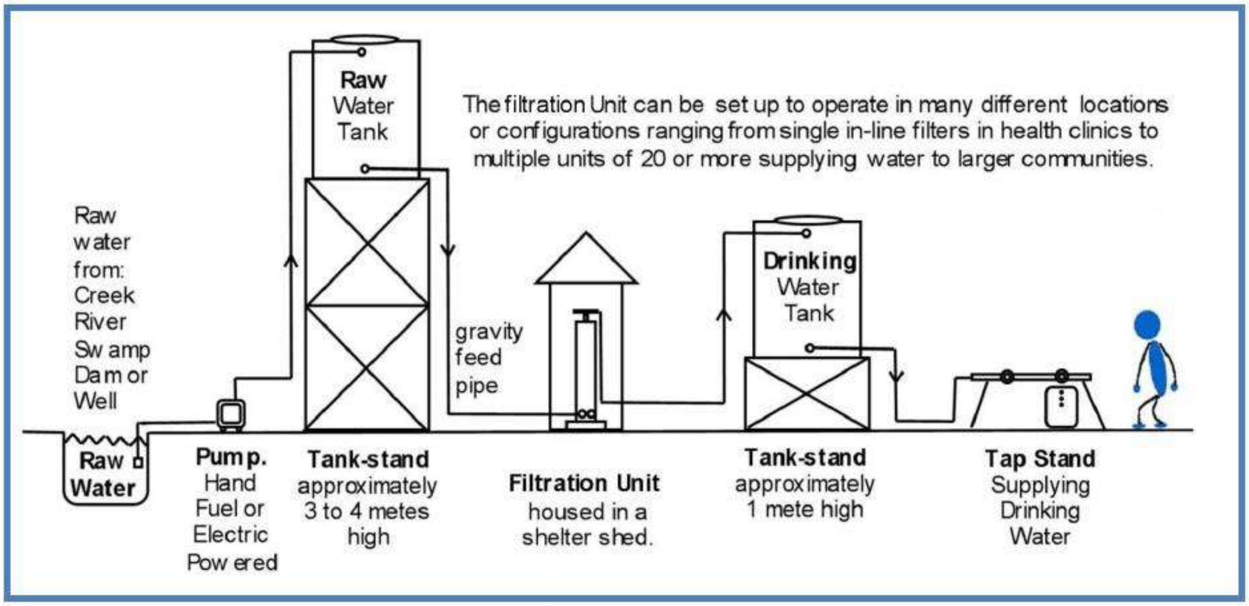


Figure 47: Schematic diagram of Sky-Hydrant system

10.2 Bill of Quantity of the Water Technologies

Local comparable costs for water technologies were assessed by the local engineers to develop the intial unit cost estimates. These cost estimates were based on DPHE's Bill of Quantities then reviewed and endorsed by DPHE. Unit costs were developed for the following water technologies (in order of increasing population supplied with water):

1. Household level RWH
2. Community-scale RWH system with a small tank volume of 45m³ and a roof in good condition
3. Community-scale RWH system with a small tank volume of 45m³ and a roof in moderate condition
4. Community-scale RWH system with a medium tank volume of 90m³ and a roof in good condition
5. Community-scale RWH system with a medium tank volume of 90m³ and a roof in moderate condition
6. Institution-scale RWH system with a large tank volume of 135m³ and a roof in good condition
7. Institution-scale RWH system with a large tank volume of 135m³ and a roof in moderate condition
8. Institution-scale RWH system with a very large tank volume of 180m³ and a roof in good condition
9. Institution-scale RWH system with a very large tank volume of 180m³ and a roof in moderate condition
10. Pond water treatment system using Sky-Hydrant and including raising embankments

The building condition is as measured in the 2016 building database or from the updated 2017 site surveys if available. The unit cost for RWH systems with "roof in moderate condition" also covers the additional buildings that are missing from the building database (since the roof condition is unknown for these buildings). The unit cost for RWH systems with "roof in moderate condition" includes additional budget for roof catchment preparation to cover the possibility that minor repairs will be required. The bills of quantities showing the development of each unit cost are shown in the tables below. These cost estimates may change (increase or decrease) after customization of the design for site-specific requirements. A contingency allowance of 7% has been included in all of the water technology unit costs to cover the potential for a minor increase in costs for the construction.

For the partial replacements, a contingency allowance was applied.

Table 46: Bill of quantity for the household level rainwater harvesting system including tank

Sl. No.	Components	Total Amount (BDT)
1	Rainwater tank (2,000 L capacity plastic tank @ 8 BDT/L)	16,000
2	Catchment (10' X 6' size CGI sheet)	3,000
3	Gutter (10' length), pipe (2" dia, 10' length), first flush system, elbow joint, t-bent, thread tape, etc. with installation cost	5,000
4	Filter material, bucket (gravel and sand) and filter stand	3,000
4	Platform material (brick, cement, sand for 4' X 4' X 2' platform with palster) with installation cost	5,500
5	Material transportation cost	3,000
Subtotal		35,500
Grand Total (with 7% contingency)		37,985

Table 47: Bill of quantity for small size rainwater harvesting tanks for 25 households with "good" roof condition

Sl. No.	Item	Unit	Quantit y	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.	m^2	75	600	45,000
(b)	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, 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.	m^2	10	890	8,900

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
2	Earth work (7 m X 5 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	18	500	9,000
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	35	350	12,250
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1-CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard mixer machine with hopper. All complete approved and accepted by the Engineer.	m^3	22	8,000	176,000
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	3000	90	270,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m^2	200	300	60,000
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m^2	150	400	60,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m^3	2	5,000	10,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	1	100,000	100,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000
16	Total Cost				896,650
17	7% Contingency				62,765.5
18	Grand Total				959,416

Table 48: Bill of quantity for small size rainwater harvesting tanks for 25 households with "moderate" roof condition

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.	m^2	75	1,200	90,000
(b)	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, 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	m^2	10	890	8,900

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
	in all floors including cost of water, electricity and other charges etc. all complete and accepted by the Engineer.				
2	Earth work (7 m X 5 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	18	500	9,000
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	35	350	12,250
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1- CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard mixer machine with hopper. All complete approved and accepted by the Engineer.	m^3	22	8,000	176,000
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	3000	90	270,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m^2	200	300	60,000
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m^2	150	400	60,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m^3	2	5,000	10,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	1	100,000	100,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000
16	Total Cost				941,650
17	7% Contingency				65,916
18	Grand Total				1,007,566

Table 49: Bill of quantity for medium size rainwater harvesting tanks for 50 households with "good" roof condition

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.	m^2	150	600	90,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
(b)	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, 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.	m^2	15	890	13,350
2	Earth work (10 m X 6 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	30	500	15,000
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	60	350	21,000
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1-CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard mixer machine with hopper. All complete approved and accepted by the Engineer.	m^3	32	8,000	256,000
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	5000	90	450,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m^2	400	300	120,000
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m^2	260	400	104,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m^3	3	5,000	15,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	2	100,000	200,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000
16	Total Cost				1,429,850
17	7% Contingency				100,090
18	Grand Total				**1,529,940**

Table 50: Bill of quantity for medium size rainwater harvesting tanks for 50 households with "moderate" roof condition

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.	m^2	150	1,200	180,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
(b)	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, 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.	m^2	15	890	13,350
2	Earth work (10 m X 6 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	30	500	15,000
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	60	350	21,000
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1-CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard mixer machine with hopper. All complete approved and accepted by the Engineer.	m^3	32	8,000	256,000
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	5000	90	450,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m^2	400	300	120,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m²	260	400	104,000
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m³	3	5,000	15,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	2	100,000	200,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000
16	Total Cost				1,519,850
17	7% Contingency				106,390
18	Grand Total				1,626,240

Table 51: Bill of quantity for large size rainwater harvesting tanks for 75 households with "good" roof (catchment)

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.	m^2	225	600	135,000
(b)	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, 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.	m^2	20	890	17,800
2	Earth work (11 m X 8 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	44	500	22,000
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	88	350	30,800
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1- CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard	m^3	45	8,000	360,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
	mixer machine with hopper. All complete approved and accepted by the Engineer.				
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	7000	90	630,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m²	600	300	180,000
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m²	350	400	140,000
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m³	3	5,000	15,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	3	100,000	300,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000
16	Total Cost				**1,976,100**
17	7% Contingency				**138,327**
18	Grand Total				**2,114,427**

Table 52: Bill of quantity for large size rainwater harvesting tanks for 75 households with "moderate" roof (catchment)

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity	m²	225	1,200	270,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
	and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.				
(b)	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, 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.	m^2	20	890	17,800
2	Earth work (11 m X 8 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	44	500	22,000
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	88	350	30,800
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1-CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard mixer machine with	m^3	45	8,000	360,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
	hopper. All complete approved and accepted by the Engineer.				
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	7000	90	630,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m^2	600	300	180,000
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m^2	350	400	140,000
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m^3	3	5,000	15,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	3	100,000	300,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000
16	Total Cost				2,111,100
17	7% Contingency				147,777

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
18	Grand Total				2,258,877

Table 53: Bill of quantity for large size rainwater harvesting tanks for 100 households with "good" roof (catchment)

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.	m^2	300	600	180,000
(b)	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, 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.	m^2	25	890	22,250
2	Earth work (13 m X 8.5 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	55	500	27,500
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	110	350	38,500

Sl. No.	Item	Unit	Quantit y	Unit Rate (BDT)	Total Amount (BDT)
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1- CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard mixer machine with hopper. All complete approved and accepted by the Engineer.	m^3	55	8,000	440,000
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	9000	90	810,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m^2	800	300	240,000
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m^2	480	400	192,000
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m^3	3	5,000	15,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	4	100,00 0	400,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
16	Total Cost				**2,510,750**
17	7% Contingency				**175,752**
18	Grand Total				**2,686,503**

Table 54: Bill of quantity for large size rainwater harvesting tanks for 100 households with "moderate" roof (catchment)

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
1	Catchment Preparation				
(a)	75 mm Damp proof course (DPC) (1:1.5:3) in cement concrete with cement, sylhet sand (F.M. 1.2) and stone chips including breaking chips, screening, centering, shuttering, casting, curing and finished with a coat including the supply of water, electricity and other charges and costs of masons, tools and plants etc. all complete and accepted by the Engineer.	m^2	300	1,200	360,000
(b)	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, 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.	m^2	25	890	22,250
2	Earth work (13 m X 8.5 m X 0.5 m) : Earthwork in excavation of tank of any dimension in all kinds of soil including cutting up to required depth including bailing out water and throwing on the embankment, breaking clods, ramming and levelling, dressing in 225 mm layer with maintaining the side slopes and level of both tank and the embankment as per design and accepted by the Engineer.	m^3	55	500	27,500
3	Brick flat solling with sand filling with labour charge: One layer of brick flat soling in foundation or in floor with first class or picked jhama bricks including preparation of bed and filling the interstices with local sand, levelling etc. complete and accepted by the Engineer.	m^2	110	350	38,500

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
4	Reinforced concrete tank preparation with labour charge: *side wall (6.42 m X 4.42 m X 0.21 m), base (6.5 m X 4.5 m X 0.21 m), roof (6.42 m X 4.42 m X 0.21 m).* Reinforcement cement concrete works using steel shutter with minimum cement content relates to mix ratio 1:1.5:3 having minimum fcr=26mpa,and satisfying a specified compressive strength f'c=21mpa at 28 days on cylinders as per standard practice of code ACI/BNBC/ASTM& Cement conforming to BDS EN-197-1- CEM1,52.5N(52.5MPa)/ASTM-C 150 Type -i,best quality sylhet sand or coarse sand of equivalent F.M 2.2 and 20 mm down well graded stone chip conforming to ASTM C-33 making, shutter, placing shutter in position and maintaining .making shutter water tight properly, placing reinforcement in position, mixing with standard mixer machine with hopper. All complete approved and accepted by the Engineer.	m^3	55	8,000	440,000
5	Reinforce bar (10 mm and 12 mm diameter)	Kg	9000	90	810,000
6	Framework, shuttering and necessary supports: necessary earth work, side filling shuttering.	m^2	800	300	240,000
7	Net finishing : cement plaster (1:4) with neat finishing on inner and outer sides, edges and top, curing etc. with mason charge all complete approved and accepted by the Engineer.	m^2	480	400	192,000
8	Construction and placing of R.C.C. inspection pit cover (slab) in (1:2:4) with 1% reinforcement excluding M.H. cover with locking/unlocking arrangement including necessary earth work, side filling shuttering, curing, cement plaster (1:4) with neat finishing on edges and top, mason charge, etc. all complete approved and accepted by the Engineer.	#	2	12,000	24,000
9	µPVC pipe (diameter 4 inch) for downpipe and water conveyance system with installation charge	m	50	600	30,000
10	T-bent, elbow, gate valve, water tap, connection joints and necessary materials with installation charge	Set	1	40,000	40,000
11	First flush diverter with installation charge	Set	1	10,000	10,000
12	Filter materials (gravel, coarse sand)	m^3	3	5,000	15,000
13	Tube well for water collection with pipes and other fixtures with installation charge	Set	1	11,500	11,500
14	Transportation of materials	L.S.	4	100,000	400,000
15	Visibility materials (sign boards, writing)	L.S.	1	30,000	30,000

Sl. No.	Item	Unit	Quantity	Unit Rate (BDT)	Total Amount (BDT)
16	Total Cost				**2,690,750**
17	7% Contingency				**188,353**
18	Grand Total				**2,879,103**

Table 55: Cost of Sky-Hydrant with climate resilient components

Sl. No.	Components	Total Amount (BDT)
1	Sky-Hydrant unit with transportation and installation costs	450,000
2	Disaster resilient housing and accessories (Solar Panel, battery, pumps, pipes, raw water and fresh water reservoirs, etc.) with transportation and installation costs	600,000
3	Embankment construction above flood level including labour and transportation costs	100,000
Subtotal		1,150,000
Total (with 7% contingency)		1,230,500

10.3 Operation and Maintenance Cost of Water Technologies

The estimated annual operation and maintenance costs of the water technologies are provided in this section and were prepared for the following list of water technologies (in order of increasing population supplied with water):

1. Household level RWH
2. Community-scale RWH system with a small tank volume of 45m³
3. Community-scale RWH system with a medium tank volume of 90m³
4. Institution-scale RWH system with a large tank volume of 135m³
5. Institution-scale RWH system with a very large tank volume of 180m³
6. Pond water treatment system using Sky-Hydrant and including raising embankments

The "new roof" does not require any additional O&M cost so is not separated out with a different O&M cost estimate. In addition to the O&M costs in the tables below, there is an allowance for one caretaker per ward on average (this may be adjusted during project set-up depending on household and water system numbers in each ward). The caretaker salary has been estimated at an average of 72,000BDT per year (6,000BDT per month). The O&M costs below are additional to the caretaker salary and allow for maintenance materials and hiring additional labour as required (for example a plumber). The O&M unit costs per year in BDT are shown in the tables below. For more details see Section 9.3 and the O&M Plan for Water Supply. The household RWH O&M cost does not include the cost of materials for cleaning their HH RWH roof catchment/tank/filter materials, which will be the responsibility of the households.

Table 56: O&M cost per year for household rainwater harvesting systems (BDT)

Description of O&M tasks and costs included for household RWH			
Sl. No.	**Item Description**	**Cost (BDT)**	**Time**
1	Yearly maintenance materials (water tap, adhesives and thread tape for repairing minor leaks in the joints (elbow and T joints))	200	per year
Total		**200**	**per year**

Table 57: O&M cost per year for community-scale and institution-scale rainwater harvesting systems (BDT)

Description of O&M tasks and costs included for community-scale and institution-scale RWH	**OM Cost by Households Supplied**			
	25 HH	**50 HH**	**75 HH**	**100 HH**
Catchment cleaning (additional labour and cleaning materials) at least twice a year.	2,500	3,750	5,000	6,250
Storage tank cleaning (additional labour and cleaning materials) at least twice a year. Bleaching powder, brush, etc.	2,000	3,000	4,000	5,000
Filter chambers cleaning (additional labour and cleaning materials) and washing/ replacing filter materials (sand/gravel) at least once a year.	2,000	3,000	4,000	5,000
Repair of taps, joints, gutter, down pipes - material and cost of hiring plumber, if needed.	3,000	4,500	6,000	7,500

Replacing parts/joints for tube wells (washer, nut, etc.) - material and cost of hiring plumber, if needed.	1,000	1,500	2,000	2,500
Minor brick works (tube well platform, stair, manholes, side walls repair etc.) - material and cost of hiring plumber, if needed.	1,500	2,250	3,000	3,750
Total per year	**12,000**	**18,000**	**24,000**	**30,000**

Table 58: O&M cost per year for community based pond treatment with the Sky-Hydrant system

Description of O&M tasks and costs included for Ponds with Sky-Hydrant system			
Sl. No.	**Item Description**	**Cost (BDT)**	**Time**
1	Battery Maintenance	12,000	Per year
2	Module maintenance cost (travel and remuneration fees for technical experts from suppliers and change of membrane and filter materials)	100,000	per year
3	Yearly maintenance of accessories	30,000	per year
4	Caretaker salary (BDT 12,000/month)	144,000	per year
5	Embankment maintenance	30,000	per year
Total		**316,000**	**per year**

11 Financial Needs

The cost of installation of water options in five Upazilas are provided in the Table 59 to Table 63 (in BDT).

Table 59: Total cost of installation of water technologies in targeted wards of Paikgacha Upazila

Union	Ward No.	Budget									
		HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
			in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
			Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Deluti	1	8,318,715	-	-	-	3,252,479	-	-	2,258,877	-	-
Deluti	5	10,445,875	-	-	-	3,252,479	-	-	-	-	-
Deluti	6	5,659,765	-	-	-	1,626,240	-	5,373,005	2,258,877	-	-
		24,424,355	-	-	-	8,131,198	-	5,373,005	4,517,754	-	-
Lata	3	1,937,235	-	1,529,940	-	3,252,479	-	-	-	-	-
Lata	4	6,001,630	-	1,529,940	-	3,252,479	-	-	-	-	-
		7,938,865	-	3,059,879	-	6,504,958	-	-	-	-	-
Chandkhali	1	21,917,345	1,918,831	6,119,758	-	3,252,479	-	-	-	-	-
Chandkhali	2	17,207,205	959,416	7,649,698	1,007,566	3,252,479	-	-	-	-	-
Chandkhali	3	8,774,535	2,878,247	-	-	3,252,479	-	-	-	-	-
		47,899,085	5,756,493	13,769,456	1,007,566	9,757,437	-	-	-	-	-
Garaikhali	3	20,663,840	-	3,059,879	-	1,626,240	-	-	-	-	-
Garaikhali	7	9,306,325	-	1,529,940	-	4,878,719	-	-	-	-	-
		29,970,165	-	4,589,819	-	6,504,958	-	-	-	-	-
Soladana	3	6,001,630	1,918,831	-	-	3,252,479	-	-	-	-	-
Soladana	6	5,773,720	-	1,529,940	-	3,252,479	-	-	-	-	-
		11,775,350	1,918,831	1,529,940	-	6,504,958	-	-	-	-	-
	Total	**122,007,820**	**7,675,324**	**22,949,093**	**1,007,566**	**37,403,509**	**-**	**5,373,005**	**4,517,754**	**-**	**-**

Table 60: Total cost of installation of water technologies in targeted wards of Koyra Upazila

Union	Ward No.	Budget									
		HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
			in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
			Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Koyra	6	11,927,290	-	-	-	3,252,479	-	-	-	-	-
Koyra	7	13,788,555	-	-	1,007,566	3,252,479	-	-	-	-	-
		25,715,845	-	-	1,007,566	6,504,958	-	-	-	-	-
Koyra	1	2,431,040	-	4,589,819	-	3,252,479	-	-	-	-	-
Koyra	8	2,317,085	-	1,529,940	-	-	-	-	2,258,877	2,879,103	-
Koyra	9	5,089,990	-	-	-	3,252,479	-	-	2,258,877	-	-
		9,838,115	-	6,119,758	-	6,504,958	-	-	4,517,754	2,879,103	-
Koyra	2	8,014,835	959,416	1,529,940	-	3,252,479	-	-	-	-	-
		8,014,835	959,416	1,529,940	-	3,252,479	-	-	-	-	-
Koyra	2	2,772,905	-	4,589,819	1,007,566	3,252,479	-	-	-	-	-
Koyra	4	873,655	-	3,059,879	-	-	-	-	-	-	-
		3,646,560	-	7,649,698	1,007,566	3,252,479	-	-	-	-	-
Koyra	2	2,393,055	959,416	-	-	-	-	-	-	-	1,230,500
Koyra	7	1,595,370	959,416	1,529,940	2,015,131	1,626,240	-	-	-	-	-
Koyra	**8**	2,127,160	959,416	4,589,819	-	-	-	-	-	-	-
		6,115,585	2,878,247	6,119,758	2,015,131	1,626,240	-	-	-	-	1,230,500
Koyra	1	8,774,535	-	-	-	3,252,479	-	-	-	-	-
Koyra	7	493,805	959,416	-	-	-	-	-	-	-	-
Koyra	9	1,139,550	959,416	-	-	3,252,479	-	-	-	-	-
		10,407,890	1,918,831	-	-	6,504,958	-	-	-	-	-
Koyra	3	1,595,370	-	-	-	3,252,479	-	-	-	-	-
Koyra	**8**	455,820	959,416	-	-	-	-	-	-	-	-
		2,051,190	959,416	-	-	3,252,479	-	-	-	-	-
	Total	**65,790,020**	**6,715,909**	**21,419,153**	**4,030,262**	**30,898,551**	**-**	**-**	**4,517,754**	**2,879,103**	**1,230,500**

Table 61: Total cost of installation of water technologies in targeted wards of Dacope Upazila

Union	Ward No.	Budget									
		HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
			in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof		
			Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Dacope	1	721,715	-	-	-	-	-	-	-	-	1,230,500
Dacope	2	911,640	-	-	-	-	-	-	-	-	1,230,500
Dacope	6	645,745	-	-	-	-	-	-	-	-	1,230,500
		2,279,100	-	-	-	-	-	-	-	-	3,691,500
Dacope	8	835,670	-	-	-	-	-	2,686,503	-	-	-
Dacope	9	1,291,490	-	-	-	-	-	-	-	-	1,230,500
		2,127,160	-	-	-	-	-	2,686,503	-	-	1,230,500
Dacope	2	1,253,505	-	-	-	-	-	-	-	-	1,230,500
Dacope	8	873,655	-	3,059,879	-	-	-	-	-	-	-
		2,127,160	-	3,059,879	-	-	-	-	-	-	1,230,500
Dacope	1	3,000,815	-	-	1,007,566	-	-	-	-	-	1,230,500
Dacope	2	2,886,860	-	-	-	-	-	-	-	-	2,461,000
Dacope	4	2,279,100	-	-	-	-	-	-	-	-	1,230,500
		8,166,775	-	-	1,007,566	-	-	-	-	-	4,922,000
Dacope	4	1,861,265	-	3,059,879	-	3,252,479	-	-	-	-	-
		1,861,265	-	3,059,879	-	3,252,479	-	-	-	-	-
Dacope	1	7,900,880	959,416	-	-	3,252,479	-	-	-	-	-
Dacope	3	1,215,520	-	1,529,940	1,007,566	1,626,240	-	-	-	-	-
		9,116,400	959,416	1,529,940	1,007,566	4,878,719	-	-	-	-	-
Dacope	6	1,899,250	-	3,059,879	-	3,252,479	-	-	-	-	-
Dacope	8	1,709,325	-	-	-	3,252,479	-	-	-	-	-
Dacope	9	1,329,475	-	-	-	-	-	-	-	-	1,230,500
		4,938,050	-	3,059,879	-	6,504,958	-	-	-	-	1,230,500
Dacope	1	797,685	-	1,529,940	-	-	-	-	-	-	-
Dacope	3	1,443,430	-	-	-	1,626,240	-	-	-	-	-
Dacope	9	1,025,595	-	1,529,940	-	-	-	-	-	-	-
		3,266,710	-	3,059,879	-	1,626,240	-	-	-	-	-
Dacope	5	1,025,595	-	-	-	-	-	2,686,503	-	-	-
Dacope	6	1,443,430	-	-	-	-	-	-	-	-	1,230,500
Dacope	7	949,625	-	-	-	-	-	-	-	-	1,230,500
		3,418,650	-	-	-	-	-	2,686,503	-	-	2,461,000
	Total	**37,301,270**	**959,416**	**13,769,456**	**2,015,131**	**16,262,395**	**-**	**5,373,005**	**-**	**-**	**14,766,000**

Table 62: Total cost of installation of water technologies in targeted wards of Shyamnagar Upazila

Union	Ward No.	Budget									
		HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
			in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
			Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Atulia	4	8,622,595	959,416	-	-	3,252,479	-	-	-	-	-
Atulia	5	2,013,205	-	-	-	-	-	-	-	-	1,230,500
Atulia	7	721,715	-	-	-	-	-	-	-	-	1,230,500
Atulia	8	2,051,190	959,416	-	-	-	-	-	-	-	1,230,500
		13,408,705	1,918,831	-	-	3,252,479	-	-	-	-	3,691,500
Ramjan Nagar	4	1,557,385	-	-	-	-	-	-	-	-	1,230,500
Ramjan Nagar	9	1,139,550	-	-	-	1,626,240	-	-	-	-	-
		2,696,935	-	-	-	1,626,240	-	-	-	-	1,230,500
Kashimari	6	151,940	959,416	-	-	-	-	-	-	-	-
Kashimari	9	379,850	-	-	-	1,626,240	-	-	-	-	-
		531,790	959,416	-	-	1,626,240	-	-	-	-	-
Burigoalini	1	2,279,100	-	-	-	-	-	-	-	-	1,230,500
Burigoalini	4	379,850	-	-	-	-	-	-	-	-	1,230,500
Burigoalini	7	2,431,040	-	-	-	1,626,240	-	-	-	-	1,230,500
		5,089,990	-	-	-	1,626,240	-	-	-	-	3,691,500
Gabura	4	1,405,445	959,416	-	-	3,252,479	-	-	-	-	-
Gabura	5	1,747,310	-	-	-	-	-	-	-	-	1,230,500
Gabura	7	2,507,010	-	-	-	-	-	-	-	-	2,461,000
		5,659,765	959,416	-	-	3,252,479	-	-	-	-	3,691,500
Kaikhali	6	1,367,460	-	-	-	-	-	-	-	-	1,230,500
Kaikhali	8	493,805	-	-	-	-	-	-	-	-	1,230,500
		1,861,265	-	-	-	-	-	-	-	-	2,461,000
Padmapukur	3	1,557,385	-	-	-	-	-	-	2,258,877	2,879,103	-
Padmapukur	4	1,747,310	-	-	-	-	-	-	-	-	1,230,500
Padmapukur	7	2,165,145	-	-	-	1,626,240	-	-	-	-	1,230,500
		5,469,840	-	-	-	1,626,240	-	-	2,258,877	2,879,103	2,461,000
Munshiganj	6	3,152,755	1,918,831	6,119,758	2,015,131	1,626,240	-	-	-	-	-
Munshiganj	9	11,205,575	-	-	-	3,252,479	-	-	-	-	-
		14,358,330	1,918,831	6,119,758	2,015,131	4,878,719	-	-	-	-	-
	Total	**49,076,620**	**5,756,493**	**6,119,758**	**2,015,131**	**17,888,635**	**-**	**-**	**2,258,877**	**2,879,103**	**17,227,000**

Table 63: Total cost of installation of water technologies in targeted wards of Assasuni Upazila

Union	Ward No.	Budget									
		HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
			in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
			Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
Anulia	2	7,900,880	-	-	1,007,566	4,878,719	-	-	-	-	-
Anulia	4	11,167,590	-	3,059,879	-	3,252,479	-	-	-	-	-
Anulia	7	46,721,550	1,918,831	-	-	-	-	-	-	-	-
Anulia	9	1,481,415	-	-	1,007,566	4,878,719	-	-	-	-	-
		67,271,435	1,918,831	3,059,879	2,015,131	13,009,916	-	-	-	-	-
Durgapur	4	1,709,325	-	-	-	-	-	-	-	-	1,230,500
Durgapur	6	3,532,605	959,416	3,059,879	-	3,252,479	-	-	-	-	1,230,500
Durgapur	9	4,596,185	-	1,529,940	-	3,252,479	-	-	-	-	-
		9,838,115	959,416	4,589,819	-	6,504,958	-	-	-	-	2,461,000
Sreeula	1	18,498,695	-	1,529,940	-	3,252,479	-	-	-	-	-
Sreeula	2	9,800,130	959,416	-	1,007,566	3,252,479	-	-	-	-	-
Sreeula	4	3,342,680	-	-	1,007,566	-	-	-	-	-	2,461,000
		31,641,505	959,416	1,529,940	2,015,131	6,504,958	-	-	-	-	2,461,000
Budhata	1	2,848,875	-	-	-	-	-	-	-	-	2,461,000
Budhata	2	4,900,065	1,918,831	3,059,879	-	3,252,479	-	-	2,258,877	-	-
Budhata	8	4,862,080	1,918,831	4,589,819	-	4,878,719	-	-	-	-	1,230,500
		12,611,020	3,837,662	7,649,698	-	8,131,198	-	-	2,258,877	-	3,691,500
Bardal	1	3,228,725	-	-	-	3,252,479	-	-	-	-	-
Bardal	4	14,814,150	959,416	3,059,879	1,007,566	-	-	2,686,503	-	-	2,461,000
Bardal	7	4,786,110	-	3,059,879	1,007,566	1,626,240	-	2,686,503	-	2,879,103	1,230,500
		22,828,985	959,416	6,119,758	2,015,131	4,878,719	-	5,373,005	-	2,879,103	3,691,500
Khajra	2	18,916,530	-	3,059,879	-	3,252,479	-	-	-	-	-
Khajra	3	14,700,195	-	1,529,940	-	3,252,479	-	-	-	-	-
Khajra	9	10,028,040	959,416	1,529,940	-	3,252,479	-	-	-	5,758,205	-
		43,644,765	959,416	6,119,758	-	9,757,437	-	-	-	5,758,205	-
Kulla	5	3,950,440	-	1,529,940	-	3,252,479	-	-	-	-	-
Kulla	6	4,786,110	959,416	1,529,940	-	3,252,479	-	-	-	-	1,230,500
Kulla	9	3,266,710	-	3,059,879	-	3,252,479	2,114,427	2,686,503	-	-	-
		12,003,260	959,416	6,119,758	-	9,757,437	2,114,427	2,686,503	-	-	1,230,500
Kadakati	2	1,481,415	-	-	-	-	-	-	-	-	1,230,500
Kadakati	3	4,026,410	959,416	-	1,007,566	3,252,479	-	-	-	-	-
Kadakati	5	949,625	-	-	-	-	-	-	-	-	1,230,500
		6,457,450	959,416	-	1,007,566	3,252,479	-	-	-	-	2,461,000
Assasuni	2	113,955	-	1,529,940	-	-	-	-	-	-	-
Assasuni	9	9,344,310	-	-	-	4,878,719	-	-	-	-	-
		9,458,265	-	1,529,940	-	4,878,719	-	-	-	-	-
Protapnaga	6	911,640	-	-	-	-	-	-	-	-	1,230,500
Protapnaga	7	8,850,505	959,416	4,589,819	-	-	-	-	-	-	-
Protapnaga	8	6,229,540	959,416	1,529,940	-	3,252,479	-	-	-	-	-
		15,991,685	1,918,831	6,119,758	-	3,252,479	-	-	-	-	1,230,500
	Total	**231,746,485**	**13,431,817**	**42,838,306**	**7,052,959**	**69,928,299**	**2,114,427**	**8,059,508**	**2,258,877**	**8,637,308**	**17,227,000**

Table 64: Total cost of installation of water technologies in five Upazilas

District	Upazila	Budget for Installation of Water Technologies (BDT)
Khulna	Paikgacha	201,086,010
	Koyra	137,481,251
	Dacope	90,446,672
Satkhira	Shyamnagar	103,221,616
	Assasuni	403,294,984
TOTAL		**935,530,532**

12 Conclusions

The coastal areas of Bangladesh are highly vulnerable to the impacts of climate change including from cyclones and tidal surges. The impacts of climate change have had a significant impact on available potable water, on both surface and groundwater in this area. The main climatic factors contributing to water scarcity in coastal areas are salinity in surface and groundwater due to sea level rise and tidal surges, and variation in precipitation pattern.

100% of the population have access to some form of drinking water sources. Only 61% of the population have access to safe drinking water sources (not year round), and only 22% of the population have access to year round safe non-saline drinking water. (Source, BBS 2011, DPHE 2016 and PRA survey 2017).

A rapid but comprehensive PRA study was conducted in the target districts to analyse the existing baseline coverage of non-saline water supplies. There is a huge demand for non-saline potable water in the climate vulnerable coastal 39 unions of 5 Upazilas under the target districts of Khulna and Satkhira. The existing water technologies quantitatively covers only 19% of the population for safe water supply and a huge supply gap (81%) remains to be met by the external support and intervention under the Green Climate Fund project. The gaps need to be filled up by identification of climate resilient appropriate water technologies, which can adequately sustainably provide safe drinking water services to all uncovered people of the above selected areas and reduce significantly the hardship of the people particularly the women for collection of water and increase their amenities for improved living and health.

A multi-criteria assessment (MCA) was undertaken on a short list of water supply technology options using evaluation criteria in-line with GCF investment criteria. Rainwater harvesting is the preferred option from the MCA analysis due to its resilience to climate changed induced salinity, capacity to provide safe drinking water year-round and lack of adverse environmental impacts. Rainwater harvesting at existing community and institution buildings will have the highest cost efficiency due to economies of scale. Household level RWH is also part of the proposed solution as it can supply people with no access to community or institution based RWH or pond treatment systems, especially people living far away from these systems, women and adolescent girl headed households, people with disabilities and minority groups.

The water supply gap in the target wards (for year-round, safe drinking water) is too large to address solely through installing RWH systems at existing community and institution buildings. The existing surface water ponds are an alternative and popular option of potable water supply in the coastal belt and arsenic prone areas. Ponds typically do not dry up during the dry season and can provide a viable additional safe water source after treatment. To improve climate-resiliency and prevent saltwater intrusion during intense cyclonic events, selected fresh water ponds (not in the vicinity of / exposed to shrimp farming or other aquaculture), will be supported by raised embankments. The pond selection will also focus on existing ponds that are not saline and can provide year-round water availability. Furthermore, 'Sky-hydrant' systems (the second preferred option from the MCA analysis) will be installed at these sites to provide filtration and ensure quality of the water. The sky-hydrant modules have filtration units that rely on gravity force to pump fresh water out (a small solar pump will be used to pump from the pond up to a raised tank to provide the head requirement for the filtration unit) and these modules are also installed in a well-protected superstructure, which are resilient to disaster shocks.

The proposed number of water supply technologies were estimated at a ward level based on the PRA data combined with a building database of existing community and institution buildings supplemented by site surveys at selected institution sites targeted for large and very large tanks. Standard design templates were developed for the proposed RWH systems, unit costs were developed and the investment costs were estimated at a ward level. The study also recommended implementation model and institutional arrangement and clear exit strategy for developing capacity of the community and private sector and empowering women for sustainable operation and maintenance of the proposed improved water facilities in the study areas.

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Appendices

Annex 1: Multi-criteria Poverty Index Approach

The Multi Criteria Poverty Index (MCPI) approach is shown below using Banishanta union of Dacope upazila in Khulna district as a sample union. The index was calculated considering three parameters: (i) income poverty; (ii) housing poverty; and (iii) livelihood poverty. The calculation is shown in the table below.

Table 65: Example Calculation of Multi-dimensional Poverty Index Figure for Baniashanta Union

Type	**Income (BDT)**	**% of HH (X)**	**Weight Factor (WF)**	**WF * (X)**	**Sub-Index**
Income poverty (based on PRA)	0 to 5,000	36	1.00	36	
	5,001 to 10,000	21	0.75	16	
	10,001 to 15,000	26	0.50	13	
	15,001 and above	17	0.25	4	
	Total	**100**		**69**	**0.69**
Housing poverty (based on PRA)	Pucca	8	0.25	2	
	Semi-pucca	12	0.50	6	
	Kutcha+jhupri	80	1.00	80	
	Total	**100**		88	0.88
Livelihood poverty (based on PRA)	% of Labour (Class)			Weight factor	
	75-100 (weight 1.0)	80	1.00	1	
	50-75 (weight 0.75)	0	0.75	0	
	25-50 (weight 0.50)	0	0.50	0	
	0-25 (weight 0.25)	0	0.25	0	
	Total			**1**	**1**
				Total score	**2.57**
				MCPI	0.86

The poverty level is categorized as follows:

- MCPI value <0.00 – 0.25> Non-Poor
- MCPI value <0.26 – 0.50> Poor
- MCPI value <0.51 – 0.75> Extreme Poor
- MCPI value <0.76 – 1.00> Ultra Poor

The Banishanta union of Dacope upazila was categorised as ultra poor as its MCPI value of 0.86 falls between 0.75 and 1.

Annex 2: Summary of Site Survey Reports

Table Summary of Site Specific Details for Proposed Institution-Scale Tank Locations

Tank #	Tank Size	Upazila	Union	Ward	Name of the Building	Minimum Roof area (m²)	Roof material	Minimum Area Available for RWH tank (m²)	Roof Shape	Height of wall under eaves (m)	Existing RWH on building?	Number of HHs within 1km
1	Very Large	Assasuni	Bardal	4	Bardal Aftabuddin Collegiate School (Building 3) - Site 3 Building 1	643	Concrete	60	Slope	3.66	No	350-400 approx.
2	Very Large	Assasuni	Bardal	7	Bardal Saint Francis Jevier Junior High School (Building 1) - Site 1	364	Tin (CI sheet)	47	Slope	3.66	No	300-400 approx.
3	Very Large (Combined)	Assasuni	Bardal	7	Bardal Saint Francis Jevier Junior High School (Building 2) - Site 1 Building 1	172	Tin (CI sheet)	47	Slope	3.66	No	350-400 approx.
		Assasuni	Bardal	7	Bardal Saint Francis Jevier Junior High School (Building 2) - Site 1 Building 3	157	Tin (CI sheet)	47	Slope	2.44	No	350-400 approx.
4	Large	Assasuni	Budhata	2	Chapra Bohumukhi Secondary School	274	Reinforced Cement Concrete (RCC)	56	Slope	3.05	20 m3 (for teachers and students only)	900-1000 approx.
5 & 6	Combined (2 Very Large)	Assasuni	Khajra	9	Tuardanga H F High School – Site 1	198	Concrete	64	Slope	3.66	No	600-700 approx.
		Assasuni	Khajra	9	Tuardanga H F High School – Site 1	116	Tin (CI sheet)	52	Slope	2.44	No	600-700 approx.
		Assasuni	Khajra	9	Tuardanga H F High School – Site 2	256	Concrete	129	Slope	3.66	No	600-700 approx.
7	Very Large	Assasuni	Kulla	9	Mushisa Danga Collegiate School (Building 1 plus adjacent)	>268	Concrete	130	Slope	3.66	No	400-500 approx.
8	Large	Assasuni	Kulla	9	Mushisa Danga Collegiate School (Building 2 plus adjacent)	>185	Concrete	128	Slope	6.71	No	400-500 approx.
9	Very Large	Dacope	Bajua	8	BK (Kocha) Govt. Primary School And Cyclone Shelter (Building 1)	336	Concrete	70	Slope	10.06	No	500-600 approx.
10	Very Large	Dacope	Kailashganj	5	Kailashganj Secondary School Building 1	390	Concrete	88	Slope	7.01	No	600-700 approx.
11	Very Large	Koyra	Maheshwaripur	8	Hodda DM Govt. Primary School And Cyclone Shelter	329	Reinforced Cement Concrete (RCC)	132	Plain	7	8 m3	110-120 approx.
12	Large	Koyra	Maheshwaripur	8	Hodda High School (Building 1)	265	Reinforced Cement Concrete (RCC)	132	Plain	5.7	8 m3	100-120 approx.
13	Large	Koyra	Maheshwaripur	9	Hodda Majher Chalk Govt. Primary School And Cyclone Shelter	313	Reinforced Cement Concrete (RCC)	215	Slope	9.1	No	70-80 approx.
14	Large	Paikgacha	Deluti	1	Girgonia Secondary School Building 1	268	Reinforced Cement Concrete (RCC)	115	Slope	3	No	200-250 approx.
15	Very Large	Paikgacha	Deluti	6	Kalinagor College	396	Reinforced Cement Concrete (RCC)	50	Plain	3.05	No	100-150 approx.
16	Very Large	Paikgacha	Deluti	6	Uddyon Girls High School (Building 1 with adjacent roof area)	>266	Reinforced Cement Concrete (RCC)	56	Slope	3.05	No	350-400 approx.
17	Large	Paikgacha	Deluti	6	Uddyon Govt. Primary School (Building 4 with adjacent roof area)	>164	Reinforced Cement Concrete (RCC)	56	Slope	3.05	No	350-400 approx.
18	Very Large	Shyamnagar	Padmapukur	3	47 No Padmapukur Govt. Primary School	350	Concrete	76	Slope	6.10	No	200-250 approx
19	Large	Shyamnagar	Padmapukur	3	75 No South Pakhimara Govt. Primary School Building 1	238	Concrete	90	Slope	6.10	3 m3	Assume 200 approx

Annex 3: Union Report of Burigoalini, Kulla, Lata, Maharajpur, and Tildanga Union

Union Report on
Climate Resilient Water Infrastructure

Union :	**Burigoalini**
Upazila :	**Shyamnagar**
District :	**Satkhira**

Reporting Date: 15 August, 2017

1. Demographic, socioeconomic, and geo-physical overview of the Union

Burigoalini Union of Shyamnagar Upazila, Satkhira district is situated in the southern part of Shyamnagar Upazila near world famous mangrove forest 'Sundarban'. A base map of Burigoalini Union is provided in Figure 1. The base map shows the following:

- Wards in yellow with boundaries shown by dashed lines
- Polder embankment locations
- Major rivers and minor rivers/canals
- Settlements in grey
- Smaller index maps showing the location of the Union within the Upazila and the district

The total area of the Union is 44 sq.km. The Union is situated 18 km away from Shyamnagar Upazila office. The Union is surrounded by Gabura Union and Kholpetia river in the East, Ishwarpur Union in the West, Atulia Union in the North, Munshiganj Union and Sunderban in the South. The important rivers flowing through this Union are Kholpetia, Chuna and Kadamtala. There are 24 villages in the Union.

Demographics: As per Local Government Division population data (2016), the population of Burigoalini was estimated at 24,913 (F: 12,011 and M: 12,902) population and 5,489 households. The ward wise population is presented in Table 1. This assessment and the proposed water solutions are based on the more recent estimate of the population by Local Government Division (LGD).

Table 66: Ward wise population and household of Burigoalini Union

Ward No.	Number of Village	Number of HH	Population		
			Female	Male	Total
1	3	662	1,361	1,740	3,101
2	3	947	2,268	1,967	4,235
3	2	713	1,443	1,665	3,138
4	4	427	960	1,037	1,997
5	4	431	892	999	1,891
6	1	424	1,032	972	2,004
7	2	756	1,832	1,572	3,404
8	2	746	1,458	1,946	3,404
9	3	383	765	975	1,740
Total	**24**	**5,489**	**12,011**	**12,902**	**24,913**

As per Bangladesh National Information Portal[100] of Burigoalini Union, there are 8 Government primary schools, 4 registered non-government primary schools, 2 girls schools, 6 high schools, 1 college and 5 Madrassas. Agriculture and shrimp farming are the main occupation of the people. The extreme poor people are mostly day labourers. During PRA session, availability of partial electricity coverage was identified partially in wards 1, 2, 3, 4, 5, 7 and 8 and there was no electricity in ward 6 and 9. There are 225 ethnic minority households (Munda) in Burigoalini[1], which is 3.86% of the total households of the Union.

Target Wards: The target wards were selected based on observed and projected salinity levels, poverty index and vulnerability to saline intrusion due to low elevation (the methodology is described in detail in Section 7.3 of the

[100] http://www.bangladesh.gov.bd/

synthesis report). The target wards in the Burigoalini Union are Wards 1, 4 and 7. There are 1,845 households in these target wards, representing 33.61% of the Burigoalini Union households. Burigoalini Union sits in the Shyamnagar sub-district, therefore 50% of the households who are without access to improved water supplies are targeted.

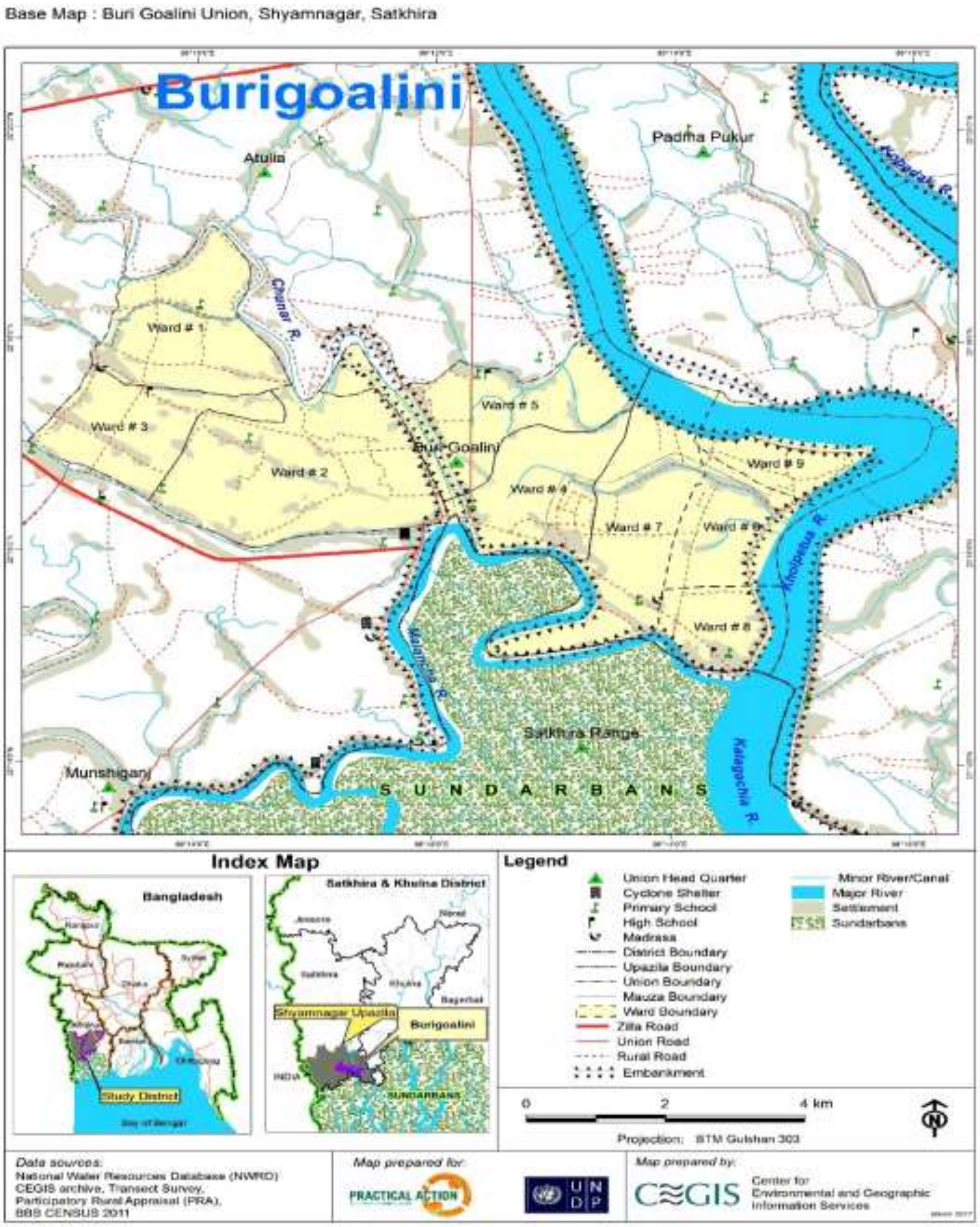


Figure 48: Base map of Burigoalini Union in Shyamnagar Upazila under Satkhira district

2. Mapping of functional and potential drinking water sources, supply, and access

Water sources: From analyses of the information collected during the PRA process and mapping done by the technical team, the baseline current safe year round drinking water sources for Burigoalini Union were identified. The baseline for the existing safe drinking water supply is based on the people supplied by non-saline drinking water sources (e.g. deep tube wells rather than shallow tube wells) that provide year round access of at least 2 LCPD drinking water to recipients. The baseline does not include water sources that are being used but are saline, e.g. shallow tube wells are not included in the baseline. There are 402 RWH units in this Union supplying water year-round, 15 functional PSF and 5 reverse osmosis systems. All of these existing water facilities cover 1,500 households, which is only 27.33% of the total households in the Union. So this Union is a water stressed area and there is a huge demand for drinking water supply in Burigoalini Union.

Baseline Coverage: Figure 2 shows at a glance the baseline drinking water coverage with functional non-saline sources that is prepared based on the findings of PRA mapping exercise done in Burigoalini Union.

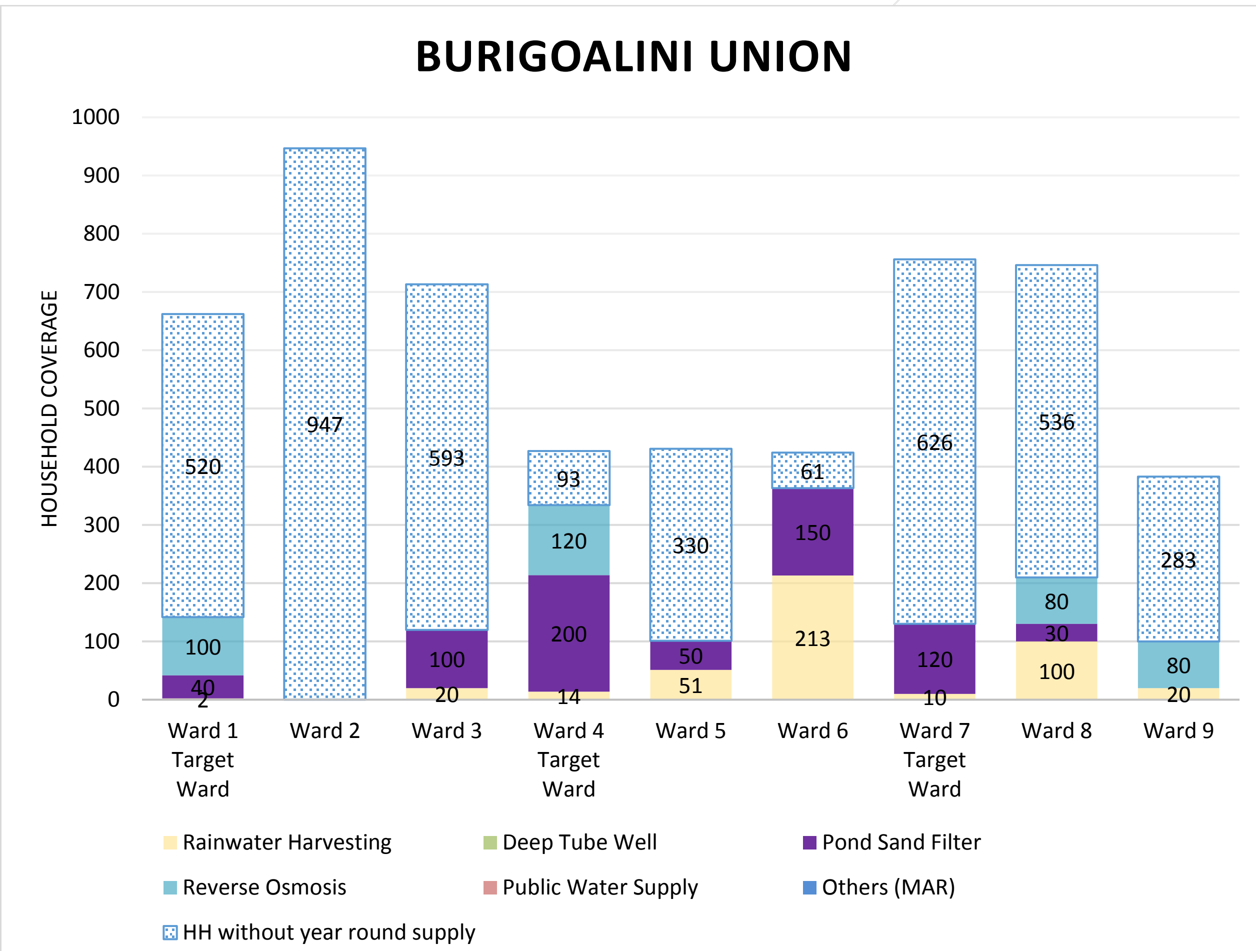


Figure 49 Baseline non-saline drinking water coverage for Burigoalini Union

Figure 3 shows a map of existing safe non-saline drinking water technologies in Burigoalini Union.

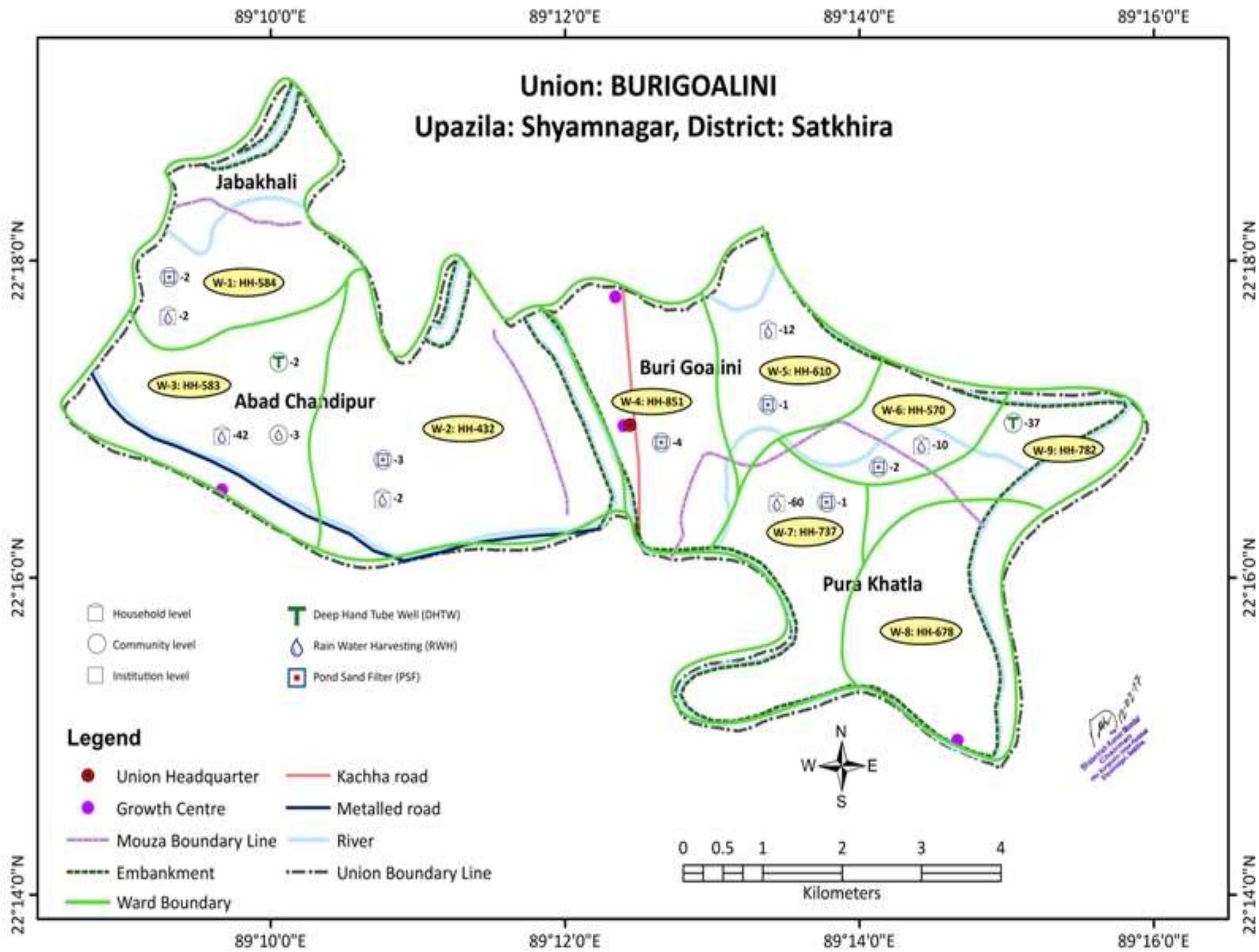


Figure 50: Map of existing non-saline drinking water technologies of Burigoalini Union

Water access: Table 2 shows access to water in Burigoalini Union with the three target wards highlighted in yellow.

Table 67: Time, distance and coast to collect water by community people of Burigoalini Union

Ward No.	Number of Village	Number of HH	Women headed household	Distance to collect water (km)	Time required (hr)	Estimated cost per liter (Tk.)
1	3	662	220	3	1.5	0.2
2	3	947	310	3.5	3	0.5
3	2	713	220	1	1.5	
4	4	427	0	1	1	
5	4	431	10	1	0.67	
6	1	424	0	2	1	1
7	2	756	220	2	2	
8	2	746	50	1.5	2	0.5
9	3	383	20	2	1.5	0.5
Total	**24**	**5,489**	**1,050**			

Table 2 depicts a clear picture of existing water supply situation of Burigoalini Union as obtained from PRA sessions at the ward level. People are traditionally used to drink rainwater as Burigoalini is in salinity affected area and the safe water sources are very scarce. There is water crisis in the dry season and people, especially women, have to travel 1-3.5 km to collect drinking water from the community based drinking water options. The situation is very critical in wards 1 and 2 where people have to collect drinking water from 3-3.5 km distance by travelling or through Van drivers. This makes lives of the women particularly in the 1,050 women headed households' miserable.

3. Impacts of climate change on water sources, supply and access

Safe drinking water is an important health indicator and climate change has affected a large population in the coastal districts of Bangladesh in terms of availability of safe water. Hence, consideration of possible impacts of climate change on water sources is of prime importance while selecting appropriate technologies in coastal area. A review of available information from secondary sources on sea level rise and natural hazards, and their impacts on water sources have been presented in this section.

3.1. Sea level rise

High salinity in groundwater was reported by the people of Burigoalini Union during the study. According to information provided by Bangladesh Water Development Board[101], the groundwater salinity in Burigoalini Union varies from 6,000 to 9,000 µS/cm.

3.2. Natural hazards and tidal surges

According to local people, the coastal embankment was badly damaged during the cyclone Aila causing intrusion of salt water into the fresh water pond in the Union. The effect of Aila and saltwater intrusion due to sea level rise on surface water sources, e.g., ponds, left a very limited number of fresh water ponds as drinking water source for people living in many villages in this Union. According to information provided by Bangladesh Water Development Board[2], surface water salinity was found around 16,500 µS/cm in this area. In absence of necessary protection measures, these sources could further be affected by tidal surges and subsurface movement of saltwater due to sea level rise.

4. Proposed climate resilient water technologies

The potential of different types of water sources were analyzed in the two target wards. This information was fed in to the selection process of water technologies to meet the needs of the target population. Current and projected availability and quality of groundwater, surface water, and rainwater were considered in the local context based on available data and information during the analysis. Three types of water technologies are proposed for the three target wards in the Burigoalini Union:

- Household based rainwater harvesting system – for individual households
- Community-scale rainwater harvesting system – for 25 and 50 households based on roof catchment size

[101] *Bangladesh Water Development Board, 2013; Mathematical Modelling Study on Saline Water Intrusion to Assess Salinity Intrusion, Salinity Level, Sea Level Rise Management Information System (MIS) : Package – 2, The Climate Change Trust Fund (CCTF) Project, Ministry of Environment and Forest.*

- Community-based pond water treatment system (Sky-hydrant)

Table 4 shows the household data and proposed technologies following the methodology described in Chapter 7 of the synthesis report with a design target of 2 litres of safely managed drinking water per person per day. The forecast population growth for Burigoalini Union is positive. The Target Beneficiary Households in Table 4 was used for the basis of design of the required water technology solutions. There are 606 households with existing functioning year-round improved water supplies in the target wards, representing 32.85% of the households in these wards.

Table 68: Proposed technology based on number of households for Burigoalini Union

Ward No.	Number of HHs	Baseline Coverage (non-saline)	Target Beneficiary Households (50% of supply gap)	Proposed Technology									
				HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
					in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
					Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
1	662	142	260	60	-	-	-	-	-	-	-	-	1
4	427	334	47	10	-	-	-	-	-	-	-	-	1
7	756	130	313	63	-	-	-	1					1
Total	**1,845**	**606**	**620**	**133**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**3**

Table 4 shows a community-scale RWHS and no institution-scale RWHS for this Union. The community-scale RWHS in ward 7 is assumed to have at least a moderate roof condition of 150m² in area. There are three pond water treatment systems proposed for this Union too.

5. Estimated budget for the proposed water technologies

The capital investment cost for the proposed water technologies in three wards of Burigoalini Union is provided in Table 5.

Table 69: Budget for Capital Costs in Burigoalini Union

Ward No.	Budget (BDT)									
	HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
		in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
		Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
1	2,279,100	-	-	-	-	-	-	-	-	1,230,500
4	379,850	-	-	-	-	-	-	-	-	1,230,500
7	2,393,055	-	-	-	1,626,240					1,230,500
Total	**5,052,005**	**-**	**-**	**-**	**1,626,240**	**-**	**-**	**-**	**-**	**3,691,500**

Union Report on
Climate Resilient Water Infrastructure

Union :	**Kulla**
Upazila :	**Assasuni**
District :	**Satkhira**

Reporting Date: August 15, 2017

1. Demographic, socioeconomic, and geo-physical overview of the Union

Kulla Union of Assasuni Upazila, Satkhira district is situated in the northern part of Assasuni Upazila. The Union is surrounded by Tala Upazila in the North, Kadakati Union in the East, Morichap and Betna rivers in the South and Budhata Union in the West. A base map of Kulla Union is provided in Figure 1. The base map shows the following:

- Wards in yellow with boundaries shown by dashed lines
- Polder embankment locations
- Major rivers and minor rivers/canals
- Settlements in grey
- Smaller index maps showing the location of the Union within the Upazila and the District

The total area of the Union is 20.58 sq.km. The Union is situated 22 km away from Assasuni Upazila office.

Demographics: As per Local Government Division population data (2016), the population of Kulla was estimated at 24,562 (F: 12,068 and M: 12,494) population and 5,889 households. The ward wise population is presented in Table 1. This assessment and the proposed water solutions are based on the more recent estimate of the population by Local Government Division (LGD).

Table 70: Ward wise population and household of Kulla Union

Ward No.	Number of Village	Number of HH	Population		
			Female	Male	Total
1	1	651	1395	1,363	2,758
2	2	1,034	1659	1,788	3,447
3	1	468	1211	1,116	2,327
4	2	1,034	2208	2,101	4,309
5	2	603	1265	1,234	2,499
6	6	566	1096	1,059	2,155
7	2	462	840	1,401	2,241
8	3	603	1319	1,267	2,586
9	2	468	1075	1,166	2,241
Total	**21**	**5,889**	**12,068**	**12,494**	**24,562**

As per Bangladesh National Information Portal[102] of Kulla Union, there are 9 government primary schools, 6 registered non-government schools, 3 high schools, 1 girl's school, 1 collegiate school, 1 Women's college, 1 vocational training school and 7 Madrassas. Agriculture, shrimp farming and small business are the main occupation of the people. The extreme poor people are mostly day labourers. During PRA session, the availability of electricity was identified fully in all wards. There is no ethnic minority household in Kulla[103].

Target Wards: The target wards were selected based on observed and projected salinity levels, poverty index and vulnerability to saline intrusion due to low elevation (the methodology is described in detail in Section 7.3 of the synthesis report). The target wards in the Kulla Union are Wards 5, 6 and 9. There are 1,637 households in these

[102] http://www.bangladesh.gov.bd/
[103] PRA

target wards, representing 27.80% of the Kulla Union households. Kulla Union sits in the Assasuni sub-district, therefore 100% of the households without access to improved water supplies are targeted.

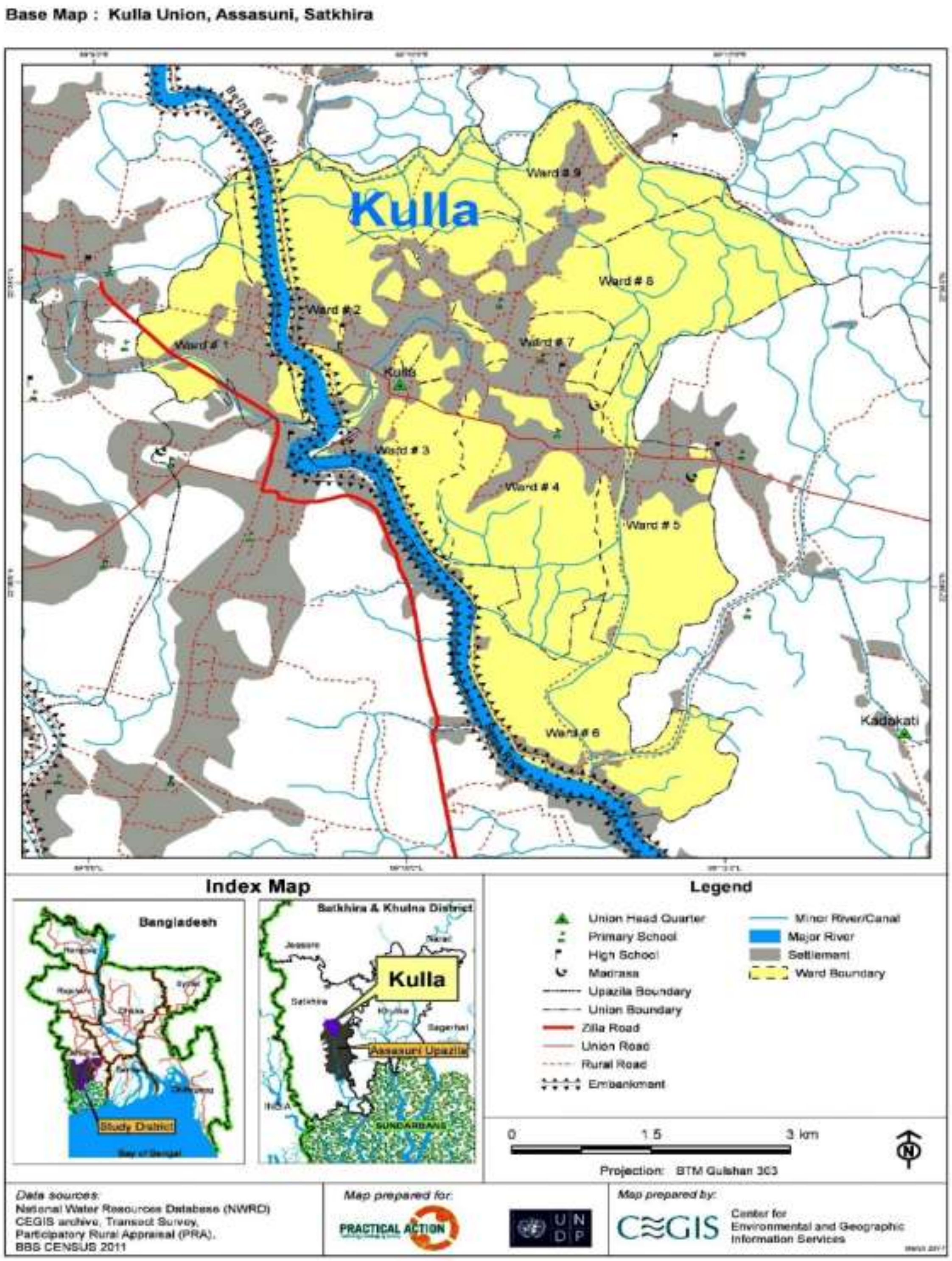


Figure 51: Base map of Kulla Union in Assasuni Upazila under Satkhira district

2. Mapping of functional and potential drinking water sources, supply, and access

Water sources: From analyses of the information collected during the PRA process and mapping done by the technical team, the baseline current safe year round drinking water sources for Kulla Union were identified. The baseline for the existing safe drinking water supply is based on the people supplied by non-saline drinking water sources (e.g. deep tube wells rather than shallow tube wells) that provide year round access of at least 2 LCPD drinking water to recipients. The baseline does not include water sources that are being used but are saline, e.g. shallow tube wells are not included in the baseline. There are 43 RWH units supplying water year-round, there are 14 PSF, 143 deep tube wells and 2 reverse osmosis plants in this Union. All of these existing water facilities cover 1295 households, which is only 22% of the total households in the Union. So this Union is a water stressed area and there is a huge demand for drinking water supply in Kulla Union.

Baseline Coverage: Figure 2 shows at a glance the baseline drinking water coverage with functional non-saline sources that is prepared based on the findings of PRA mapping exercise done in Kulla Union.

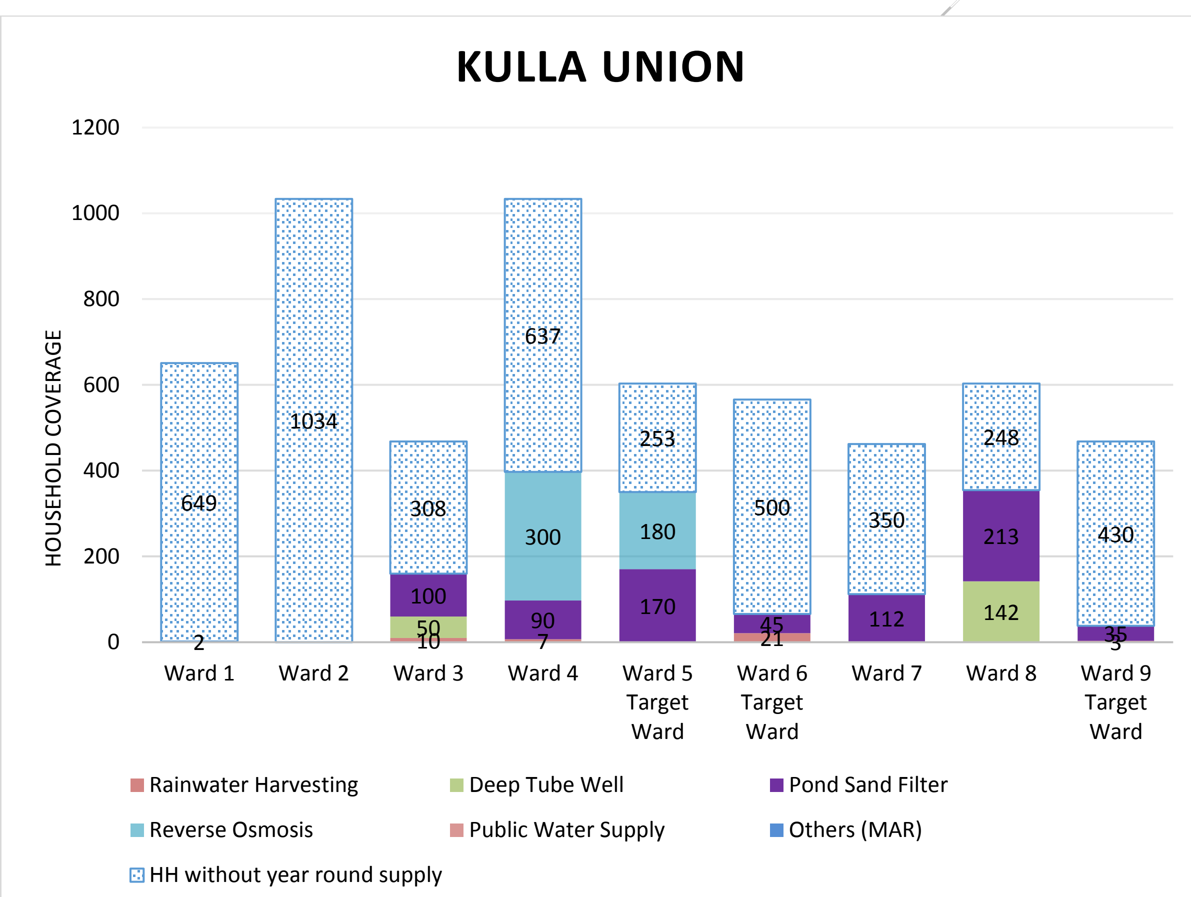


Figure 52: Baseline of non-saline drinking water coverage for Kulla Union

Figure 3 shows a map of existing safe non-saline drinking water technologies in Kulla Union.

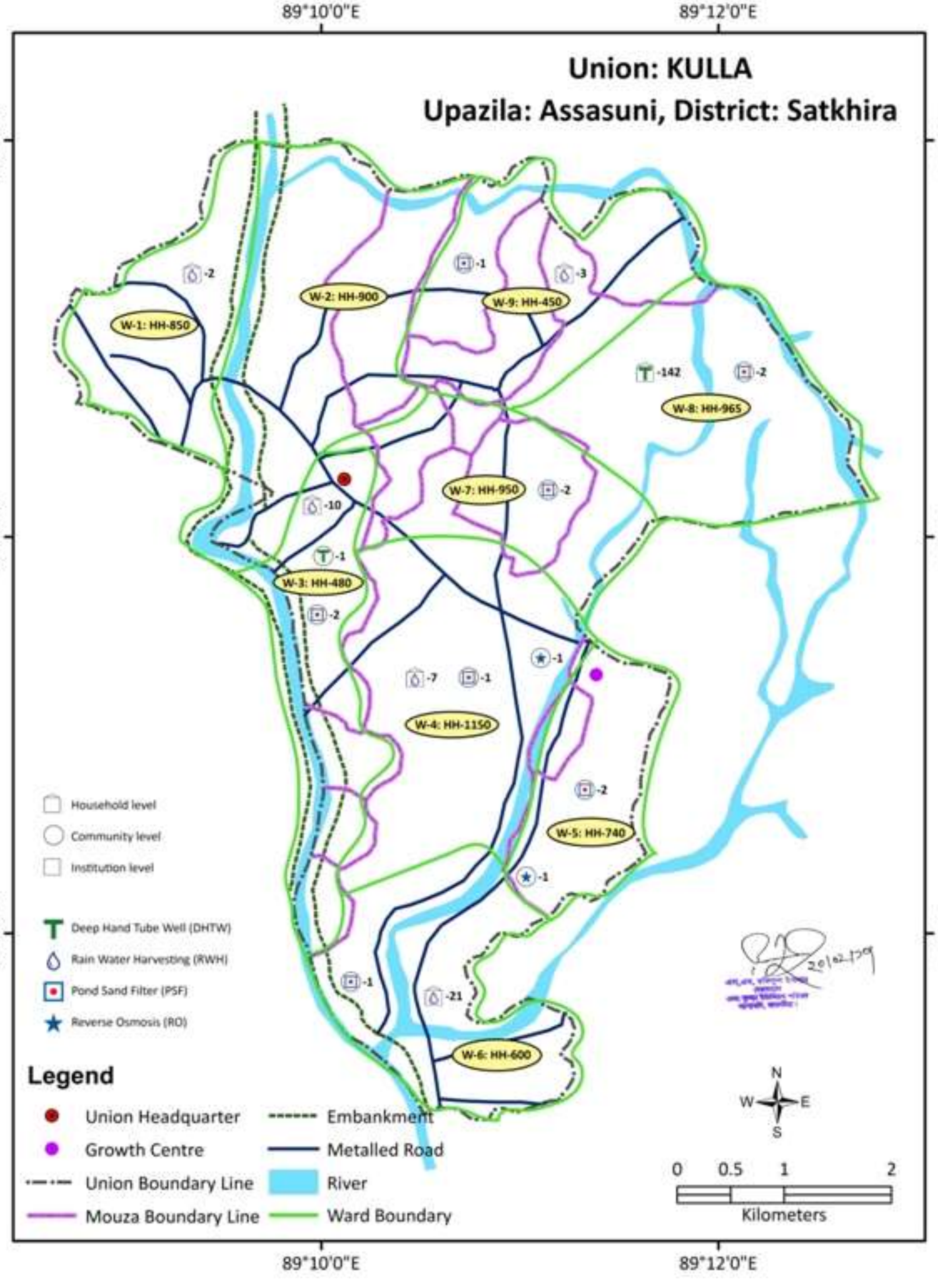


Figure 53: Map of existing drinking water technologies of Kulla Union

Water access: Table 2 shows access to water in Kulla Union with the three target wards highlighted in yellow.

Table 71: Time, distance and cost to collect water in Kulla Union

Ward No.	Number of Village	Number of HH	Women headed household	Distance to collect water (km)	Time required (hr)	Estimated cost per liter (Tk.)
1	1	651	20	3	0.83	1
2	2	1,034	30	3.5	1	1
3	1	468	20	2	0.58	1
4	2	1,034	0	1.5	0.67	0
5	2	603	0	1.5	1.5	0
6	6	566	0	1	0.67	0
7	2	462	50	1.5	1.5	0.5
8	3	603	0	1	0.84	0
9	2	468	0	1.5	0.75	0
Total	**21**	**5,889**	**120**			

Table 2 depicts a clear picture of existing water supply situation of Kulla Union as obtained from PRA session at the ward level. People are traditionally used to drink rainwater as Kulla is in general salinity affected and the safe water sources are very scarce. The fresh ground water layer is not available anywhere in the Union. There is water crisis in the dry season and the people especially the women have to travel 1-3.5 km to collect drinking water from the community based safe drinking water options or fresh ponds. The situation is very critical in ward number 2 and 3 where people have to collect drinking water from 3-3.5 km distance by travelling or through Van drivers. This makes the lives of the women particularly the women headed 120 households' miserable.

3. Impacts of climate change on water sources, supply and access

Safe drinking water is an important health indicator and climate change has affected a large population in the coastal districts of Bangladesh in terms of availability of safe water. Hence, consideration of possible impacts of climate change on water sources is of prime importance while selecting appropriate technologies in coastal area. A review of available information from secondary sources on sea level rise and natural hazards, and their impacts on water sources have been presented in this section.

3.1. Sea level rise

The salinity intrusion process is very difficult to identify because of the complexity of hydrogeology of the costal aquifer in Bangladesh. High salinity in groundwater was reported by the people of Kulla Union during the study. According to information provided by Bangladesh Water Development Board[104], the groundwater salinity in Kulla Union varies from 4,000 to 5,500 µS/cm.

[104] *Bangladesh Water Development Board, 2013; Mathematical Modelling Study on Saline Water Intrusion to Assess Salinity Intrusion, Salinity Level, Sea Level Ris Management Information System (MIS) : Package – 2, The Climate Change Trust Fund (CCTF) Project, Ministry of Environment and Forest.*

3.2. Natural hazards and tidal surges

The effect of 'Aila' and saltwater intrusion due to sea level rise on surface water sources, e.g., ponds, left a very limited number of fresh water ponds as drinking water source for people living in many villages. According to a study of Bangladesh Water Development Board[3], surface water salinity varies from 2,000 to 3,000 µS/cm in this area.

4. Proposed climate resilient water technologies

The potential of different types of water sources were analyzed in the two target wards. This information was fed in to the selection process of water technologies to meet the needs of the target population. Current and projected availability and quality of groundwater, surface water, and rainwater were considered in the local context based on available data and information during the analysis. Four types of water technologies are proposed for the three target wards in the Kulla Union:

- Household based rainwater harvesting system – for individual households
- Community-scale rainwater harvesting system – for 25 and 50 households based on roof catchment size
- Institution-scale rainwater harvesting system – for 75 and 100 households based on roof catchment size
- Community-based pond water treatment system (Sky-hydrant)

The available community and institution buildings with a roof area suitable for rainwater harvesting are shown in Table 3.

Table 72: Existing community and institutional buildings as potential source of Rain Water Harvesting Systems in Kulla Union

Ward	Name of the Building	Site Category	Building Condition[105]	Roof area (m^2)	Tank Size
5	114 No. Arar Gobindopur Govt. Primary School	Community	Good	161	Medium
6	Gabtola Govt. Primary School and Cyclone Shelter	Community	Good	323	Medium
6	Gabtola High School	Community	Good	135	Small
9	143 No. Uttor Mushisa Danga Govt. Primary School	Community	Good	161	Medium
9	31 No. Mushisa Danga Govt. Primary School	Community	Good	161	Medium
9	Mushisa Danga Collegiate School (Building 1)	Institution	Good	268	Combined (One Large and One Very Large)
9	Mushisa Danga Collegiate School (Building 2)	Institution	Good	185	

Table 4 shows the household data and proposed technologies following the methodology described in Chapter 7 of the synthesis report with a design target of 2 litres of safely managed drinking water per person per day. The forecast population growth for Kulla Union is positive. The Target Beneficiary Households in Table 4 was used for the basis of

[105] Building condition of "good" means that the roof is suitable for rainwater harvesting with minor roof repairs. "Moderate" meas the roof and building both need minor treatment and retrofit. "Bad" means major repairs of roof and building required.

design of the required water technology solutions.. There are 454 households with existing functioning year-round improved water supplies in the target wards, representing 27.73% of the households in these wards.

Table 73: Proposed technology based on number of households for Kulla Union

Ward No.	Number of HHs	Baseline Coverage (non-saline)	Target Beneficiary Households (100%of supply gap)	Proposed Technology										
				HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
					in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
					Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
5	603	350	253	103	-	1	-	2	-	-	-	-	-
6	566	66	500	125	1	1	-	2	-	-	-	-	1
9	468	38	430	86	-	2	-	2	1	1	-	-	-
Total	**1,637**	**454**	**1,183**	**314**	**1**	**4**	**-**	**6**	**1**	**1**	**-**	**-**	**1**

Table 4 shows a total of eleven community-scale RWHs and two institution-scale RWHS. The 2016 building database covers five of the community-scale RWHS and all institution-scale RWHS as shown in Table 3. The five remaining community-scale RWH are assumed to have at least a moderate roof condition of 150m² in area (two in ward 5, 6 and 9 each). One pond water treatment system has been proposed in ward 6 of this Union. The key site specific data for the two institution-scale RWH tanks is summarised in Table 74.

Table 74: Site specific data for the institution-scale RWH tanks

Name of the Building	**Roof area (m²)**	**Roof material**	**Area available for RWH tank (m²)**	**Roof Shape**	**Height of wall under eaves (m)**	**Existing RWH on building?**	**Number of HHs within 1km**
Mushisa Danga Collegiate School (Building 1)	268	Reinforced Cement Concrete (RCC)	148	Slope	3.65	No	400-500 approx.
Mushisa Danga Collegiate School (Building 2)	185	Reinforced Cement Concrete (RCC)	232	Slope	6.71	No	400-500 approx.

5. Estimated budget for the proposed water technologies

The capital investment cost for the proposed water technologies in three wards of Kulla Union is provided in Table 6.

Table 75: Budget for Capital Costs in Kulla Union

Ward No.	Budget (BDT)									
	HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
		in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
		Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
5	3,912,455	-	1,529,940	-	3,252,479	-	-	-	-	-
6	4,748,125	959,416	1,529,940	-	3,252,479	-	-	-	-	1,230,500
9	3,266,710	-	3,059,879	-	3,252,479	2,114,427	2,686,503	-	-	-
Total	**11,927,290**	**959,416**	**6,119,758**	**-**	**9,757,437**	**2,114,427**	**2,686,503**	**-**	**-**	**1,230,500**

Union Report on
Climate Resilient Water Infrastructure

Union :	**Lata**
Upazila :	**Paikgacha**
District :	**Khulna**

Reporting Date: August 15, 2017

6. A demographic, socioeconomic, and geo-physical overview of the Union

Lata union of Paikgacha Upazila, Khulna district is surrounded by Magurkhali union in the north, Sholadana union in the south, Lata union in the east and kapilmoni union in the west. A base map of Lata Union is provided in Figure 1. The base map shows the following:

- Wards in yellow with boundaries shown by dashed lines
- Polder embankment locations
- Major rivers and minor rivers/canals
- Settlements in grey
- Smaller index maps showing the location of the union within the Upazilla and the District

The total area of the union is 47 sq.km. The union is situated at a distance of 40 km from Paikgacha Upazilla HQ. The union is blessed with a number of rivers which flow through this union. These are Gunkhali, Betangi, Nora, Haria, Poda and Ulubunia.

Demographics: As per Local Government Division population data (2016), the population of Lata was estimated at 10,856 (F: 5,506 and M: 5,350) population and 2,651 households. The ward wise population is presented in Table 1. This assessment and the proposed water solutions are based on the more recent estimate of the population.

Table 76: Ward wise population and household of Lata Union

Ward No	Village number	Number of HH		Population	
			F	M	Total
1	2	296	655	686	1,341
2	3	341	682	788	1,470
3	3	208	453	424	877
4	3	313	605	500	1,105
5	3	265	622	575	1,197
6	2	240	489	598	1,087
7	1	264	623	510	1,133
8	4	384	802	702	1,504
9	2	340	575	567	1,142
Total	**23**	**2,651**	**5,506**	**5,350**	**10,856**

As per Bangladesh National Information Portal of Lata Union, there are there are 13 Primery schools, 4 High schools and 1 Madrasha. During PRA session, the availability of full electricity was identified in Ward number 1, 3, 4, 5 and 9 and partial electricity in Ward number 2 and 8. There is no ethnic minority household in Lata[106].

Target Wards: The target wards were selected based on observed and projected salinity levels, poverty index and vulnerability to saline intrusion due to low elevation (the methodology is described in detail in Section 7.3 of the synthesis report). The target wards in the Lata Union are Wards 3 and 4. There are 521 households in these target wards, representing 19.65% of the Lata Union households. Lata Union sits in

[106] PRA

the Paikgacha sub-district, therefore 100% of the households who are without access to improved water supplies are targeted.

Base Map : Lata Union, Paikgacha, Khulna

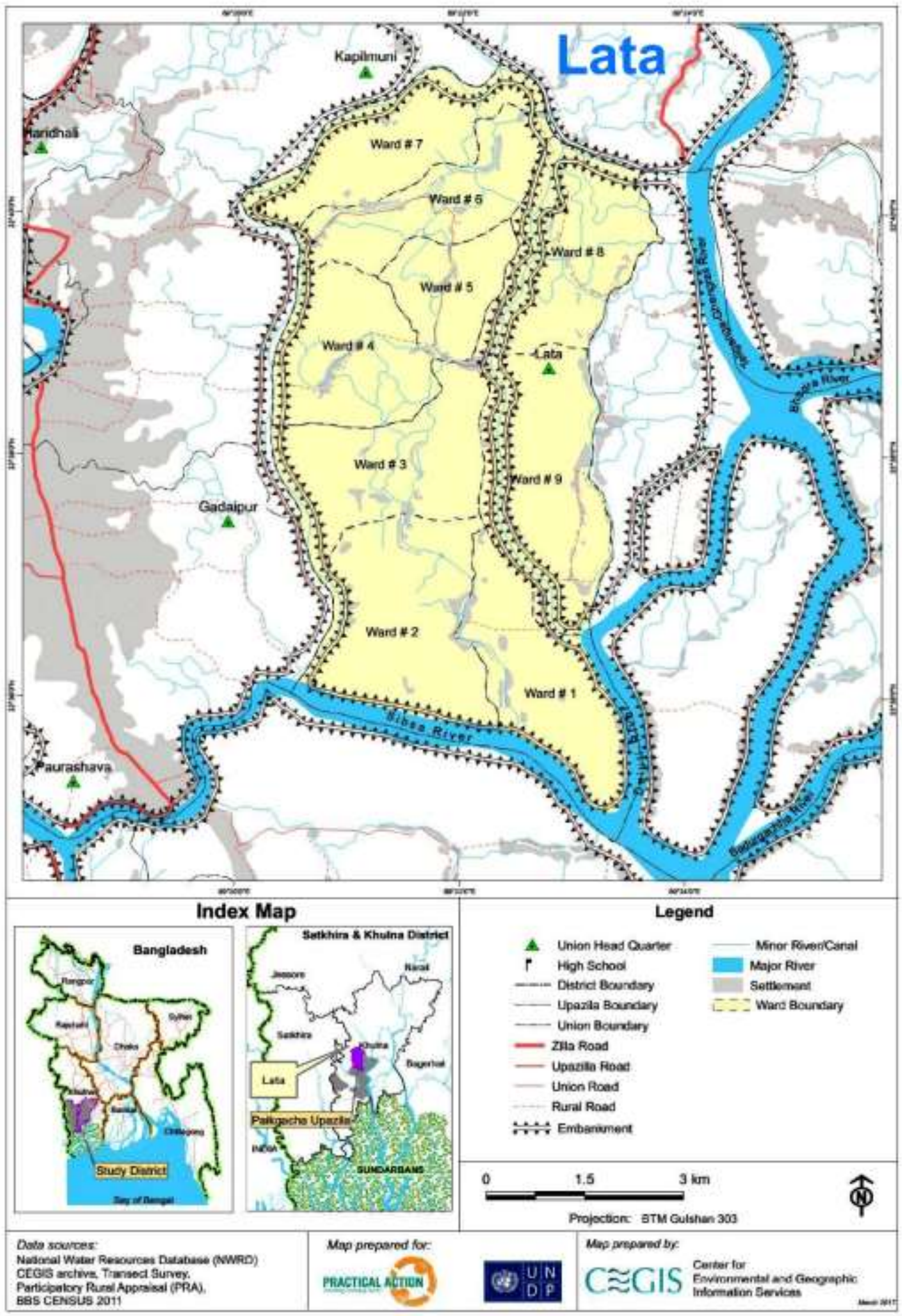


Figure 54: Base map of Lata Union in Paikgacha Upazila under Khulna district

7. Mapping of functional and potential drinking water sources, supply, and access

Water sources: Lata union has 23 villages having a total population of 10,856 of which male is 5,350 and the female is 5,506. The number of total households in the union is 2,651. From analyses of the information collected during the PRA process and mapping done by the technical team, the baseline current safe year round drinking water sources for Lata Union were identified. The baseline for the existing safe drinking water supply is based on the people supplied by non-saline drinking water sources (e.g. deep tube wells rather than shallow tube wells) that provide year round access of at least 2 LCPD drinking water to recipients. The baseline does not include water sources that are being used but are saline, e.g. shallow tube wells are not included in the baseline. There are 81 RWH units spread over all wards except ward number 2 and only one PSF in ward number 1. All of these existing water facilities cover 101 households, which is only 3.81% of the total households in the union. There is no fresh ground water layer and that is why no DHTW is feasible in this union. So this union is a water stressed area and there is a huge demand for drinking water supply in Lata union.

Baseline Coverage: Figure 2 shows at a glance the baseline drinking water coverage with functional non-saline sources that is prepared based on the findings of PRA mapping exercise done in Lata union.

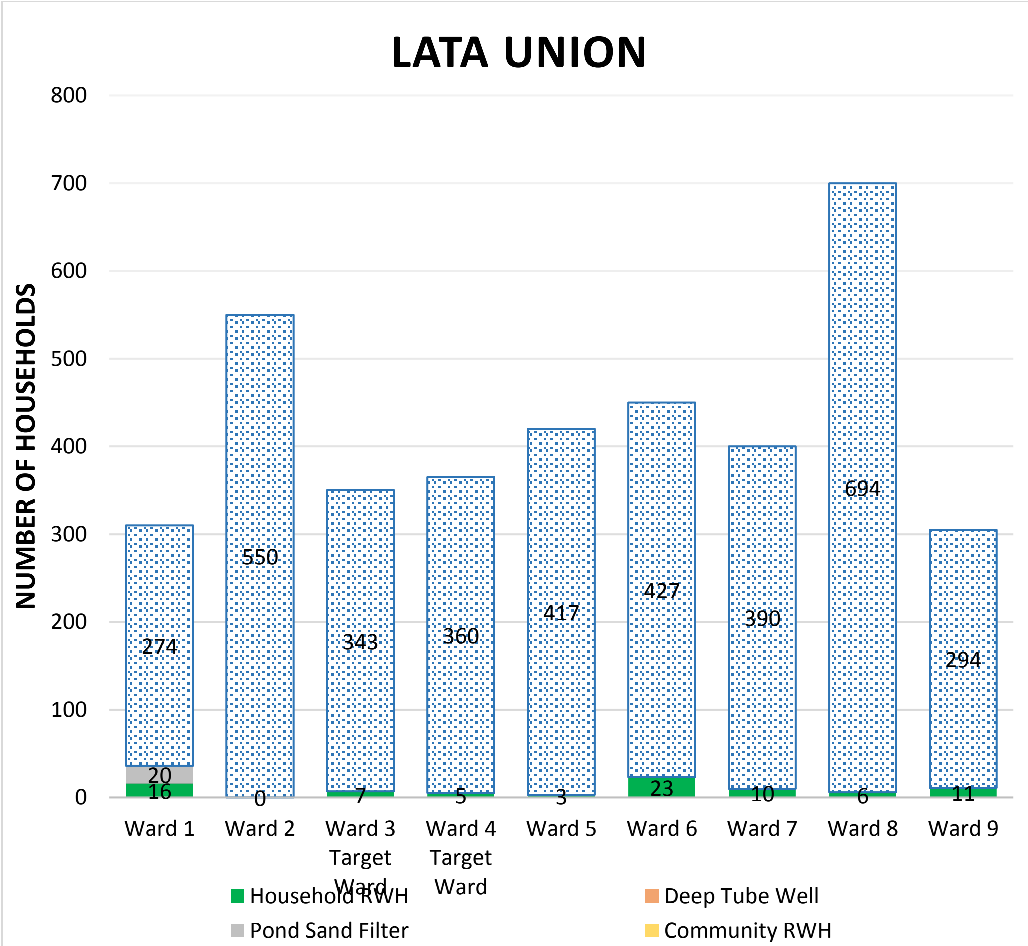


Figure 55 Baseline non-saline drinking water coverage for Lata union

Figure 3 shows a map of existing safe non-saline drinking water technologies in Lata Union.

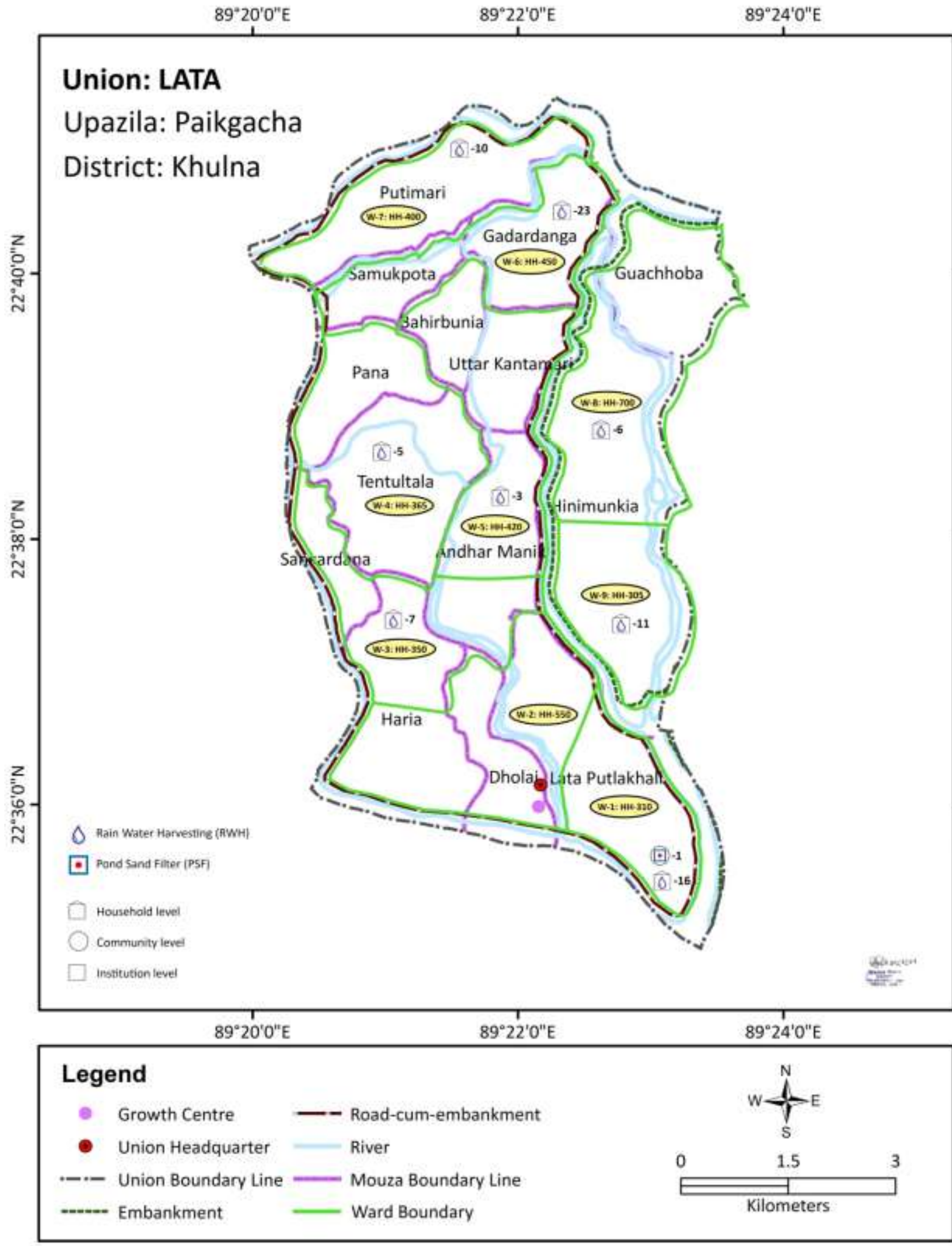


Figure 56: Map of existing non-saline drinking water technologies of Lata union

Water access: Table 2 shows access to water in Lata Union with the two target wards highlighted in yellow.

Table 77: Time, distance and coast to collect water and proposed technology by community people of Lata union

Ward Number	Number of village	Total Number of HH	Women headed household	Distance to collect water	Time require	Estimated Cost per Liter
				km	hr	(Tk.)
1	2	296	35	5	3	0.2
2	3	341	2	4	2	0.5
3	3	208	25	6	1.5	2.5
4	3	313	20	13	1.5	2.5
5	3	265	25	13	1.8	2.5
6	2	240	20	5	3	1
7	1	264	25	3	3	2
8	4	384	60	1	1.5	0.8
9	2	340	2	2.5	3	0.75
Total	**23**	**2,651**	**214**			

Table 2 depicts a clear picture of existing water supply situation of Lata union as obtained from PRA session at the ward level. Peoples are traditionally used to drink rainwater as Lata is in general salinity affected and the safe water sources are very scarce. The fresh ground water layer is not available anywhere in the union. There is water crisis in the dry season and the people especially the women have to travel 1-6 km to collect drinking water from the community based safe drinking water options or fresh ponds. The situation is very critical in ward number 4 and 5 where the people have to collect safe drinking water from a long distance 13 km away directly by travelling or through Van drivers. This makes the lives of the women particularly the women headed 214 households' miserable. During the PRA session, the Ward level people proposed to install 49 new DTWs (ward number 1, 4 and 5), 34 new PSFs (ward number 3, 4, 5, 6 and 7), rehabilitate only one non-functional PSFs (ward number 6), 48 community based RWH units spread over all ward and 4 institution based safe water schemes (RWH) at ward number 3, 5, and 7.

8. Impacts of climate change on water sources, supply and access

Safe drinking water is an important health indicator and climate change has affected a large population in the coastal districts of Bangladesh in terms of availability of safe water. Hence, consideration of possible impacts of climate change on water sources is of prime importance while selecting appropriate technologies in coastal area. A review of available information from secondary sources on sea level rise, rainfall and natural hazards, and their impacts on water sources have been presented in this section.

8.1. Sea level rise

High salinities both in monsoon and dry season in the South-West coast and along Passur-Shibsa system of this area are associated with the decreasing upstream freshwater flow as well as siltation of the major channels[1]. High salinity in groundwater was reported by the people of Lata union during the study. According to information provided by Bangladesh Water Development Board, the groundwater salinity in Lata union varies from 3,500 to 4,000 µS/cm.

8.2. Natural hazards and tidal surges

According to local people, the coastal embankment was badly damaged during the cyclone Aila causing intrusion of salt water into the fresh water pond in the union. The effect of Aila and saltwater intrusion due to sea level rise on surface water sources, e.g., ponds, left a very limited number of fresh water ponds as drinking water source for people living in many villages in this union. According to information provided by Bangladesh Water Development Board, surface water salinity varies from 500 to 1,000 µS/cm in this area. In absence of necessary protection measures, these sources could further be affected by tidal surges and subsurface movement of saltwater due to sea level rise.

9. Proposed climate resilient water technologies

The potential of different types of water sources were analyzed in the two target wards. This information was fed in to the selection process of water technologies to meet the needs of the target population. Current and projected availability and quality of groundwater, surface water, and rainwater were considered in the local context based on available data and information during the analysis. Three types of water technologies are proposed for the two target wards in the Lata Union (there are no known ponds available in the three target wards):

- Household based rainwater harvesting system – for individual households
- Community-scale rainwater harvesting system – for 25 and 50 households based on roof catchment size
- Institution-scale rainwater harvesting system – for 75 and 100 households based on roof catchment size

The available community and institution buildings with a roof area suitable for rainwater harvesting are shown in Table 3.

Table 78: Existing community and institutional buildings as potential source of Rain Water Harvesting Systems in Lata Union

Ward	Village	Site Category	Building Condition[107]	Roof area (m²)	Tank Size
3	13 no. Hariakhashmohol govt. primary school	Institution	Good	216	Medium
3	Chochiarbond Bashonti Mundir	Community	Moderate	75	Small

[107] Building condition of "good" means that the roof is suitable for rainwater harvesting with minor roof repairs. "Moderate" means the roof and building both need minor treatment and retrofit. "Bad" means major repairs of roof and building required.

Ward	Village	Site Category	Building Condition[107]	Roof area (m²)	Tank Size
4	Pana New Govt. Primary School	Institution	Good	219	Medium

Table 4 shows the household data and proposed technologies following the methodology described in Chapter 7 of the synthesis report with a design target of 2 litres of safely managed drinking water per person per day. The forecast population growth for Lata Union is negative. The Target Beneficiary Households in Table 4 was used for the basis of design of the required water technology solutions. There are 12 households with existing functioning improved water supplies in the target wards, representing 2.3% of the households in these wards.

Table 79: Proposed technology based on number of households for Lata Union

Ward No.	# of HH	Baseline Coverage (non-saline)	Target Beneficiary Households (100% of supply gap)	Proposed Technology									
				HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
					in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
					Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
3	208	7	201	51	-	1	-	2	-	-	-	-	-
4	313	5	308	158	-	1	-	2	-	-	-	-	-
Total	**521**	**12**	**509**	**209**	**-**	**2**	**-**	**4**	**-**	**-**	**-**	**-**	**-**

Table 4 shows a total of six community-scale RWHs and no institution-scale RWHS. The 2016 building database covers three of the community-scale RWHs as shown in Table 3. The three remaining community-scale RWH are assumed to have at least a moderate roof condition of 150m² in area.

There are no institution-scale RWH tanks in Lata Union.

10. Estimated budget for the proposed water technologies

The capital investment cost for the proposed water technologies in three wards of Lata Union is provided in Table 5.

Table 80: Capital Investment Cost for Water in Lata Union

Ward No.	Budget (BDT)			
		Community-scale RWHS	Institution-scale RWHS	

	HH based RWHS	in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		Community based Pond Water Treatment System (Sky-hydrant)
		Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
3	1,937,235	-	1,529,940	-	3,252,479	-	-	-	-	-
4	6,001,630	-	1,529,940	-	3,252,479	-	-	-	-	-
Total	**7,938,865**	**-**	**3,059,879**	**-**	**6,504,958**	**-**	-	-	-	-

Union Report on
Climate Resilient Water Infrastructure

Union :	**Maharajpur**
Upazila :	**Koyra**
District :	**Khulna**

Reporting Date: 15 August, 2017

11. Demographic, socioeconomic, and geo-physical overview of the Union

Maharajpur Union of Koyra Upazila, Khulna district is adjacent of Koyra Upazila, it is located on North of the Upzila. Bagali Union on North, Koyra Sadar Union and Upazila on South, Sundarban Forest on East and Kapataksa River flows on West. A base map of Maharajpur Union is provided in Figure 1. The base map shows the following:

- Wards in yellow with boundaries shown by dashed lines
- Polder embankment locations
- Major rivers and minor rivers/canals
- Settlements in grey
- Smaller index maps showing the location of the Union within the Upazila and the district

Demographics: As per Local Government Division population data (2016), the population of Maharajpur was estimated at 31,068 (F: 15,714 and M: 15,354) population and 6,128 households. The ward wise population is presented in Table 1. This assessment and the proposed water solutions are based on the more recent estimate of the population by Local Government Division (LGD).

Table 81: Ward wise population and household of Maharajpur Union

Ward No.	Number of Village	Number of HH	Population		
			Female	Male	Total
1	1	1,104	2,984	2,922	5,906
2	2	739	1,987	1,963	3,950
3	4	583	1,456	1,393	2,849
4	2	698	1,758	1,711	3,469
5	3	534	1,342	1,300	2,642
6	3	715	1,752	1,807	3,559
7	3	624	1,577	1,496	3,073
8	1	582	1,474	1,426	2,900
9	5	549	1,384	1,336	2,720
Total	**24**	**6,128**	**15,714**	**15,354**	**31,068**

As per Bangladesh National Information Portal[108] of Maharajpur Union, full electricity coverage was identified only in one ward (number 8), partially available in three wards (ward 4, 7 and 9) and not found in remaining wards of the Union.

Target Wards: The target wards were selected based on observed and projected salinity levels, poverty index and vulnerability to saline intrusion due to low elevation (the methodology is described in detail in Section 7.3 of the synthesis report). The target wards in the Maharajpur Union are Wards 2, 7 and 8. There are 1,945 households in these target wards, representing 31.74% of the Maharajpur Union households. Maharajpur Union sits in the Koyra sub-district, therefore 50% of the households who are without access to improved water supplies are targeted.

[108] http://www.bangladesh.gov.bd/

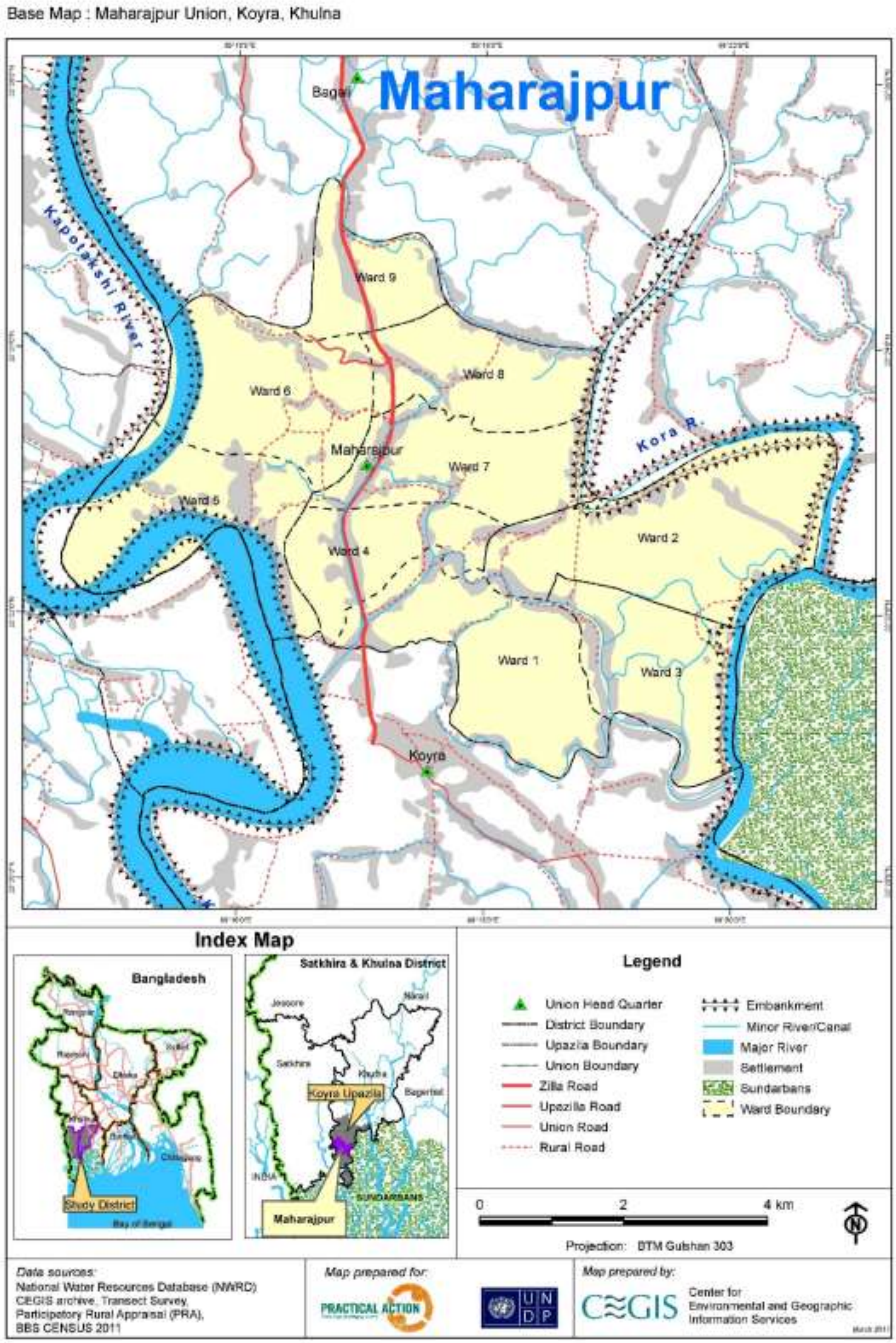


Figure 57: Base map of Maharajpur Union in Koyra Upazila under Khulna district

12. Mapping of functional and potential drinking water sources, supply, and access

Water sources: From analyses of the information collected during the PRA process and mapping done by the technical team, the baseline current safe year round drinking water sources for Maharajpur Union were identified. The baseline for the existing safe drinking water supply is based on the people supplied by non-saline drinking water sources (e.g. deep tube wells rather than shallow tube wells) that provide year round access of at least 2 LCPD drinking water to recipients. The baseline does not include water sources that are being used but are saline, e.g. shallow tube wells are not included in the baseline. There are 88 RWH units spread over all wards except ward 6 which are supplying water year-round, but no PSF in this Union. There are also 109 deep tube wells (50 household based and 59 community based) distributed in wards 1 to 8. All of these existing water facilities cover 831 households, which is only 13.56% of the total households in the Union. So this Union is a water stressed area and there is a huge demand for drinking water supply in Maharajpur Union.

Baseline Coverage: Figure 2 shows at a glance the baseline drinking water coverage with functional non-saline sources that is prepared based on the findings of PRA mapping exercise done in Maharajpur Union.

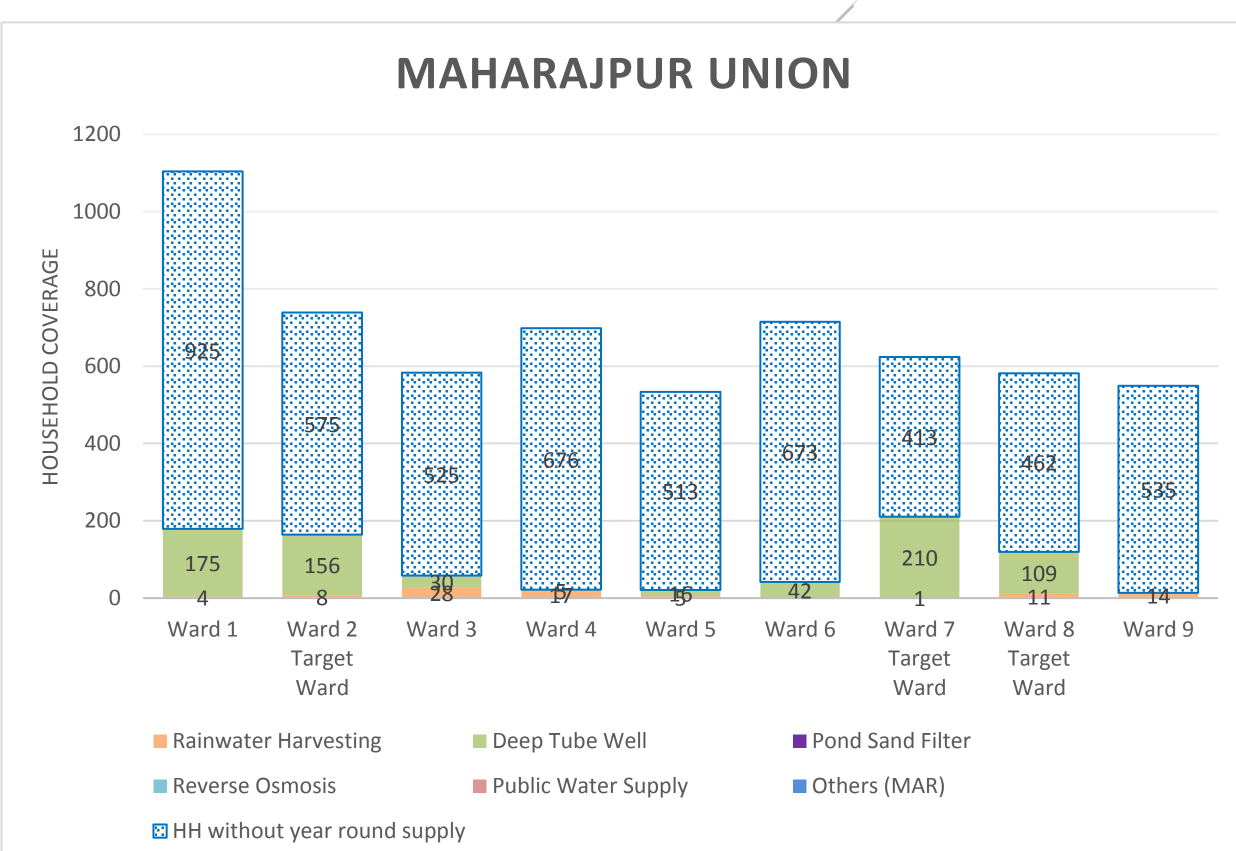


Figure 58 Baseline non-saline drinking water coverage for Maharajpur Union

Figure 3 shows a map of existing safe non-saline drinking water technologies in Maharajpur Union.

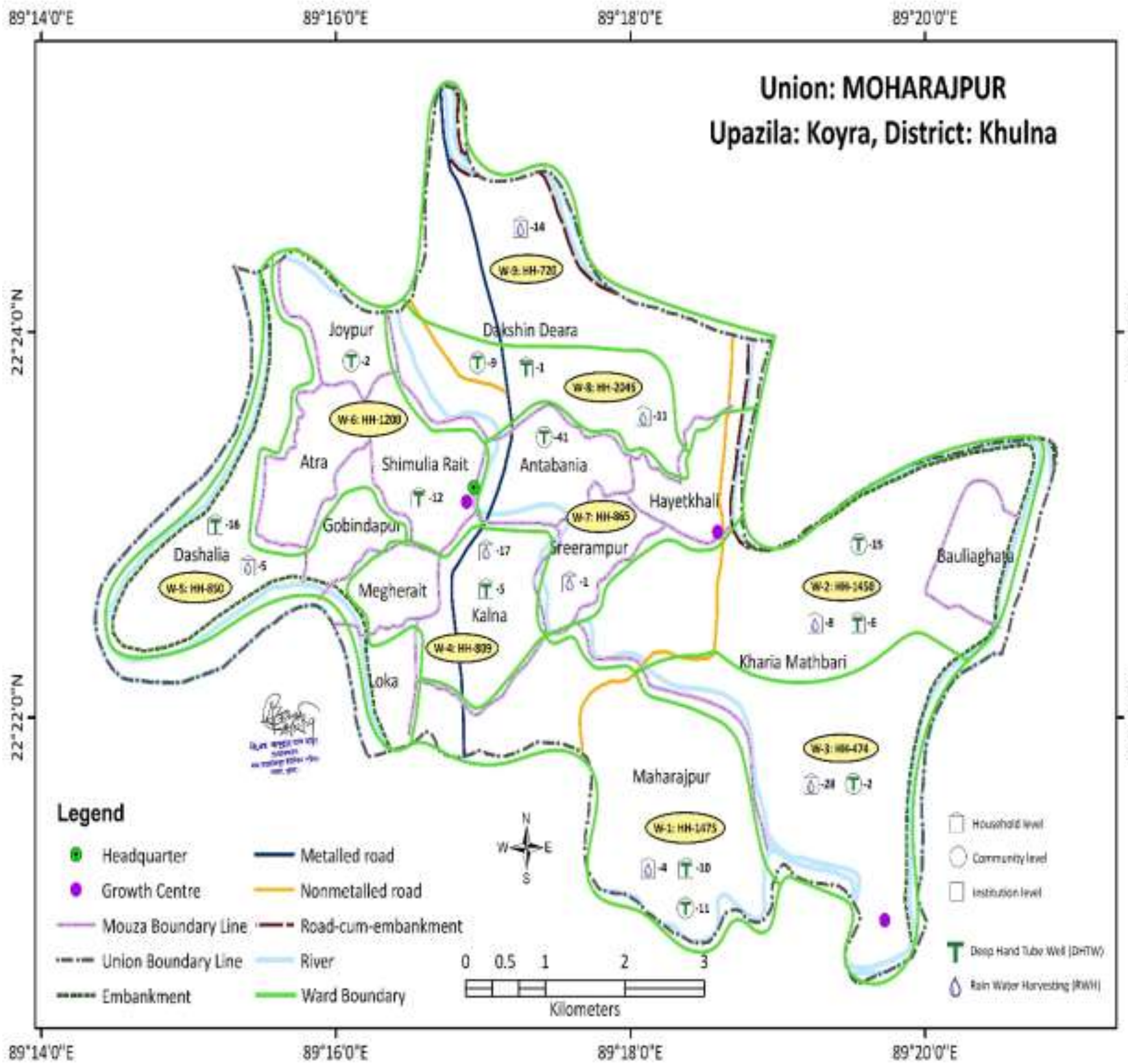


Figure 59: Map of existing non-saline drinking water technologies of Maharajpur Union

Water access: Table 2 shows access to water in Maharajpur Union with the three target wards highlighted in yellow.

Table 82: Time, distance and cost to collect water by community in Maharajpur Union

Ward No.	Number of Village	Number of HH	Women headed household	Distance to collect water (km)	Time required (hr)	Estimated cost per liter (Tk.)
1	1	1,104	120	2	0.67	
2	2	739	160	3	1	
3	4	583	60	3	1	
4	2	698	20	2	2	0.5
5	3	534	25	2	2.5	0.25
6	3	715	10	1	1.5	0.25

Ward No.	Number of Village	Number of HH	Women headed household	Distance to collect water (km)	Time required (hr)	Estimated cost per liter (Tk.)
7	3	624	30	0.25	0.5	
8	1	582	115	0.25	0.33	0.1
9	5	549	140	3	2	0.33
Total	**24**	**6,128**	**680**			

Table 2 depicts a clear picture of existing water supply situation of Maharajpur Union as obtained from PRA session at the ward level. Peoples are traditionally used to drink rainwater as Maharajpur is in general salinity affected and the safe water sources are very scarce. The fresh ground water layer is not available anywhere in the Union. There is water crisis in the dry season and the people especially the women have to travel 0.25-3 km to collect drinking water from the community based safe drinking water options or fresh ponds. The situation is very critical in wards 2, 3 and 9 where people have to collect drinking water from 3 km distance by travelling or through Van drivers. This makes the lives of the women particularly the women headed 680 households' miserable.

13. Impacts of climate change on water sources, supply and access

Safe drinking water is an important health indicator and climate change has affected a large population in the coastal districts of Bangladesh in terms of availability of safe water. Hence, consideration of possible impacts of climate change on water sources is of prime importance while selecting appropriate technologies in coastal area. A review of available information from secondary sources on sea level rise and natural hazards, and their impacts on water sources have been presented in this section.

13.1. Sea level rise

The salinity intrusion process in groundwater is very difficult to identify because of the complexity of hydrogeology of the costal aquifer in High salinity in groundwater was reported by the people of Maharajpur Union during the PRA process as well High salinity in groundwater was reported by the people of Maharajapur Union during the study. According to information provided by Bangladesh Water Development Board[109], the groundwater salinity in Maharajapur Union varies from 5,000 to 5,500 µS/cm.

13.2. Natural hazards and tidal surges

According to local people, the coastal embankment was badly damaged during the cyclone Aila causing intrusion of salt water into the fresh water pond in the Union. The effect of Aila and saltwater intrusion due to sea level rise on surface water sources, e.g., ponds, left a very limited number of fresh water ponds as drinking water source for people living in many villages in this Union. According to information provided by Bangladesh Water Development Board[2], surface water salinity varies from 10,000 to 12,000 µS/cm in this area. In absence of necessary protection measures, these sources could further be affected by tidal surges and subsurface movement of saltwater due to sea level rise.

[109] *Bangladesh Water Development Board, 2013; Mathematical Modelling Study on Saline Water Intrusion to Assess Salinity Intrusion, Salinity Level, Sea Level Ris Management Information System (MIS) : Package – 2, The Climate Change Trust Fund (CCTF) Project, Ministry of Environment and Forest.*

14. Proposed climate resilient water technologies

The potential of different types of water sources were analyzed in the three target wards. This information was fed in to the selection process of water technologies to meet the needs of the target population. Current and projected availability and quality of groundwater, surface water, and rainwater were considered in the local context based on available data and information during the analysis. Three types of water technologies are proposed for the three target wards in the Maharajpur Union.

- Household based rainwater harvesting system – for individual households
- Community-scale rainwater harvesting system – for 25 and 50 households based on roof catchment size
- Community-based pond water treatment system (Sky-hydrant)

The available community and institution buildings with a roof area suitable for rainwater harvesting are shown in Table 3.

Table 83: Existing community and institutional buildings as potential source of Rain Water Harvesting Systems in Maharajpur Union

Ward	Name of the Building	Site Category	Building Condition[110]	Roof area (m²)	Tank Size
2	Mothbari Baolioghata Govt Primary School	Community	Good	261	Medium
2	Mothbari Santimoyee Govt Primary School cum Cyclone Center	Community	Good	342	Medium
2	Mothbari Serazi Bohumukhi High School cum Cyclone Center (Building 1)	Community	Good	366	Medium
2	Mothbari Serazi Bohumukhi High School cum Cyclone Center (Building 2)	Community	Good	274	Medium
2	Mothbari Serazia Govt Primary School	Community	Good	187	Medium
2	Police Camp	Community	Good	349	Medium
7	Antabunia Baitul Aman Jame Masjid	Community	Moderate	86	Small
7	Khoria Govt Primary School	Community	Good	304	Medium
7	Moharazpur UP Office	Community	Moderate	351	Medium
7	Sreerampur Antabunia Govt primary School	Community	Moderate	123	Small
7	Sreerampur Jame Masjid	Community	Good	100	Small
8	Deara Antobunia Dakhil Madrasha (Building 1)	Community	Good	253	Medium
8	Deara Antobunia Dakhil Madrasha (Building 2)	Community	Good	125	Small
8	Deara Pantobunia Govt Primary School cum Cyclone Center	Community	Good	158	Medium
8	Jakaria Sikha Niketo	Community	Good	211	Medium
8	Mohrazpur Land Office	Community	Good	94	Small

Table 4 shows the household data and proposed technologies following the methodology described in Chapter 7 of the synthesis report with a design target of 2 litres of safely managed drinking water per person per day. The forecast population growth for Maharajpur Union is positive. The Target Beneficiary Households in Table 4 was used for the

[110] Building condition of "good" means that the roof is suitable for rainwater harvesting with minor roof repairs. "Moderate" meas the roof and building both need minor treatment and retrofit. "Bad" means major repairs of roof and building required.

basis of design of the required water technology solutions. There are 495 households with existing functioning improved water supplies in the target wards, representing 25.45% of the households in these wards.

Table 84: Proposed technology based on number of households for Maharajpur Union

Ward No.	Number of HHs	Baseline Coverage (non-saline)	Target Beneficiary Households (50% of supply gap)	Proposed Technology									
				HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
					in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
					Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
2	739	164	288	63	1	-	-	-	-	-	-	-	1
7	624	211	207	42	1	1	2	1	-	-	-	-	-
8	582	120	231	56	1	3	-	-	-	-	-	-	-
Total	**1,945**	**495**	**726**	**161**	**3**	**4**	**2**	**1**	**-**	**-**	**-**	**-**	**1**

Table 4 shows a total of ten community-scale RWHS and no institution-scale RWHS. The 2016 building database covers sixteen community-scale RWHs as shown in Table 3, from which ten sites can be selected. There are no institution-scale RWH tanks in Maharajpur Union but one pond water treatment system in ward 2 of the Union.

15. Estimated budget for the proposed water technologies

The capital investment cost for the proposed water technologies in three wards of Maharajpur Union is provided in Table 5.

Table 85: Budget for Capital Costs in Maharajpur Union

Ward No.	Budget (BDT)									
	HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
		in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
		Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
2	2,393,055	959,416	-	-	-	-	-	-	-	1,230,500
7	1,595,370	959,416	1,529,940	2,015,131	1,626,240	-	-	-	-	-
8	2,127,160	959,416	4,589,819	-	-	-	-	-	-	-
Total	**6,115,585**	**2,878,247**	**6,119,758**	**2,015,131**	**1,626,240**	**-**	**-**	**-**	**-**	**1,230,500**

Union Report on
Climate Resilient Water Infrastructure

Union :	**Tildanga**
Upazila :	**Dacope**
District :	**Khulna**

Reporting Date: August 15, 2017

16. Demographic, socioeconomic, and geo-physical overview of the Union

Tildanga Union of Dacope Upazila, Khulna district is located on front of Vadar river, on East Kamarkhola Union, on South Chara river and Sundarban. A base map of Tildanga Union is provided in Figure 1. The base map shows the following:

- Wards in yellow with boundaries shown by dashed lines
- Polder embankment locations
- Major rivers and minor rivers/canals
- Settlements in grey
- Smaller index maps showing the location of the Union within the Upazila and the district

Total area of this Union is 44.07 sq km. There are 12 of villages and three hat/bazars in this Union.

Demographics: As per Local Government Division population data (2016), the population of Tildanga was estimated at 17,006 (F: 8,176 and M: 8,830) population and 4,295 households. The ward wise population is presented in Table 1. This assessment and the proposed water solutions are based on the more recent estimate of the population by Local Government Division (LGD).

Table 86: Ward wise population and household of Tildanga Union

Ward No.	Number of Village	Number of HH	Population		
			Female	Male	Total
1	1	775	1,440	1,417	2,857
2	3	457	857	949	1,806
3	1	482	812	867	1,679
4	1	397	830	831	1,661
5	1	448	946	980	1,926
6	1	460	959	1,001	1,960
7	1	482	771	1,081	1,852
8	1	362	702	773	1,475
9	2	432	859	931	1,790
Total	**12**	**4,295**	**8,176**	**8,830**	**17,006**

As per Bangladesh National Information Portal[111] of Tildanga Union, there are 16 primary schools, 1 secondary school and 4 Madrassas in this Union. During PRA session, availability of electricity was identified in all wards of the Union.

Target Wards: The target wards were selected based on observed and projected salinity levels, poverty index and vulnerability to saline intrusion due to low elevation (the methodology is described in detail in Section 7.3 of the synthesis report). The target wards in the Tildanga Union are Wards 1 and 3 There are 1,257 households in these

[111] http://www.bangladesh.gov.bd/

target wards, representing 29.27% of the Tildanga Union households. Tildanga Union sits in the Tildanga sub-district, therefore 50% of the households who are without access to improved water supplies are targeted.

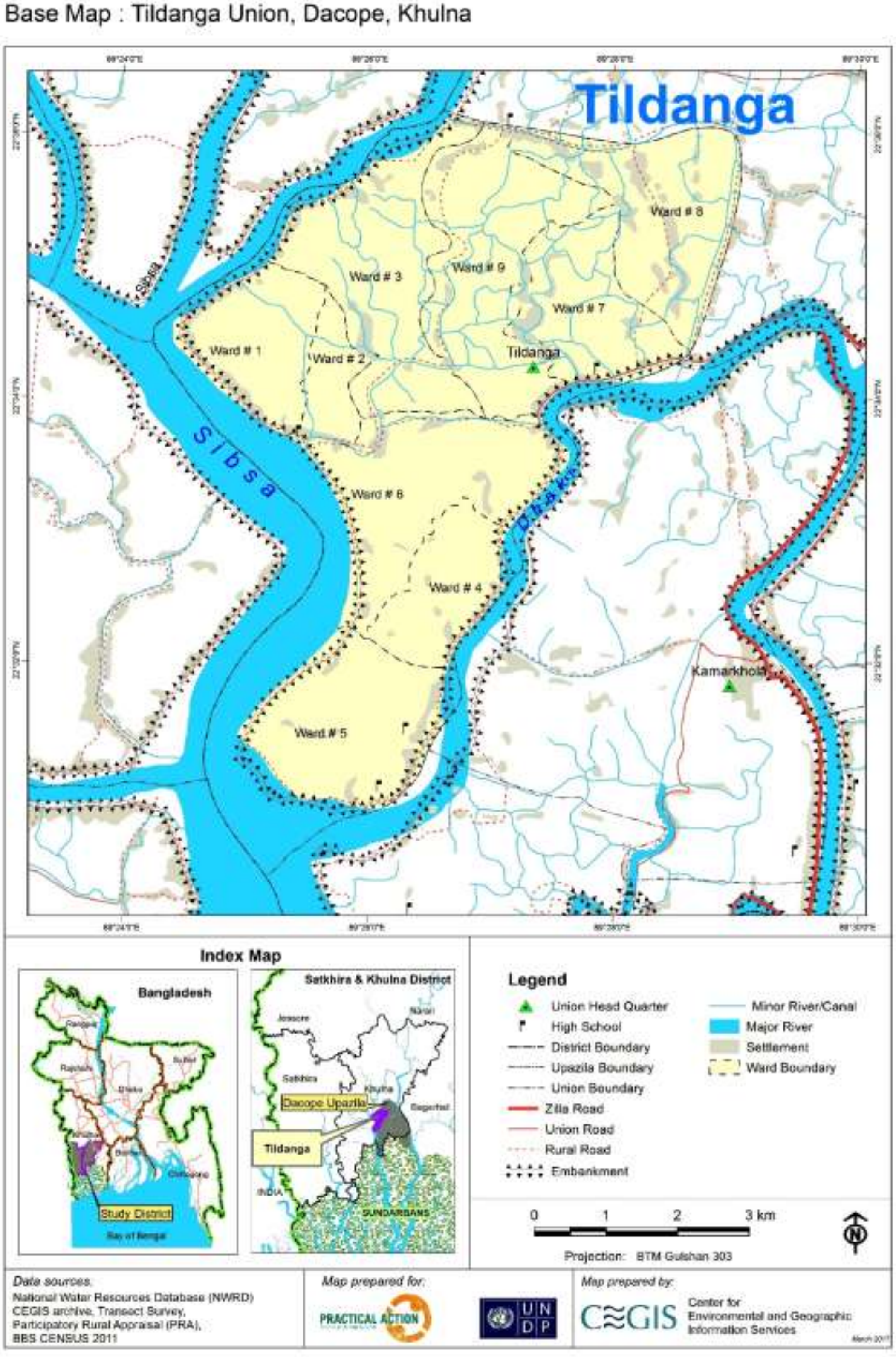


Figure 60: Base map of Tildanga Union in Dacope Upazila under Khulna district

17. Mapping of functional and potential drinking water sources, supply, and access

Water sources: From analyses of the information collected during the PRA process and mapping done by the technical team, the baseline current safe year-round drinking water sources for Tildanga Union were identified. The baseline for the existing safe drinking water supply is based on the people supplied by non-saline drinking water sources (e.g. deep tube wells rather than shallow tube wells) that provide year-round access of at least 2 LCPD drinking water to recipients. The baseline does not include water sources that are being used but are saline, e.g. shallow tube wells are not included in the baseline. There are 696 RWH units in this Union supplying water year-round, 1 functional PSF, 2 managed aquifer recharge System and 28 deep tube wells. All of these existing water facilities cover 1,217 households, which is only 28.34% of the total households in the Union. So this Union is a water stressed area and there is a huge demand for drinking water supply in Tildanga Union.

Baseline Coverage: Figure 2 shows at a glance the baseline drinking water coverage with functional non-saline sources that is prepared based on the findings of PRA mapping exercise done in Tildanga Union.

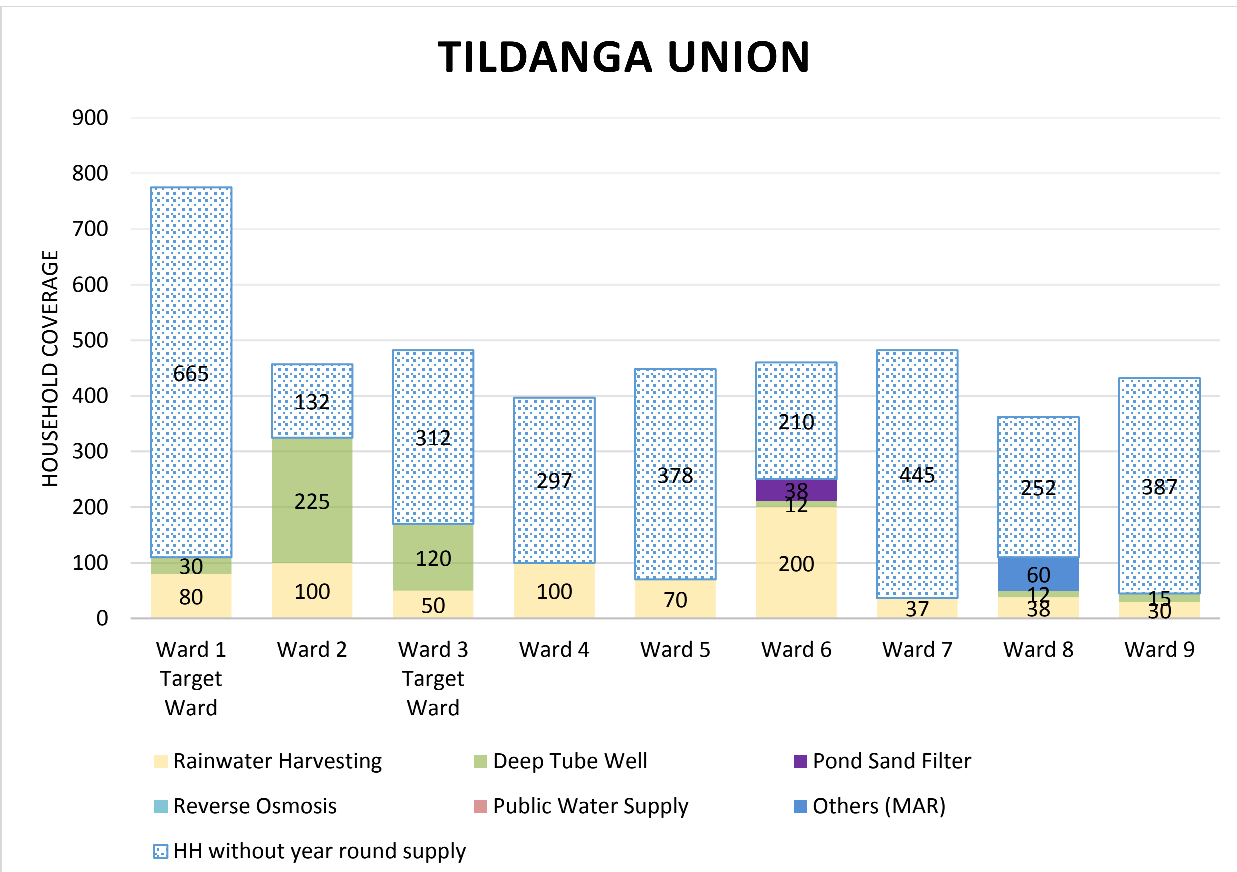


Figure 61: Baseline non-saline drinking water coverage for Tildanga Union

Figure 3 shows a map of existing safe non-saline drinking water technologies in Tildanga Union.

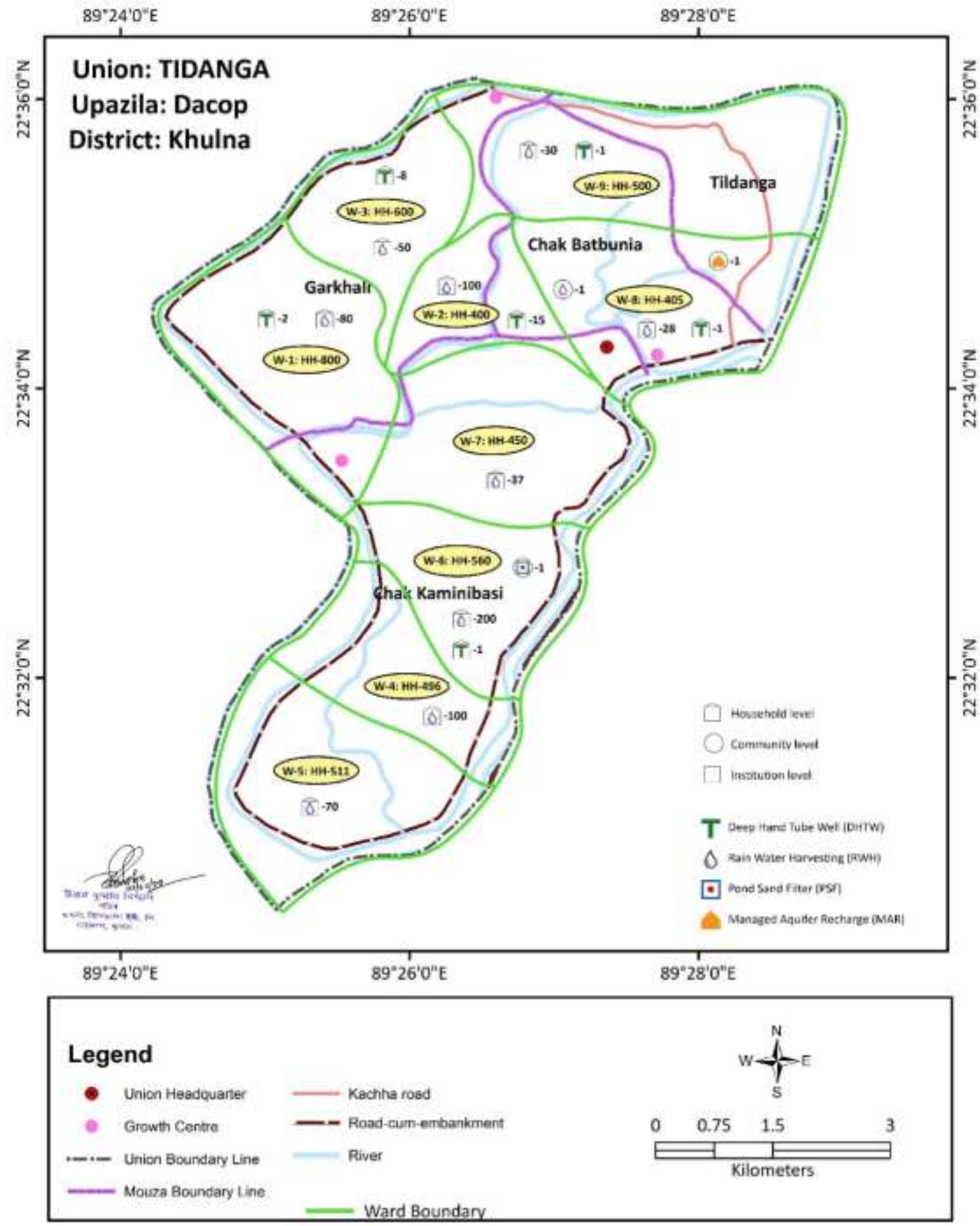


Figure 62 :Map of existing drinking water technologies of Tildanga Union

Water Access: Table 2 shows access to water in Tildanga Union with the two target wards highlighted in yellow.

Table 87: Time, distance and cost to collect water by community people of Tildanga Union

Ward No.	Number of Village	Number of HH	Women headed household	Distance to collect water (km)	Time required (hr)	Estimated cost per liter (Tk.)
1	1	775	15	2.5	1	1
2	3	457	15	0.15	0.5	
3	1	482	20	2	1	1
4	1	397	20	3	1	0.5
5	1	448	25	3	1.5	0.67
6	1	460	22	1.5	0.83	0.5
7	1	482	35	2	1	1
8	1	362	20	2.5	1.5	1
9	2	432	35	3	1.16	1
Total	**12**	**4,295**	**207**			

Table 2 depicts a clear picture of existing water supply situation of Tildanga Union as obtained from PRA sessions at the ward level. People are traditionally used to drink rainwater as Tildanga is in salinity affected area and the safe water sources are very scarce. There is water crisis in the dry season and people, especially women, have to travel up to 3 km to collect drinking water from the community based drinking water options. The situation is very critical in wards 4, 5 and 9 where people have to collect drinking water from 3 km distance by travelling or through Van drivers. This makes lives of the women particularly in the 207 women headed households' miserable.

18. Impacts of climate change on water sources, supply and access

Safe drinking water is an important health indicator and climate change has affected a large population in the coastal districts of Bangladesh in terms of availability of safe water. Hence, consideration of possible impacts of climate change on water sources is of prime importance while selecting appropriate technologies in coastal area. A review of available information from secondary sources on sea level rise and natural hazards, and their impacts on water sources have been presented in this section.

18.1. Sea level rise

High salinities both in monsoon and dry season in the South-West coast and along Passur-Shibsa system of this area are associated with the decreasing upstream freshwater flow as well as siltation of the major channels[112]. The salinity intrusion process in groundwater is very difficult to identify because of the complexity of hydrogeology of the costal aquifer in Bangladesh[1]. However, the findings from a World Bank[113] study on coastal aquifers of Bangladesh suggests that the direct impacts of sea-level rise on coastal inundation and extent of storm surges is of greater concern on groundwater conditions than classical lateral intrusion. High salinity in groundwater was reported by the people of Tildanga Union during the PRA process as well High salinity in groundwater was reported by the people of Tildanga Union during the study. According to information provided by Bangladesh Water Development Board[2], the groundwater salinity in Tildanga Union varies from 5,000 to 6,000 µS/cm

[112] *Bangladesh Water Development Board, 2013; Mathematical Modelling Study on Saline Water Intrusion to Assess Salinity Intrusion, Salinity Level, Sea Level Rise Management Information System (MIS) : Package – 2, The Climate Change Trust Fund (CCTF) Project, Ministry of Environment and Forest.*
[113] *World Bank, 2010*

18.2. Natural hazards and tidal surges

According to local people, the coastal embankment was badly damaged during the cyclone Aila causing intrusion of salt water into the fresh water pond in the Union. The effect of Aila and saltwater intrusion due to sea level rise on surface water sources, e.g., ponds, left a very limited number of fresh water ponds as drinking water source for people living in many villages in this Union According to information provided by Bangladesh Water Development Board[2], surface water salinity varies from 1,000 to 3,000 µS/cm in this area. In absence of necessary protection measures, these sources could further be affected by tidal surges and subsurface movement of saltwater due to sea level rise.

19. Proposed climate resilient water technologies

The potential of different types of water sources were analyzed in the two target wards. This information was fed in to the selection process of water technologies to meet the needs of the target population. Current and projected availability and quality of groundwater, surface water, and rainwater were considered in the local context based on available data and information during the analysis. Two types of water technologies are proposed for the two target wards in the Tildanga Union:

- Household based rainwater harvesting system – for individual households
- Community-scale rainwater harvesting system – for 25 and 50 households based on roof catchment size

The available community and institution buildings with a roof area suitable for rainwater harvesting are shown in Table 3.

Table 88: Existing community and institutional buildings as potential source of Rain Water Harvesting Systems in Tildanga Union

Ward	Name of the Building	Site Category	Building Condition[114]	Roof area (m^2)	Tank Size
1	Uniyon Health Complex	Community	Good	117	Small
3	Gorkhali Pollimongol Govt. primary School	Community	Good	223	Medium

Table 4 shows the household data and proposed technologies following the methodology described in Chapter 7 of the synthesis report with a design target of 2 litres of safely managed drinking water per person per day. The forecast population growth for Tildanga Union is negative. The Target Beneficiary Households in Table 4 was used for the basis of design of the required water technology solutions. There are 280 households with existing functioning year-round improved water supplies in the target wards, representing 22.28% of the households in these wards.

Table 4 shows a total of six community-scale RWHS and no institution-scale RWHS. The 2016 building database covers two of the community-scale RWHS as shown in Table 3. Among the four remaining community-scale RWHS, two in ward 1 and one in ward 3 are assumed to have at least a moderate roof condition of 150m^2 in area, and one in ward 3 is assumed to have at least a moderate roof condition of 75m^2 area. There is no pond water treatment system proposed in this Union.

[114] Building condition of “good” means that the roof is suitable for rainwater harvesting with minor roof repairs. “Moderate” means the roof and building both need minor treatment and retrofit. “Bad” means major repairs of roof and building required.

Table 89: Proposed technology based on number of households for Tildanga Union

Ward No.	Number of HHs	Baseline Coverage (non-saline)	Target Beneficiary Households (50% of supply gap)	Proposed Technology									
				HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
					in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
					Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
1	775	110	333	208	1	-	-	2	-	-	-	-	-
3	482	170	156	32	-	1	1	1	-	-	-	-	-
Total	**1,257**	280	**489**	**240**	**1**	**1**	**1**	**3**	**-**	**-**	**-**	**-**	**-**

20. Estimated budget for the proposed water technologies

The capital investment cost for the proposed water technologies in two wards of Tildanga Union is provided in Table 5.

Table 90: Budget for Capital Costs in Tildanga Union

Ward No.	Budget (BDT)									
	HH based RWHS	Community-scale RWHS				Institution-scale RWHS				Community based Pond Water Treatment System (Sky-hydrant)
		in buildings with "good" roof condition		in buildings with "moderate" roof condition		in buildings with "good" roof condition		in buildings with "moderate" roof condition		
		Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Small Tanks (25 HHs)	Medium Tanks (50 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	Large Tanks (75 HHs)	Very Large Tanks (100 HHs)	
1	7,900,880	959,416	-	-	3,252,479	-	-	-	-	-
3	1,215,520	-	1,529,940	1,007,566	1,626,240	-	-	-	-	-
Total	**9,116,400**	**959,416**	**1,529,940**	**1,007,566**	**4,878,719**	**-**	**-**	**-**	**-**	**-**

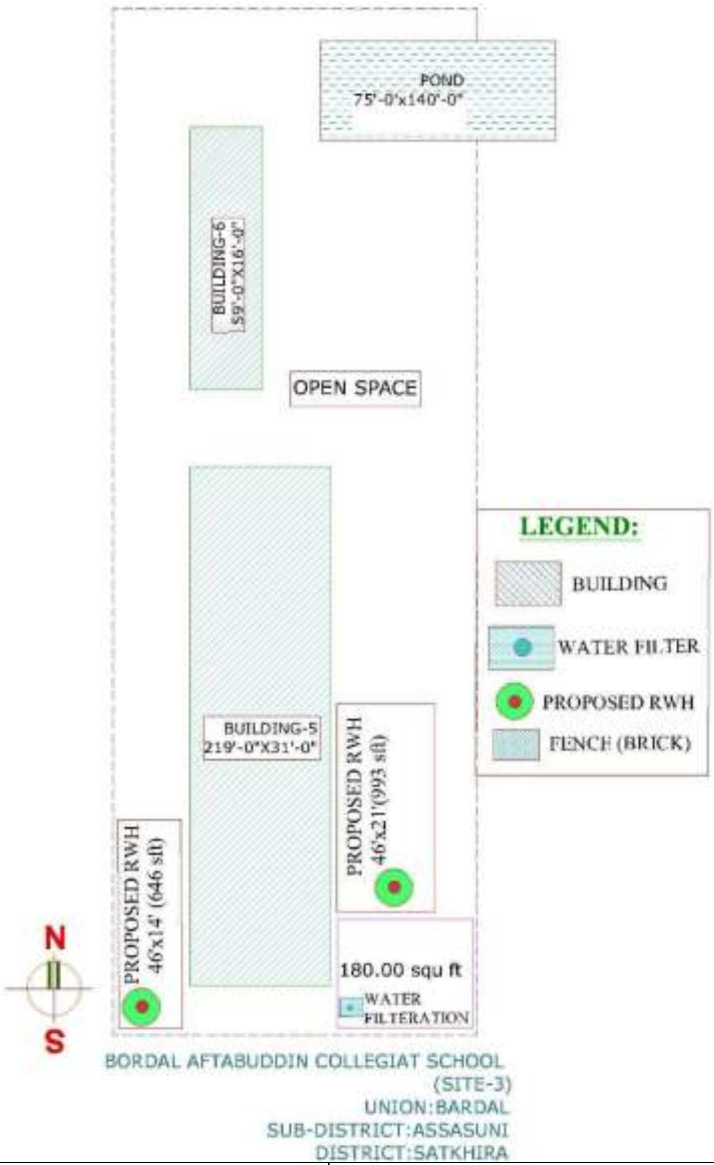
Annex 4: Site Survey Reports by AOSED

1. Model Site Profile: Bordol Aftabuddin Collegiate School Site-3

Site SI no: _________________, RF SI no: ______________________

Latitude: 22° 32' 27" Longitude: 89° 14' 11"

Site Location	**Village: Bordal** **Union: Bordal** ▪ **Ward: 4** **Upazila: Asasuni** **District:Satkhira**

Details layout plan of Site	
	
Proposed Drinking Water Source	Rain Water harvesting System

Proposed Building Type	Educational
Number of building	2
Site Chief name /Position / Contact Number	MDS. Sahajan Ali, Arts Teacher Contact: 01749 917309
Assistant Chief Contact person & Number	D. Sahabuddin, Head Teacher Contact: 01718 310593
Available space to install 1136 cubic meter	Yes, around 1600sft
Soil type	Sandy Clay
Available open space that is not used for any purpose	Yes around 25oosft
Space for filtration Infrastructure (**minimum 100sft.**)	Yes, 180sft (12x15)
Power connectivity available and condition	REB, Good (4-5 hours load shedding daily)
Total land area	5.67 acre
Total open area	4 acre
Land elevation **(Mean Sea Level)**	11 m
Highest Flooding Depth	3 ft.
Groundwater level (**ft.)**	160 ft.
Nearby surface water(ponds) source and distance	Yes, 20 meter away from building no. 1 
Salinity in nearby Pond	Yes, slightly saline, people usually avoid to drink this pond water. But in emergency they obliged to drink this pond water.

Potential threats(Industry/Chimney) of surface water/rainwater pollution	Yes 
Height of nearby industry/brickfield chimney	150 feet
Site Boundary condition	Not good
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Health Clinic, 500 meter from school
Nearby Bazar name and distance	Bordol Bazar, 300 meter from school
Distance from Upazila Sadar and medium of communication from	7 kilometer away; motorcycle, battery van, easy bike
Road network condition from site to Upazila Sadar	Good
Total perimeter of the site	340 meter.
Site Boundary Available	Yes
Site Boundary	

School/ institution authority will permit to install RWH	Yes, need permission of the SMC
They will allow local community to take water from this point	Yes
School/ institution authority will commit to maintain and operate RWH with nominal support from community authority?	Yes
Number of HH within 1km from the institution	350-400 approx.

Building Information

Number of building	2
Number of floor of Building:	**Building: 5**: 1 storied building
Number of floor of Building:	**Building: 6**: 1 (tin shade semi pacca building)
Roof type	Building 5: Concrete Building 6 : Tin (CI sheet)
Roof dimension (m)	Building 5: (66.77 x 9.63) m / (219 x 31) ft. Building 6: (18 x 5) m / (59 x 16)ft.
Building 5: one storied building	Yes 
Building 2 : Tin Shed (CI seet)	Yes

		
Under construction building	No	
Roof slope **(mm)**	Building 5- 1:1000 Building 6- 1: 1200	
Roof Length (in meter)	Building 5: 66.77 m Building 6: 18 m	**Area (m^2)** Building 1: 643 m^2 Building 2: 90 m^2
Roof Width (in meter)	Building 5: 9.63 m Building 6: 5 m	
Roof materials	Building 5: Concrete Building 6: Tin (CI Sheet)	
Roof Condition and treatment	Building 5: Moderate repair needed Building 6: Moderate repair needed	
The shape of the roof (gable, lean to etc.)	Building 5: slope Building 6: slope	
Percent (%) of roof length with existing guttering	Building 5: No Building 6 : No	
Volume of existing rainwater storage tanks if there are any	Building 5: No Building 6: No	
Who use the existing tanks if there are/is any	No	
User feedback on existing water tanks if there are any	NA	
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 5: 12 feet Building 6: 10 feet	

Roof type: Building 5 one storied building		
Roof type: building 6	Yes 	
Specific queries	Building 1	Building 2
Roof treatment needed for RWH	Yes	Yes
Any obstacles on roof (tree, garbage storage, others)	No	Yes
Roof area covered by tree/garbage storage/others.	No	Yes (around 50%)
Rainfall intensity	1700 mm	1700 mm
Potentiality of rainwater volume (70% efficiency)annually	765 cubic meter	107 cubic meter
Existing Downpipe availability	No	No
Available drawing of Building	No	No
Available drainage pipe Network	No	No
Construction completions	2015	2000
Evidence of leakage on existing pipe network	NA	NA
Number of toilets in building	2 inside the building	2 Inside building
Number of occupants in the building	300 students and teachers	50 residential students
Secondary catchment area	NA	90 sqm
Potentiality of rain water volume (70% efficiency)	NA	107 cubic meter

Evidence of wall damping	No, it is new building
Wet section of the top ceiling	No, it is new building
Existing Water Source?	Yes
What Types?	Motorize tube-well water treatment plant
When installed?	1 year ago
How many HH uses?	Almost 1000 (according to informant)
Water Quality?	Satisfactory
Users Feedback?	People usually satisfied of exiting water plant. Almost 4-5 thousand people drink from this water plant. Before this people was obliged to drink pond water. This plant water is drinkable. But informant said that, this plant is not enough for all the community people. People buy water 50 paisa per liter from here. This money is cost for maintenance purposes of this plant.
Any other water source	Yes; water treatment plant Goaldanga Bazar, 3 km away from school. That is personal water treatment plant owned by Merazul. Sometimes people of this community take water from here.
% of site boundary that is fenced	70-75%
Type of fence	Brick fence
Site boundary	
More site photos	

Remarks:

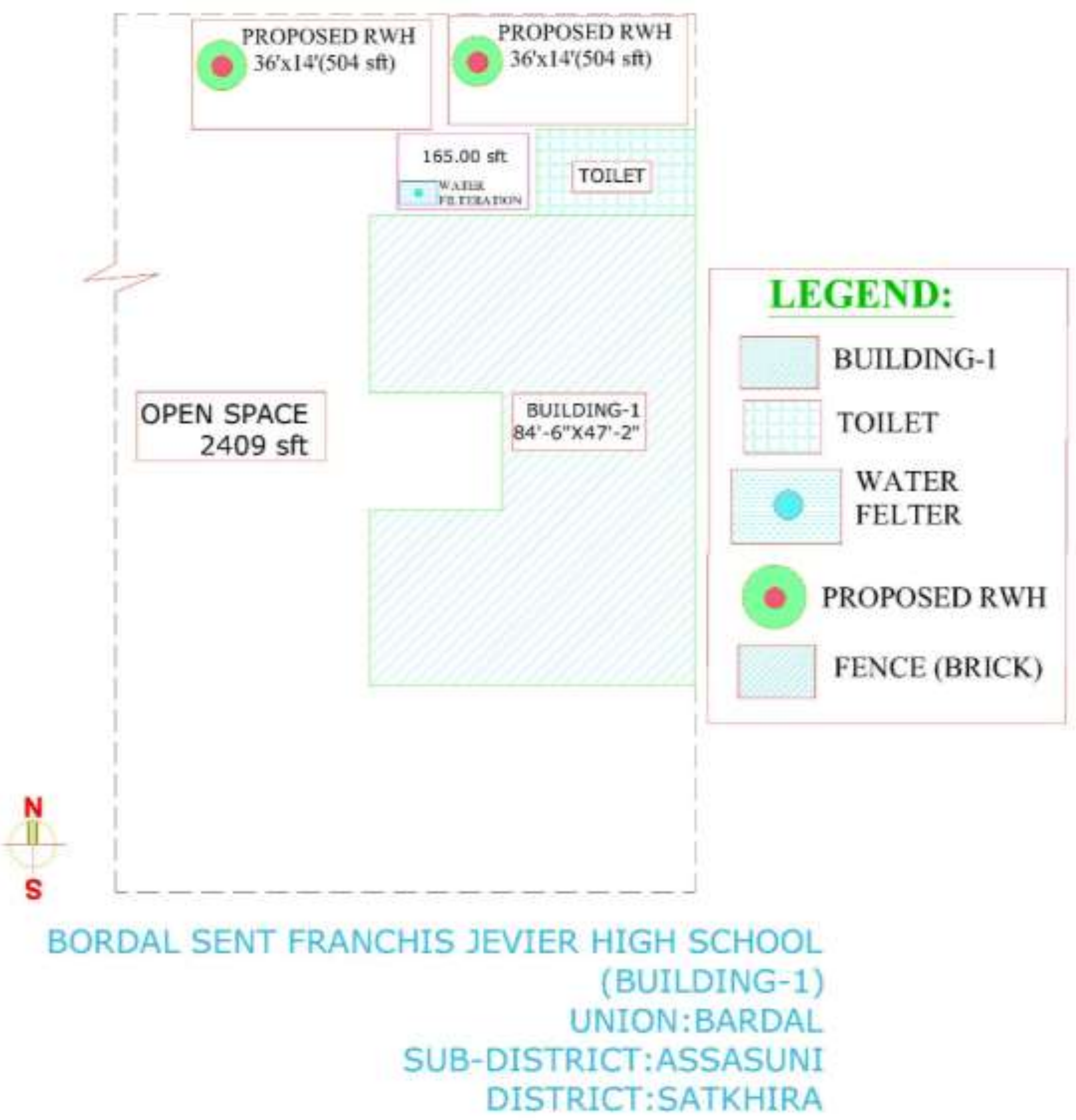
- The informant person said that if there will be established any RWH water treatment plant, then all the community people can take advantages from the established plant for drinking water purpose.

2. Model Site Profile: Bordal St. Francis Xavier Junior High School (Building- 1)

Site SI no: __________________, RF SI no: _______________________

Latitude: 22° 32' 7" **Longitude: 89° 14' 35"**

Site Location	**Village: Bordal Christian para** **Union: Bordal** ▪ **Ward no: 7** **Upazila: Asasuni** **District: Satkhira**

Details layout plan of Site	
	
Proposed Drinking Water Source	Rain Water harvesting System

Proposed Building Type	Educational
Number of building	1
Site Chief name /Position / Contact Number	Father Philip Mondol (Father) 01719729176
Assistant Chief Contact person & Number	Augustine Guine (Headmaster) 01727440112
Available space to install 621 cubic meter	Yes, around 1000sft
Soil Type	Sandy Clay
Area of available open space that is not used for any purpose	Around 2400sft
Space for filtration Infrastructure (**minimum 100sft.**)	165 sft (11x15)
Power connectivity available and condition	REB, Good (4-5 hours load shedding daily)
Total land area	1 acre
Total open area	0.7 acre
Land elevation **(Mean Sea Level)**	11 m (source http://www.worldatlas.com/as/bd/d/where-is-satkhira.html)
Highest Flooding Depth	3 feet
Groundwater level (**ft.)**	160 ft.
Nearby surface water(ponds) source and distance	Yes, 50-60 meter away from building no. 1 (this pond is inside of church)
Salinity in nearby Pond	No. This surface water is used Pond Sand Filter (PSF) for drinking purposes.

Potential threats(Industry/Chimney) of surface water/rainwater pollution	Yes 
Height of nearby industry/brickfield chimney	150 feet
Site Boundary condition	Good
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Health Clinic,3 km from the school
Nearby Bazar name and distance	Bordol Bazar, 500 meter from the school
Distance from Upazila Sadar and medium of communication from	10 kilometers away, motorcycle, battery van, easy bike
Road network condition from site to Upazila Sadar	Good
Total perimeter of the site	258 meter.
Site Boundary Available	Yes
Site Boundary	

% of site boundary that is fenced	100%
Type of fence	Brick fence
School/ institution authority will permit to install RWH	Yes, need offical permission of SMC.
They will allow local community to take water from this point	Yes
School/ institution authority will commit to maintain and operate RWH with nominal support from community authority?	Yes
Number of Household within 1km from the institution	300-400 approx.

Building Information

Number of building	1	
Number of floor of Building 1	1 	
Roof type	Building 1: Tin shade (Originally tile-roofted,after the tiles get damaged they repaired the roof with Tin. The ceiling is still made of tiles and wood with Tin covered outside)	
Roof dimension (m)	Building 1: (25.8×14.10) m	
Building 1: one storied building	Yes	
Under construction building	No	
Roof slope **(mm)**	Building 1- 1:1000	
Roof Length (in meter)	Building 1: 25.8 m	**Area (m^2)**

Roof Width (in meter)	Building 1: 14.10	Building 1: 364 m^2
Roof materials	Building 1: Tin (CI Sheet)	
Roof Condition and treatment	Building 1: Repair needed because of poor tin condition	
The shape of the roof (gable, lean to etc.)	Building 1: slope	
Percent (%) of roof length with existing guttering	Building 1: No	
Volume of existing rainwater storage tanks if there are any	Building 1: No	
Who use the existing tanks if there are/is any	NA	
User feedback on existing water tanks if there are any	NA	
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building-1: 12 feet	
Roof type: Building 1	Tin	
Roof type: building 2	NA	
Roof type: building 3	NA	
Specific queries	Building 1	
Roof treatment needed for RWH	Yes	
Any obstacles on roof (tree, garbage storage, others)	No	
Roof area covered by tree/garbage storage/others.	No	
Rainfall intensity	1700 mm	
Potentiality of rainwater volume (70% efficiency)annually	433 cubic meter	
Existing Downpipe availability	No	
Available drawing of Building	No	
Available drainage pipe Network	No	
Construction completions	1978	
Evidence of leakage on existing pipe network	NA	

Number of toilets in building	2 outside the building
Number of occupants in the building	200 students and teachers
Secondary catchment area	No
Potentiality of rain water volume (70% efficiency)	NA
Evidence of wall damping	Yes 
Wet section of the top ceiling	Yes 
Existing Water Source?	Yes
What Types?	PSF (drinking water sharing with the church)
When installed?	3 years
How many HH uses?	Almost 300 (according to informant)
Water Quality?	Satisfactory

Users Feedback?	The water is fresh but there is not enough water supply in year round, needed alternative drinking water source to reduce water scarcity
Any other water source	Tube-wells not drinking purpose
Site boundary	
Site boundary	
Site boundary	

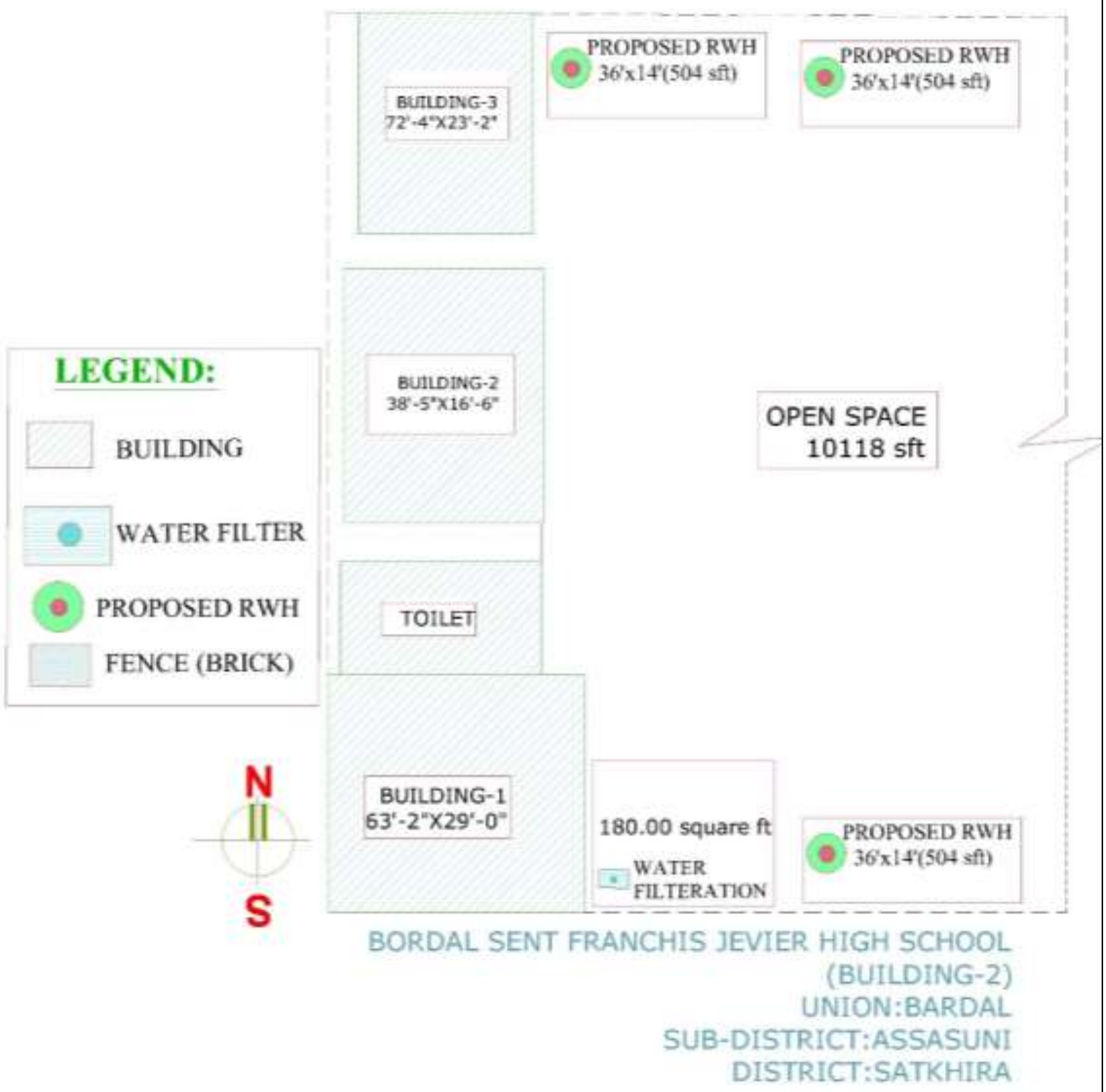
More Site photos	

3. **Model Site Profile: St. Francis Xavier Junior High School (Building- 2)**

Site SI no: ________________, RF SI no: ______________________

Latitude: 22° 32' 9" **Longitude: 89° 14' 34"**

Site Location	**Village: Bordal Christian para** **Union: Bordal** ▪ **Ward no: 7** **Upazila: Asasuni** **District: Satkhira**

Details layout plan of Site	
	
Proposed Drinking Water Source	Rain Water harvesting System
Proposed Building Type	Educational

Number of building	3
Site Chief name /Position / Contact Number	Father Philip Mondol (Father) 01719729176
Assistant Chief Contact person & Number	Augustine Guine (Headmaster) 01727440112
Available space to install 319 cubic meter	Yes, around 1500 sft
Soil type	Sandy Clay
Available open space that is not used for any purpose	Yes, around 2500 sft
Space for filtration Infrastructure (**minimum 100sft.**)	Yes 180 sft (12x15)
Power connectivity available and condition	REB, Good (4-5 hours load shedding daily)
Total land area	1 acre
Total open area	0.7 acre
Land elevation **(Mean Sea Level)**	11 m(Source http://www.worldatlas.com/as/bd/d/where-is-satkhira.html)
Highest Flooding Depth	3 feet
Groundwater level (**ft.)**	160 ft.
Nearby surface water(ponds) source and distance	Yes,10 m.
Salinity in nearby Pond	No. This surface water is used Pond Sand Filter (PSF) for drinking purposes

Potential threats(Industry/Chimney) of surface water/rainwater pollution	Yes 
Height of nearby industry/brickfield chimney	150 feet
Site Boundary condition	Good
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Health Clinic,3 km from school
Nearby Bazar name and distance	Bordol Bazar, 500 meter from school
Distance from Upazila Sadar and medium of communication from	10 kilometer away; motorcycle, battery van, easy bike
Road network condition from site to Upazila Sadar	Good
Total perimeter of the site	258 meter (2 cite in a same compound)
Site Boundary Available	Yes
Site Boundary	
School/ institution authority will permit to install RWH	Yes, need permission of the SMC.

They will allow local community to take water from this point	Yes
School/ institution authority will commit to maintain and operate RWH with nominal support from community authority?	Yes
Number of HH within 1km from the institution	350-400 approx.

Building Information

Number of building	3
Number of floor of Building 1	Yes, (Semi-pacca Tin Shade) 
Number of floor of Building 2	Yes, (Semi-pacca Tin Shade) 

Number of floor of Building 3	Yes, (Semi-pacca Tin Shade) 
Roof type	Building 1: Tin shade (Originally tile-roofted, after the tiles get damaged they repaired the roof with Tin. The ceiling is still made of tiles and wood with Tin covered outside) Building 2: Tin Shade Building 3: Tin Shade
Roof dimension (m)	Building 1: (19.3×8.9) m Building 2: (11.8×5.1) m Building 3: (22.1×7.1) m
Building 1: semi pacca tin shade building	Yes 

Building 2: Semi-pacca tin Shade	Yes 	
Building 3: Semi-pacca tin Shade	Yes 	
Under construction building	No	
Roof slope **(mm)**	Building 1- 1:800 Building 2- 1:600 Building 3- 1:600	
Roof Length (in meter)	Building 1: 19.3 m Building 2:11.8 m Building 3: 22.1 m	**Area (m^2)** Building 1: 172 m^2 Building 2: 60 m^2 Building 3: 157 m^2
Roof Width (in meter)	Building 1: 8.9 m Building 2: 5.1 m Building 3: 7.1 m	
Roof materials	Building 1: Tin (CI Sheet) Building 2: Tin (CI Sheet) Building 3: Tin (CI Sheet)	
Roof Condition and treatment	Building 1: Moderate repair needed Building 2: Moderate repair needed	

	Building 3: Moderate repair needed
The shape of the roof (gable, lean to etc.)	Building 1: Slope Building 2: Slope Building 3: Slope
Percent (%) of roof length with existing guttering	Building 1: No Building 2: No Building 3: No
Volume of existing rainwater storage tanks if there are any	Building 1: NA Building 2:NA Building 3:NA
Who use the existing tanks if there are/is any	NA
User feedback on existing water tanks if there are any	NA
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building-1: 12ft. Building 2: 8 ft. Building 3: 8 ft.
Roof type: Building 1	Tin
Roof type: building 2	Tin
Roof type: building 3	Tin

Specific queries	Building 1	Building 2	Building 3
Roof treatment needed for RWH	Yes	Yes	Yes
Any obstacles on roof (tree, garbage storage, others)	No	No	No
Roof area covered by tree/garbage storage/others.	No	No	No
Rainfall intensity	1700 mm	1700 mm	1700mm
Potentiality of rainwater volume (70% efficiency)annually	204 cubic meter	71 cubic meter	187 cubic meter
Existing Downpipe availability	No	No	No
Available drawing of Building	No	No	No
Available drainage pipe Network	No	No	No
Construction completions	1978	2002	1997
Evidence of leakage on	NA	NA	NA

existing pipe network			
Number of toilets in building	2 outside the building	No	No
Number of occupants in the building	200 students and teachers	40 including trainer and trainee	100 including teacher and student
Secondary catchment area		60 sqm	157 sqm
Potentiality of rain water volume (70% efficiency)		71 cubic meter	187 cubic meter
Evidence of wall damping	Yes 		
Wet section of the top ceiling	 Yes		
Existing Water Source?	Yes		
What Types?	Motorized pond ground water extraction		
When installed?	3 years		
How many HH uses?	Almost 300 (according to informant)		
Water Quality?	Satisfactory		
Users Feedback?	The water is sweet but there is not enough water supply all year round, an alternate source of water is very much needed		
Any other water source	No		

Site boundary	
% of site boundary that is fenced	100%
Type of fence	Brick fence
	
More Site photos	

Remarks:

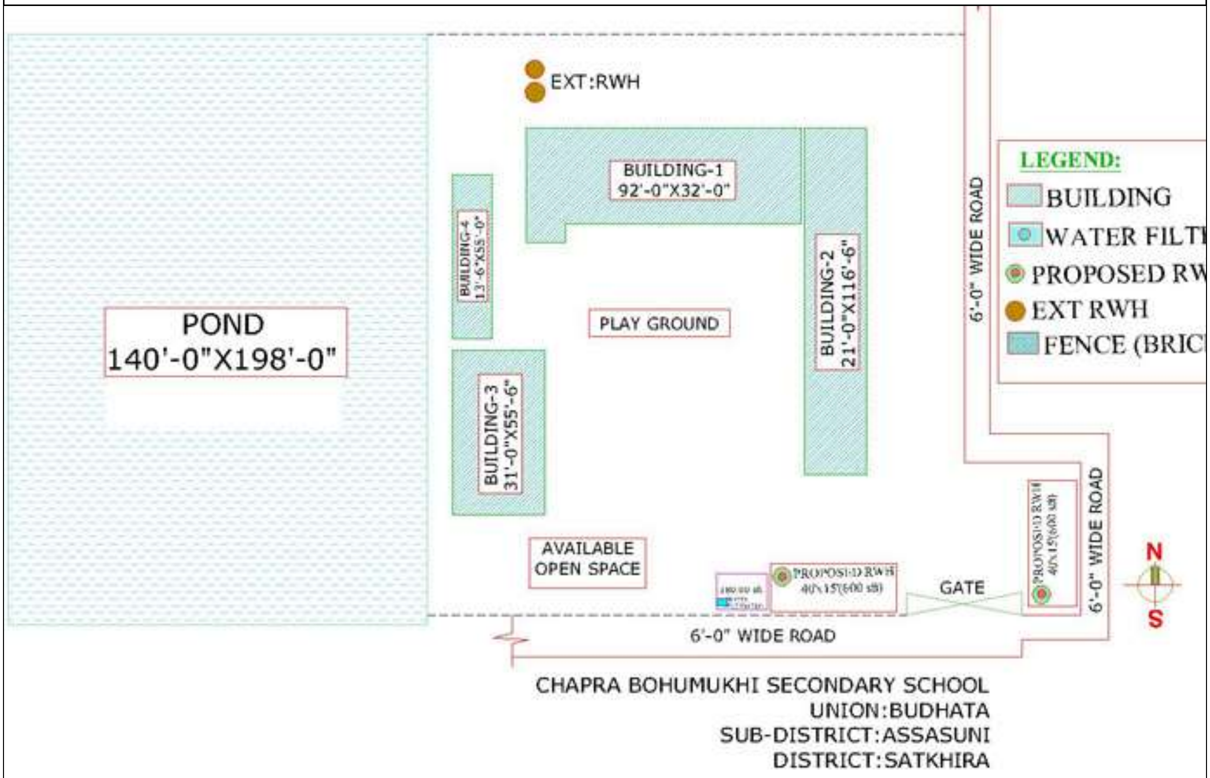
- The informant person said that with the establishment of RWH Plant in this school compounds, then the scarcity of safe drinking water will be reduced for all the students, teachers and community people.

4. **Model Site Profile**: Chapra Bohumukhi Secondary School

Site SI no: ___________________, RF SI no: _________________________

Site Location	**Village: Chapra** **Union: Budhhata** **Ward no: 2** **Upazila: Ashasuni** **District: Sathkhira.**

Details layout plan of Site



Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Educational
Number of building	Four (4)
Site Chief name /Position / Contact Number	Md. Abul Hasem (President)-School Management Committee Cell- 01743931633 ASM Mustafizur Rahman (Headmaster) Cell-01720587089
Assistant Chief Contact person & Number	Md. Shahidul Islam (Chief Staff) Cell-01725920940
Available space to install 1018 cubic meter	**7132.72** sq ft (The school authority already have the RWH tank of 20 cubic meter which is only used by the school students and authority.)
Soil type	Sandy

Area of available open space that is not used for any purpose	7132.72 sq ft (189.7 x 37.6) sq ft
Space for filtration infrastructure (**minimum 100sft.**)	600 sq ft (40 x 15)
Power connectivity available and condition	Electricity available (2-3 hours daily load shedding)
Total land area	59123.06 sq ft (298.3 x 198.2)
Total open area	16832.72 sq ft
Land elevation **(Mean Sea Level)**	6-7 feet
Highest Flooding Depth	4-5 feet
Groundwater level (**ft.)**	10-15 feet
Nearby surface water (ponds) source and distance	30 feet
Salinity in nearby Pond	Saline water-undrinkable
Potential threats (Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	N/A
Site Boundary condition-	Brick wall- North and South side Open-East side Pond-West side
Availability filter materials (Coarse sand, stone)	Available (near 1km distance)
Skilled construction manpower availability	Yes (Expert-As School Authority comments)
Nearby Hospital/community clinic name and distance	Ashasuni Hospital-Distance between 2-3km Uttar Chapra Community Clinic-2km
Nearby Bazar name and distance	Chapra Bazar- less than 1km distance
Distance from Upazila Sadar and medium of communication from	Distance between 2-3 km Easy accessibility of local transports like van, Machine van, Easy bike, Motorcycle and others

Road network condition from site to Upazila Sadar	Pith road (Roads in very well condition)
Total perimeter of the site	993 ft
Site boundary available	Brick wall- North and South side Open-East side Pond-West side
Site boundary	
More site photos	

Building Information

Number of Building	4
Number of floor of building 1	One Storied Building
Number of floor of building 2	CI Sheet Building
Number of floor of building 3	CI Sheet Building
Number of floor of building 4	CI Sheet Building
Roof types	Building 1: Reinforcement Cement Concrete (RCC) SLAB Building 2: CI Sheet (Tin) Building 3: CI Sheet (Tin) Building 4: CI Sheet (Tin)
Roof dimension (m)	Building 1: 92 x 32 x 10 ft Building 2: 116.6 x 21 x 8 ft Building 3: 55.6 x 31 x 8 ft Building 4: 55 x 13.6 x 8 ft
Building 1: One Storied Building	
Building 2: CI Sheet Building	

Building 3: CI Sheet Building		
Building 4: CI Sheet Building		
Roof slope **(mm)**	Building 1: 1:1000 Building 2: 1:2 Building 3: 1:2 Building 4: 1:2	
Roof Length (in meter)	Building 1: 92 ft Building 2: 116.6 ft Building 3: 55.6 ft Building 4: 55 ft	**Area (ft^2)** Building 1: 2944 Building 2: 2448.6 Building 3: 1723.6 Building 4: 748
Roof Width (in meter)	Building 1: 32 ft Building 2: 21 ft Building 3: 31 ft Building 4: 13.6 ft	
Roof materials	Building 1: Reinforcement Cement Concrete (RCC) SLAB Building 2: CI Sheet (Tin) Building 3: CI Sheet (Tin) Building 4: CI Sheet (Tin)	
Roof Condition and treatment	Building 1: Small treatment needed Building 2: Moderate Treatment needed Building 3: Moderate Treatment needed Building 4: Moderate Treatment needed	
The shape of the roof (gable, lean to etc.)	Building 1: Slope Building 2: Slope Building 3: Slope Building 4: Slope	
Percent (%) of roof length with existing guttering	Building 1: 100 Building 2: 100 Building 3: 100 Building 4: 100	
Volume of existing rainwater storage tanks if there are any	Building 1: 20000 liter, two tank (10000x2)	
Who use the existing tanks if there are/is any	Only School Students and Teachers Restricted for community people	
User feedback on existing water tanks if there are any	Water supply is available six months in year. Only used for school students and teachers Restricted for community people	

Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 1: 10ft Building 2: 8 ft Building 3: 8 ft Building 4: 8 ft
Roof type: Building 1: one storied building	
Roof type: Building 2:	
Roof type: Building 3:	
Roof type: Building 4:	

Specific Quarries	Building 1:	Building 2	Building 3	Building 4
Roof treatment needed for RWH?	Yes	Yes	Yes	Yes
Any obstacles on roof (tree, garbage storage, others)	No	No	No	No
Roof area covered by tree /garbage storage/others.	No	No	No	No
Rainfall intensity	1700mm	1700mm	1700mm	1700mm
Potentiality of rainwater volume (70% efficiency) annually	1190	1190	1190	1190
Existing Downpipe	No	No	No	No

availability				
Available drawing of Building	No	No	No	No
Available drainage pipe network	No	No	No	No
Construction completions in	2009	1998	1998	1998
Evidence of leakage on existing pipe network	No	No	No	No
Number of toilets in building	3	2	1	1
Number of occupants in the building	2	2	1	1
Secondary catchment area,	No			
Potentiality of rain water volume (70% efficiency)annually	1190			
Evidence of wall damping	Yes  			
Wet section of the top ceiling	No			
Existing Water Source?	Shallow Tube well (Saline), Water Body (Saline)			
What Types?	Shallow			
When installed?	1998			
How many HH uses?	around 3500-4000 people			
Water Quality?	Saline			
Users Feedback?	Not drinkable			
Any other water sources?	No, Poor drinking water availability			
Any other RWHs	Yes, 20000 liter RWH only for students and teachers of the school			

Other Questioner	
The school authority will permit to install the water tank?	Yes

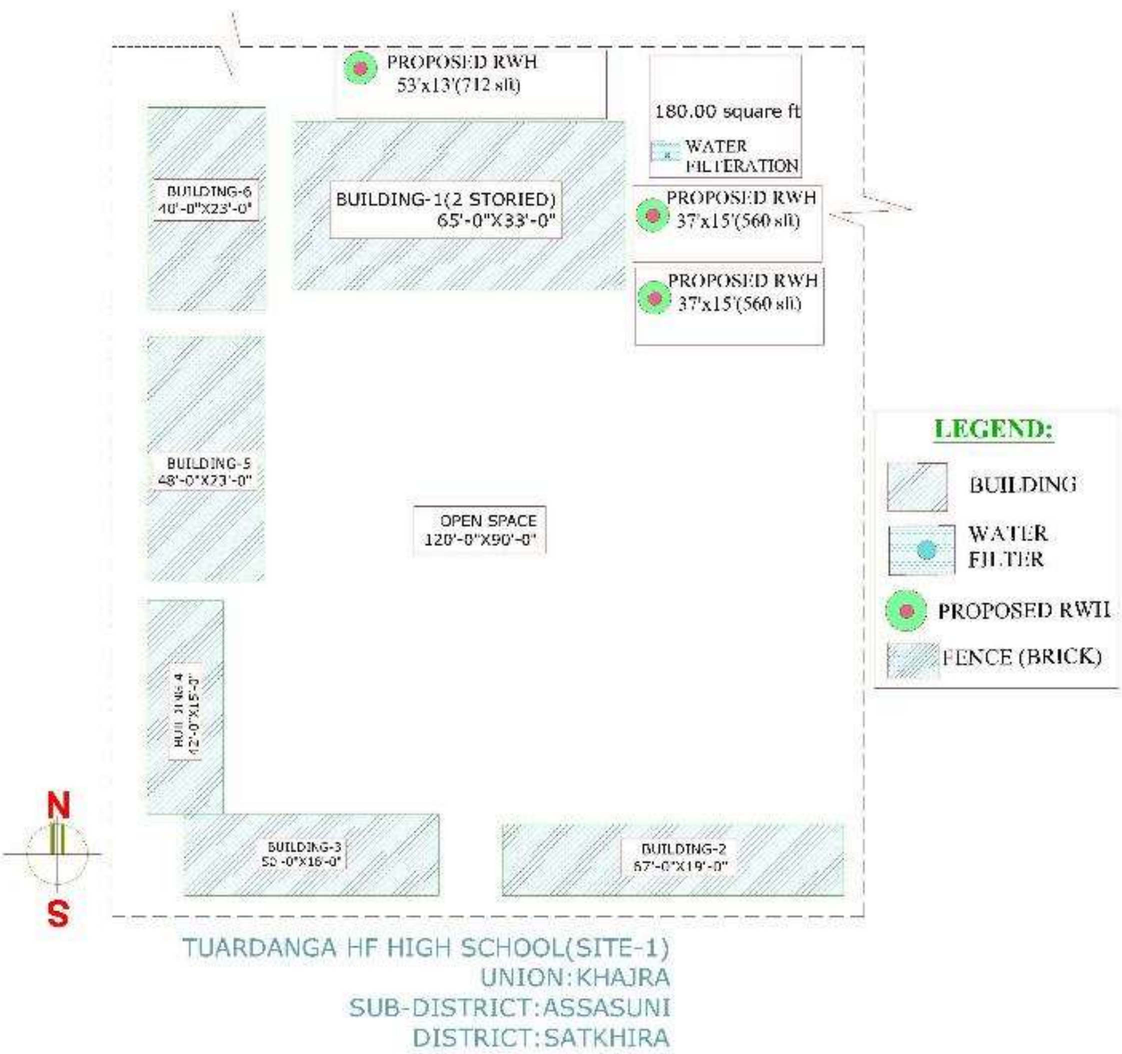
They will allow local community to take water from this point,? to maintain and operate the water	Yes
School committee will commit tank with nominal support from community and school authority?	Yes
Number of HH and Population located within 1 km	900-1000 and almost 3500-4000 people

5. **Model Site Profile: Tuardanga H F High School Site-1**

Site SI no: _________________, RF SI no: ______________________

Latitude: 22° 30' 33" **Longitude: 89° 11' 58"**

Site Location	**Village: Tuardanga** **Union: Khajra** ▪ **Ward no: 9** **Upazila: Asasuni** **District: Satkhira**

Details layout plan of Site	
	
Proposed Drinking Water Source	Rain Water harvesting System
Proposed Building Type	Educational
Number of building	6

Site Chief name /Position / Contact Number	Mongol Chandra Mondol, Biology Teacher Contact: 01788 734571
Assistant Chief Contact person & Number	Subroto Kumar Mondol, Head Master Contact: 01721 760485
Available space to install 421 cubic meter	Yes, 1800sft.
Soil Type	Sandy Clay
Area of available open space that is not used for any purpose	Around 2600sft.
Space for filtration Infrastructure (**minimum 100sft.**)	180 sft (12x15)
Power connectivity available and condition	REB, Good (4-5 hours load shedding daily)
Total land area	1 acre
Total open area	0.5 acre
Land elevation **(Mean Sea Level)**	11m (Source http://www.worldatlas.com/as/bd/d/where-is-satkhira.html)
Highest Flooding Depth	2 feet
Groundwater level (**ft.)**	150 ft.
Nearby surface water(ponds) source and distance	Yes, 30 meter away from building no. 1 
Salinity in nearby Pond	No, people usually drink from this pond. There is a PSF beside this pond.
Potential threats(Industry/Chimney) of surface water/rainwater pollution	No (nearest brickfield is 8-9 km away from here)

Height of nearby industry/brickfield chimney	NA
Site Boundary condition	Good
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Tuardanga Community Health Clinic, 500 meter from school
Nearby Bazar name and distance	Hazi Moqbul Bazar, 500 meter from school
Distance from Upazila Sadar and medium of communication from	5 kilometer away; motorcycle, battery van, easy bike
Road network condition from site to Upazila Sadar	Good,
Total perimeter of the site	175 meter.
Site Boundary Available	Yes
Site Boundary	
% of site boundary that is fenced	85-90%
Type of fence	Brick Fence
School/ institution authority will permit to install RWH	Yes, they need final confirmation through SMC meeting.
They will allow local community to take water from this point	Yes
School/ institution authority will commit to maintain and operate RWH with nominal support from community authority?	Yes

Number of HH within 1km from the institution	600-700 approx.

Building Information

Number of building	6
Number of floor of Building 1	2 storied building
Number of floor of Building 2	1, tin shade semi pacca building
Number of floor of Building 3	1, tin shade semi pacca building
Number of floor of Building 4	1, tin shade semi pacca building
Number of floor of Building 5	1, tin shade semi pacca building
Number of floor of Building 6	1, tin shade semi pacca building
Roof type	Building 1: Concrete Building 2 : Tin (CI Sheet) Building 3: Tin(CI Sheet) Building 4: Tin(CI Sheet) Building 5: Tin (CI Sheet) Building 6: Tin(CI Sheet)
Roof dimension (m)	Building 1: (19.8 x 10) m Building 2: (20.4 x 5.7) m Building 3: (15.2 x 4.9) m Building 4: (12.8 x 4.6) m Building 5: (14.6 x 7) m Building 6: (12.2 x 7) m
Building 1: Two storied building	

Building 2: Tin shade semi pacca	
Building 3: Tin shade semi pacca	
Building 4: Tin shade semi pacca	
Building 5: Tin shade semi pacca	

<table>
<tr><td>Building 6: Tin shade semi pacca</td><td colspan="2"></td></tr>
<tr><td>Under construction building</td><td colspan="2">No</td></tr>
<tr><td>Roof slope (mm)</td><td colspan="2">Building 1- 1:1000
Building 2- 1: 1400
Building 3- 1: 1400
Building 4- 1: 1400
Building 5- 1: 1400
Building 6 – 1:1400</td></tr>
<tr><td>Roof Length (in meter)</td><td>Building 1: 19.8 m
Building 2: 20.4 m
Building 3: 15.2 m
Building 4: 12.8 m
Building 5: 14.6 m
Building 6: 12.2 m</td><td rowspan="2">Area (m^2)
Building 1: 198
Building 2: 116.28
Building 3: 74.48
Building 4: 58.88
Building 5: 102.2
Building 6: 85.4</td></tr>
<tr><td>Roof Width (in meter)</td><td>Building 1: 10 m
Building 2: 5.7 m
Building 3: 4.9 m
Building 4: 4.6 m
Building 5: 7 m
Building 6: 7 m</td></tr>
<tr><td>Roof materials</td><td colspan="2">Building 1: Concrete
Building 2: Tin (CI Sheet)
Building 3: Tin(CI Sheet)
Building 4: Tin(CI Sheet)
Building 5: Tin(CI Sheet)
Building 6: Tin(CI Sheet)</td></tr>
<tr><td>Roof Condition and treatment</td><td colspan="2">Building 1: need moderate repair
Building 2: need moderate repair
Building 3: need moderate repair</td></tr>
</table>

	Building 4: need moderate repair Building 5: need moderate repair Building 6: need moderate repair
The shape of the roof (gable, lean to etc.)	Building 1: slope Building 2: slope Building 3: slope Building 4: slope Building 5: slope Building 6: slope
Percent (%) of roof length with existing guttering	Building 1: No Building 2: No Building 3: No Building 4: No Building 5: No Building 6: No
Volume of existing rainwater storage tanks if there are any	Building 1: NA Building 2: NA Building 3: NA Building 4: NA Building 5: NA Building 6: NA
Who use the existing tanks if there are/is any	NA
User feedback on existing water tanks if there are any	Besides the school building there is a PSF, community people use this plant for their drinking purpose. They are satisfied using this PSF. But this is not enough water for the community. They suffered for the lack of drinking water for 4-5 months every year.
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building-1: 12 feet Building-2: 8 feet Building-3: 8 feet Building-4: 8 feet Building-5: 8 feet Building-6: 8 feet

Roof type: Building 1 two storied building	
Roof type: Building 2 tin shade semi pacca	
Roof type: Building 3 tin shade semi pacca	
Roof type: Building 4 tin shade semi pacca	

Roof type: Building 5 tin shade semi pacca						
Roof type: Building 6 tin shade semi pacca						
Specific queries	Building 1	Building 2	Building 3	Building 4	Building 5	Building 6
Roof treatment needed for RWH	Yes	No	No	No	Yes	Yes
Any obstacles on roof (tree, garbage storage, others)	Yes	Yes	Yes	Yes	Yes	Yes
Roof area covered by tree/garbage storage/others.	Yes	Yes	Yes	Yes	Yes	Yes
Rainfall intensity	1700 mm	1700 mm	1700 mm	1700 mm	1700 mm	1700 mm
Potentiality of rainwater volume (70% efficiency)annually	236 cubic meter	132 cubic meter	80 cubic meter	104 cubic meter	173 cubic meter	104 cubic meter
Existing Downpipe availability	No	No	No	No	No	No
Available drawing of Building	No	No	No	No	No	No
Available drainage pipe Network	No	No	No	No	No	No
Construction completions	2005	2005	2006	2006	2006	2005
Evidence of leakage on existing pipe network	NA	NA	NA	NA	NA	NA

Number of toilets in building	2 inside the building	2 outside (common of 5 building)	2 outside (common of 5 building)	2 outside (commo n of 5 building)	2 outside (commo n of 5 building)	2 outside (commo n of 5 building)e
Number of occupants in the building	150 including students and teachers room	100 students	100 students	100 students	100 students	100 student s
Secondary catchment area	NA	116.85 sqm	74.48sqm	58.88 sqm	102.2 sqm	85.4 sqm
Potentiality of rain water volume (70% efficiency)	NA	139 cubic meter	88 cubic meter	70 cubic meter	173 cubic meter	145 cubic meter
Evidence of wall damping	Yes 					
Wet section of the top ceiling	Yes 					
Existing Water Source?	Yes					

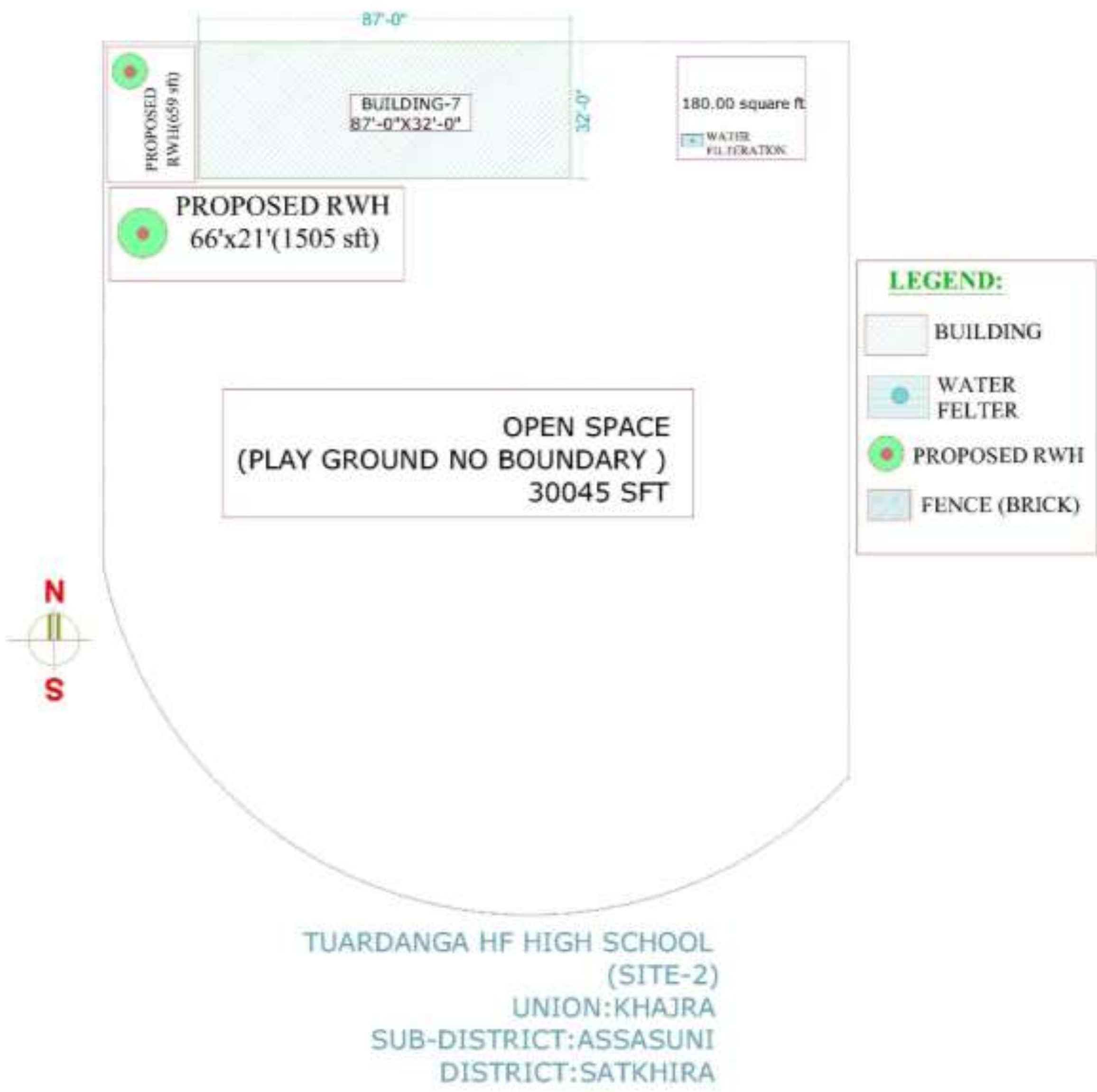
What Types?	PSF with nearby pond
When installed?	2 year ago
How many HH uses?	Almost 200 HH (according to informant)
Water Quality?	Satisfactory
Users Feedback?	People usually satisfied with this water plant. But this is the only water plant which doesn't fulfill the demand. Another point, water quality is not good if compared with its first years' service. Around 4 month in a year the water scarcity becomes high especially in April-May and December-January.
Any other water source	Yes, there is a tube-well beside school. But the water of that tube-well is saline.
Site boundary	
Site boundary	
More site photos	

6. **Model Site Profile: Tuardanga H F High School Site-2**

Site SI no: __________________, RF SI no: _______________________

Latitude: 22° 30' 32" **Longitude: 89° 11' 59"**

Site Location	**Village: Tuardanga** **Union: Khajra** ▪ **Ward no: 9** **Upazila: Asasuni** **District: Satkhira**

Details layout plan of Site	
	
Proposed Drinking Water Source	Rain Water harvesting System

Proposed Building Type	Educational
Number of building	1
Site Chief name /Position / Contact Number	Mongol Chandra Mondol, Biology Teacher Contact: 01788 734571
Assistant Chief Contact person & Number	Subroto Kumar Mondol, Head Master Contact: 01721 760485
Available space to install 420 cubic meter	Yes, around 2000sft
Soil Type	Sandy Clay
Area of available open space that is not used for any purpose	Around 2500 sft
Space for filtration Infrastructure (**minimum 100sft.**)	Yes
Power connectivity available and condition	REB, Good (4-5 hours load shedding daily)
Total land area	4 acre
Total open area	3.7 acre
Land elevation **(Mean Sea Level)**	11 m
Highest Flooding Depth	2 feet
Groundwater level (**ft.)**	150
Nearby surface water(ponds) source and distance	Yes, 50-60 meter away from building no. 2 
Salinity in nearby Pond	No, people usually drink this pond water. There is a PSF tank beside this pond.

Potential threats(Industry/Chimney) of surface water/rainwater pollution	No
Height of brickfield chimney	NA
Site Boundary condition	60-70% of site boundary is available which is fenced
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Tuardanga Community Health Clinic, 500 meter from school
Nearby Bazar name and distance	Hazi Moqbul Bazar, 500 meter from school
Distance from Upazila Sadar and medium of communication from	5 kilometer away; motorcycle, battery van, easy bike
Road network condition from site to Upazila Sadar	Good, communication system is now good enough here. But couple of years ago this was one of the most concerning problems of this area.
Total perimeter of the site	300 meter.
Site Boundary Available	Yes
Site Boundary	
% of site boundary that is fenced	60-70%
Type of fence	Brick Fence
School/ institution authority will permit to install RWH	Yes, but they have to acquire the final decision through SMC meeting
They will allow local community to take water from this point	Yes

School/ institution authority will commit to maintain and operate RWH with nominal support from community authority?	Yes
Number of HH within 1km from the institution	600-700 approx.

Building Information

Number of building	1	
Number of floor of Building	**Building 7:** 1 storied building	
Roof type	Building 7: Concrete	
Roof dimension (m)	Building 7: (26.50 x 9.77) m (87 x 32) ft	
Building 7: one storied building	Yes 	
Under construction building	No	
Roof slope **(mm)**	Building 7- 1:1000	
Roof Length (in meter)	Building 7: 26.50	**Area (m^2)**
Roof Width (in meter)	Building 7: 9.77	Building 1: 259
Roof materials	Building 7: Concrete	
Roof Condition and treatment	Building 7: Roof concrete damaged, repair needed	
The shape of the roof (gable, lean to etc.)	Building 7: slope	
Percent (%) of roof length with existing guttering	Building 7: No	
Volume of existing rainwater storage tanks if there are any	Building 7: NA	
Who use the existing tanks if there are/is any	NA	

User feedback on existing water tanks if there are any	Besides the school building there is a PSF, community people use this plant for their drinking purpose. They are satisfied using this PSF. But this is not enough water for the community. They suffered for the lack of drinking water for 4-5 months every year.
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building-7: 12 feet
Roof type: Building- 7 one storied building	
Specific queries	Building 7
Roof treatment needed for RWH	Yes
Any obstacles on roof (tree, garbage storage, others)	Yes
Roof area covered by tree/garbage storage/others.	Yes
Rainfall intensity	1700 mm
Potentiality of rainwater volume (70% efficiency)annually	308 cubic meter
Existing Downpipe availability	No
Available drawing of Building	No
Available drainage pipe Network	No
Construction completions	2005
Evidence of leakage on existing pipe network	NA
Number of toilets in building	2 outside the building
Number of occupants in the building	250 including students and teachers

Secondary catchment area	No
Potentiality of rain water volume (70% efficiency)	NA
Evidence of wall damping	Yes 
Wet section of the top ceiling	Yes
Existing Water Source?	Yes
What Types?	PSF with nearby pond
When installed?	2 year ago
How many HH uses?	Almost 800 (according to informant)
Water Quality?	Satisfactory
Users Feedback?	People usually satisfied with this water plant. But this is the only water plant which doesn't fulfill the demand. Another point, water quality is not good if compared with its first years' service. Around 4 month in a year the water scarcity becomes high especially in April-May and December-January.
Any other water source	Yes, there is a tube-well beside school. But the water of that tube-well is saline.
Road condition	

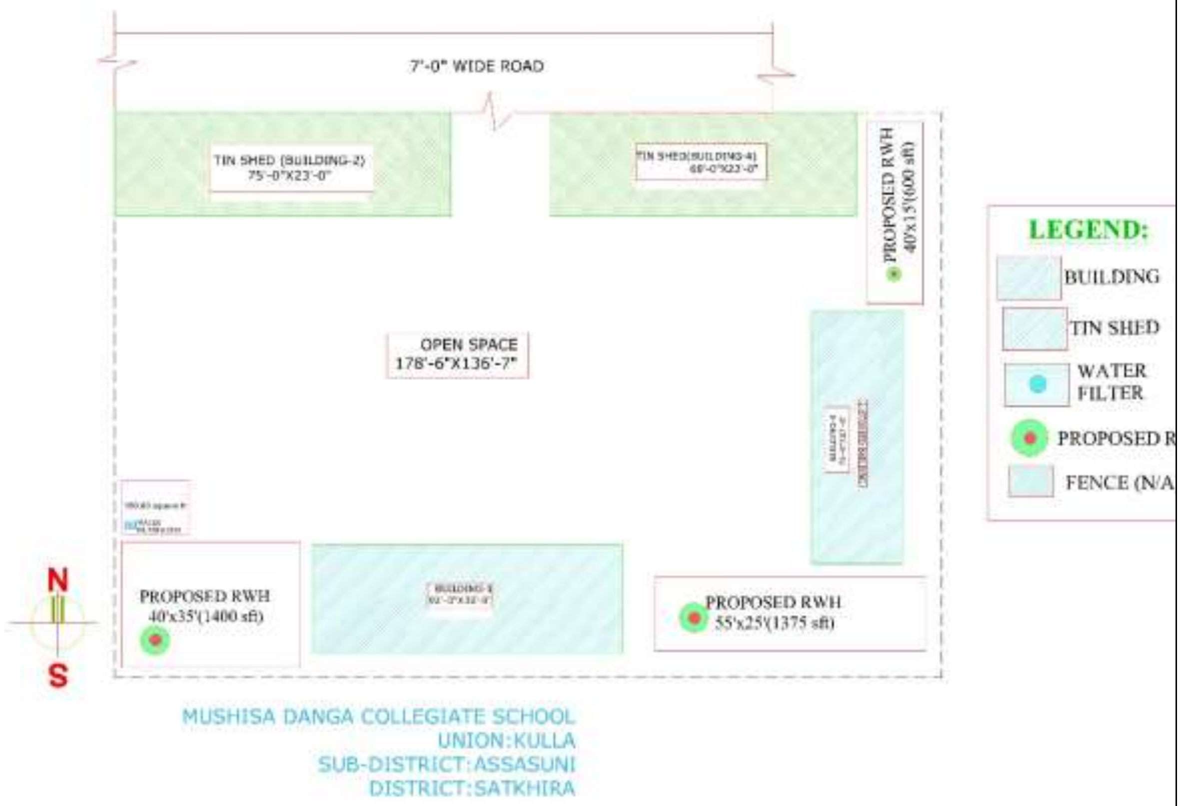
Site Photo	
More site photos	

7.-8. Model Site Profile: Mushisadanga Collegiate School

Site SI no: _________________, RF SI no: ______________________

Latitude: 22°36'6" **Longitude: 89°14'40"**

Site Location	**Village: Mushisa danga** **Union: Kulla** ▪ **Ward no: 9** **Upazila: Asasuni** **District: Satkhira**

Details layout plan of Site	
	
Proposed Drinking Water Source	Rain Water harvesting System
Proposed Building Type	Educational
Number of building	4
Site Chief name /Position / Contact Number	Dharani Kumar Biswas (Lecturer) 01739518542
Assistant Chief Contact person & Number	Shankar Kumar Roy (Headmaster) 01720590372

Available space to install 742 cubic meter	Yes, around 3375 sft
Soil Type	Sandy Clay
Area of available open space that is not used for any purpose	Around 5100 sft.
Space for filtration Infrastructure (**minimum 100sft.**)	180 sft (12x15)
Power connectivity available and condition	REB, Good (4-5 hours load shedding daily)
Total land area	1.2acre
Total open area	0.8acre
Land elevation **(Mean Sea Level)**	11m (Source http://www.worldatlas.com/as/bd/d/where-is-satkhira.html)
Highest Flooding Depth	2 feet
Groundwater level (**ft.**)	120 ft.
Nearby surface water(ponds) source and distance	Yes, 30 meter away from the site 
Salinity in nearby Pond	Yes, slightly saline.
Potential threats(Industry/Chimney) of surface water/rainwater pollution	No (nearby brickfields 8-10 km away from school)

Height of nearby industry/brickfield chimney	NA
Site Boundary condition	NA
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Health Clinic,2.5 km from College
Nearby Bazar name and distance	Mushisadanga Bazar, 0.5 km from school
Distance from Upazila Sadar and medium of communication from	15 Km. away; motorcycle, battery van, easy bike
Road network condition from site to Upazila Sadar	Good, communication system is now good enough here. But the roads in some places have pot holes.
Total perimeter of the site	240 meter.
Site Boundary Available	No
Site Boundary	NA
School/ institution authority will permit to install RWH	Mutually agreed, they need final permission through a SMC meeting.
They will allow local community to take water from this point	Yes
School/ institution authority will commit to maintain and operate RWH with nominal support from community authority?	Yes
Number of HH within 1km from the institution	450-500 approx.

Building Information

Number of building	4
Number of floor of Building	Building 1: one storied building Building 2: Tin shed (CI sheet) Building 3: two storied building Building 4: Tin shed (CI sheet)
Roof type	Building 1: Concrete

	Building 2: Tin (CI sheet) Building 3: Concrete Building 4: Tin (CI sheet)
Roof dimension (m)	Building 1: (27.9× 9.6) m Building 2: (22.8×6.8) m Building 3: (22× 8.4) m Building 4: (20.8×6.8) m
Building 1: (one storied building)	Yes 
Building 2: (tin shed-CI Sheet)	Yes 
Building 3:	

Building 4:		
Under construction building	No	
Roof slope **(mm)**	Building 1- 1:1000mm Building 2- 1:2 Building 3- 1:1000mm Building 4- 1:2	
Roof Length (in meter)	Building 1: 27.9m Building 2:22.8m Building 3: 22 m Building 4: 20.6 m	**Area (m^2)** Building 1: 268 m^2 Building 2:155 m^2 Building 3: 185 m^2 Building 4: 140 m^2
Roof Width (in meter)	Building 1: 9.6m Building 2:6.8m Building 3: 8.4 m Building 4:6.8m	
Roof materials	Building 1: Concrete Building 2:Tin (CI Sheet) Building 3: Concrete Building 4:Tin (CI Sheet)	
Roof Condition and treatment	Building 1: moderate repair needed Building 2: Bad, extensive repair needed Building 3: Moderate repair needed Building 4: Bad, Extensive repair needed	
The shape of the roof (gable, lean to etc.)	Building 1: slope Building 2: slope Building 3: slope Building 4: slope	
Percent (%) of roof length with existing guttering	Building 1: 25% Building 2: No	
Volume of existing rainwater storage tanks if there are any	Building 1: No Building 2:No Building 3: No	

	Building 4:No
Who use the existing tanks if there are/is any	NA
User feedback on existing water tanks if there are any	NA
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building-1: 12 feet Building 2: 6 ft. Building-3: 22 ft Building 4: 6 ft
Roof type: Building 1	Concrete 
Roof type: building 2	Tin
Roof type: building 3	

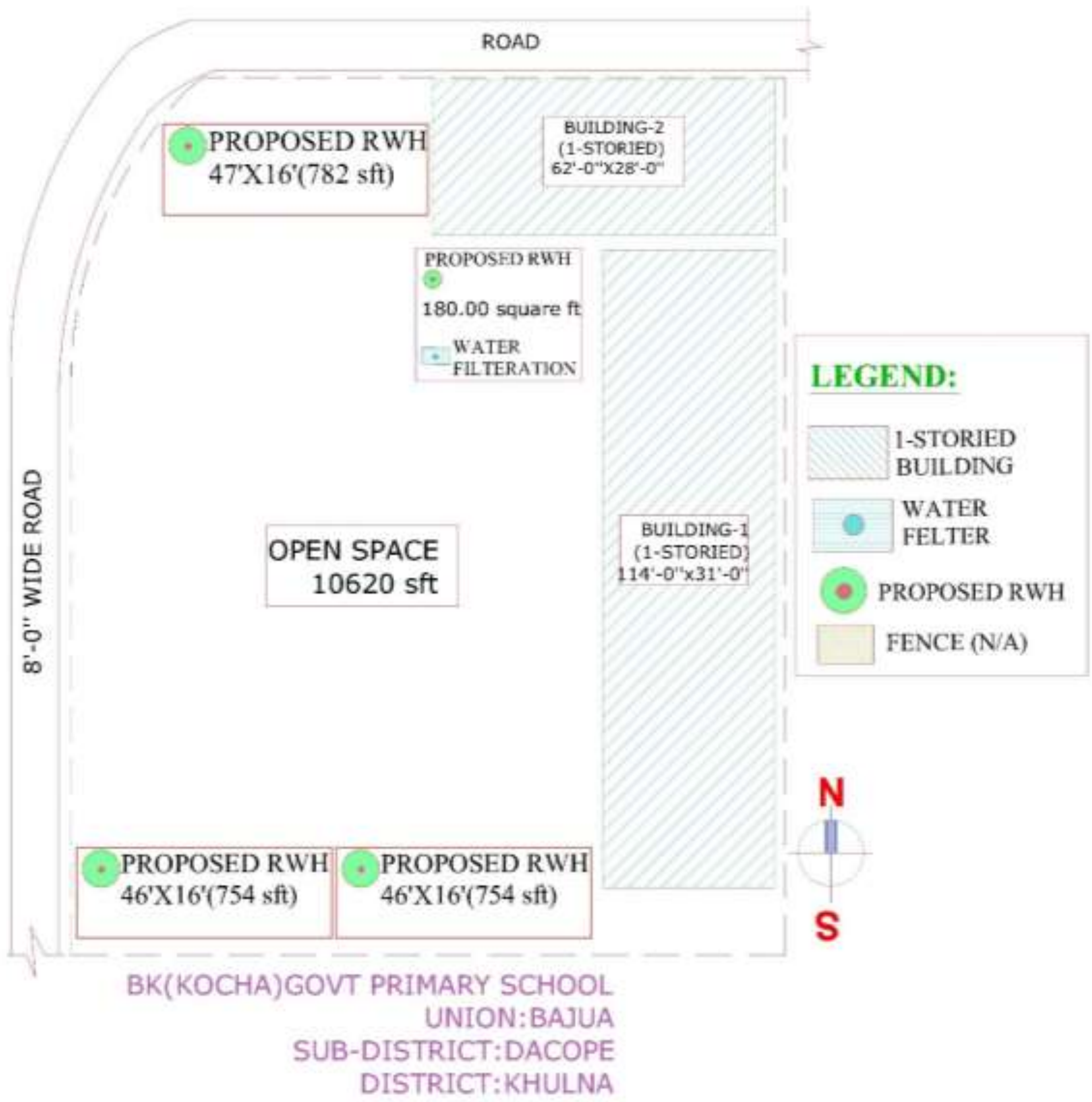
Roof type: building 4				
Specific queries	Building 1	Building 2	Building 3	Building 4
Roof treatment needed for RWH	Yes	Yes	Yes	Yes
Any obstacles on roof (tree, garbage storage, others)	Yes	No	No	Yes
Roof area covered by tree/garbage storage/others.	Yes	No	No	Yes
Rainfall intensity	1700 mm	1700 mm	1700 mm	1700 mm
Potentiality of rainwater volume (70% efficiency)annually	N/A	185 cubic meter	221cubic meter	167 cubic meter
Existing Downpipe availability	No	No	No	No
Available drawing of Building	No	No	No	No
Available drainage pipe Network	No	No	No	No
Construction completions	2008	2001	2001	2001
Evidence of leakage on existing pipe network	NA	NA	NA	NA
Number of toilets in building	3 inside the building	No	3 inside the building	No
Number of occupants in the building	170 students and teachers	100 students and teachers	150 including Students and teachers	No
Secondary catchment area		155 sq. meter		140 sq. meter
Potentiality of rain water volume (70% efficiency)		185 cubic meter		168 sq. meter
Evidence of wall damping	Building no 1 and 3 (the building was built recently 1.5 years ago) Building no 2 and 4 wall damping			

	
Wet section of the top ceiling	No for Building no 1 and 3
Existing Water Source?	Yes
What Types?	Commercial Water Plant/ 0.50paisa per liter
When installed?	1 month ago
How many HH uses?	Almost 1200 (according to informant)
Water Quality?	Good
Users Feedback?	The people are satisfied with the plant but it is not enough to fulfill the community demand. Before the plant the people of the community used to drink slightly saline tube-well water.
Any other water source	Yes. (tube-well water is saline)
Site boundary	No
More site photos	

9. Model Site Profile: BK (Kocha) Govt. Primary School and Cyclone Shelter

Latitude: 22.540393 **Longitude: 89.572342**

Site Location	**Village: Bajua (kocha)** **Union: Bajua** ▪ **Ward no: 8** **Upazila: Dacop** **District: Khulna**

Details layout plan of Site	
	
Proposed Drinking Water Source	RWH
Proposed Building Type	Educational

Number of building	2
Site Chief name /Position / Contact Number	Sochindronath Mondol, Head Master 01920-760708
Assistant Chief Contact person & Number	Murari Mohon Thandar, Secretary of School Managing Committee 01915-193967
Available space to install 538 cubic meter	Yes, 1560 sft
Soil Type	Sandy clay soil
Available open space that is not used for any purpose	Around 2500 sft.
Space for filtration Infrastructure (**minimum 100sft.**)	Yes, 180 sft (12x15)ft
Power connectivity available and condition	REB (3-4 hours load shedding per day)
Total land area	0.39 acre
Total open area	0.20 acre
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	2.5 feet
Groundwater level (**ft.**)	120 feet (saline) sluice
Nearby surface water (Canal) source and distance	Yes, 500 m. canal controlled by sluice gate and no high tide and low tide 
Salinity in nearby Canal	Yes

Potential threats(Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	NA
Site Boundary condition	No Site Boundary
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Subodh Memorial Community Clinic, 500 meter
Nearby Bazar name and distance	Bajua Hat, 5 km away
Distance from Upazila Sadar and medium of communication from	10, auto van, motor cycle, engine boat
Road network condition from site to Upazila Sadar	Good, carpeted road 
Total perimeter of the site	177 meter
Site Boundary Available	No
Site Boundary	NA
School authority will permit to install the water tank?	Yes but they need official decision by SMC meeting

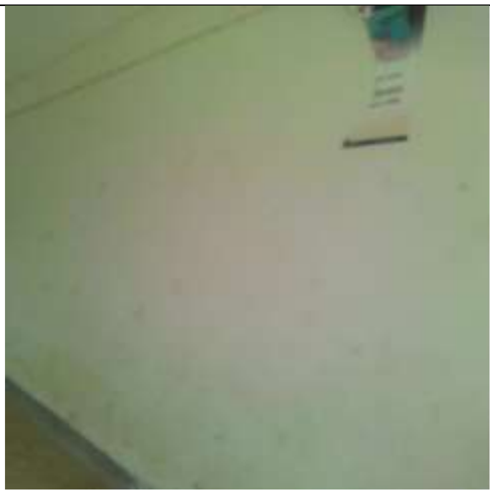
They will allow local community to take water from this point?	Yes
School committee will commit to maintain and operate the water tank with nominal support from community and school authority?	Yes
Number of household located within 1km from the institution	500-600 approx.

Building Information

Number of building	2
Number of floor of Building: 1	3
Number of floor of Building: 2	1 (abandoned)
Roof type	Building 1: Concrete Building 2: Tin (CI Sheet)
Roof dimension (m)	Building 1: (35 x 9.6) meter Building 2: (19 x 8.5) meter (abandoned)
Building 1: three storied building	Yes 
Building 2: Tin shed building	Yes 
Under construction building	No
Roof slope **(mm)**	Building 1- 1: 1000

	Building 2- 1: 1000	
Roof Length (in meter)	Building 1: 35 meter Building 2: 19 meter	**Area (m²)** Building 1: 336 sqm Building 2: 161.5 sqm
Roof Width (in meter)	Building 1: 9.6 meter Building 2: 8.5 meter	
Roof materials	Building 1: Concrete Building 2: concrete (abandoned)	
Roof Condition and treatment	Building 1: Good and moderate treatment needed Building 2: Building is abandoned	
The shape of the roof (gable, lean to etc.)	Building 1: slope Building 2: slope	
Percent (%) of roof length with existing guttering	Building 1: 50% Building2 : no	
Volume of existing rainwater storage tanks if there are any	Building 1: no Building 2: Yes (but abandoned and does not work)	
Who use the existing tanks if there are/is any	NA	
User feedback on existing water tanks if there are any	NA	
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 1: 33 ft. Building 2: 10 ft.	
Roof type: Building 1 two storied building	Yes 	
Roof type: building 2	Abandoned	

		
Specific queries	Building 1	Building 2
Roof treatment needed for RWH	yes	Unnecessary
Any obstacles on roof (tree, garbage storage, others)	No	yes
Roof area covered by tree/garbage storage/others.	NA	30
Rainfall intensity	1700 mm	1700 mm
Potentiality of rainwater volume (70% efficiency)annually	400 cubic meter	173 cubic meter
Existing Downpipe availability	Yes	No
Available drawing of Building	No	No
Available drainage pipe Network	No	No
Construction completions	2015	1995
Evidence of leakage on existing pipe network	No	No
Number of toilets in building	5 inside	No
Number of occupants in the building	120 students and teacher	abandoned
Secondary catchment area	NA	161 sqm (abandoned)
Potentiality of rain water volume (70% efficiency)	NA	192 cubic meter (abandoned)
Evidence of wall damping	No, there is no wall dumping	

	
Wet section of the top ceiling	No, there is no wet section 
Existing Water Source?	Yes
What Types?	Tube-well water pumped to tanks
When installed?	2016
How many HH uses?	120
Water Quality?	Slightly saline (but people also drinking)
Users Feedback?	This water is saline but community people drink this plant's water because they haven't alternative options
Any other water source	No
Site boundary	No

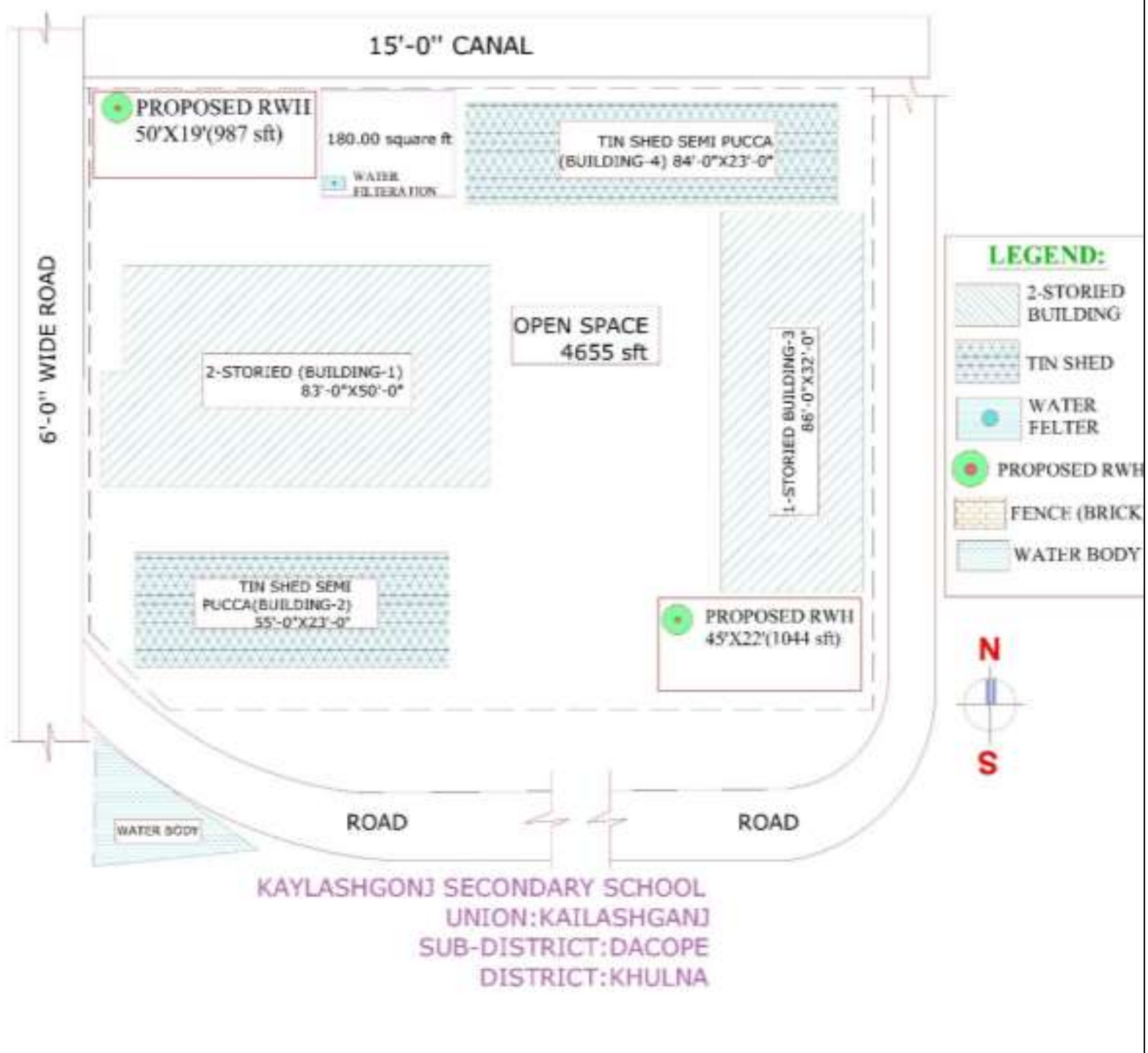
More site photos	 

10. Model Site Profile: Kailashganj Secondary School

Latitude: 22.511837 **Longitude: 89.502878**

Site Location	- **Village:** Kailashganj - **Union:** Kailashganj - **Ward No:** 5 - **Upazila:** Dacope - **District:** Khulna

Details layout plan of Site



Proposed Drinking Water Source	RWH
Proposed Building Type	Educational
Number of building	4
Site Chief name /Position / Contact Number	Manikanchan Chakroborty (Assistant Headmaster) Contact: 01724-002851

Assistant Chief Contact person & Number	Manikchandra Jain (Headmaster) Contact: 01716-537171
Available space to install 682 cubic meter	Yes, around 2000 sft
Soil Type	Sandy clay soil
Available open space that is not used for any purpose	Yes around 3500 sft
Space for filtration Infrastructure (**minimum 100sft.**)	180sft (12' X15')
Power connectivity available and condition	REB, (4-5 hour load shedding)
Total land area	1.5 acre
Total open area	0.5 acre
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	1.5 to 2 feet
Groundwater level (**ft.)**	60 feet (saline)
Nearby surface water(ponds) source and distance	Yes, 50 meter
Salinity in nearby Pond	yes (undrinkable)
Potential threats(Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	NA
Site Boundary condition	Old and condition is not good
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Kailashganj Comxmunity Clinic, 1 km

Nearby Bazar name and distance	Bajua Bazar, 5-6 km away Burirdabur Bazar, 2 km away
Distance from Upazila Sadar and medium of communication from	10 meter
Road network condition from site to Upazila Sadar	Very good
Total perimeter of the site	200 meter
Site Boundary Available	Yes
Site Boundary	
% of site boundary that is fenced	100%
Type of fence	Brick fence
School authority will permit to install the water tank?	Yes but they need formal decision through SMC meeting
They will allow local community to take water from this point?	Yes
School committee will commit to maintain and operate the water tank with nominal support from community and school authority?	Yes, but negotiable
Number of HH within 1km from the institution	600-700 approx.

Building Information

Number of building	4
Number of floor of Building: 1	2
Number of floor of Building: 2	1
Number of floor of Building: 3	1
Number of floor of Building: 4	1

Roof type	Concrete and tin shed
Roof dimension (m)	Building 1: (26m×15m) Building 2: (16.8m×7m) Building 3: (26.2m×9.75m) Building 4: (25.9m×7m)
	
Building 2: one storied tin shed semi pucca	
Building 3: one storied	

Building 4: one storied tin shed semi pucca		
Roof slope **(mm)**	Building 1-1:1000 Building 2- 1:1200 Building 3-1:1000 Building 4-1:1200	
Roof Length (in meter)	Building 1: 26 m Building 2: 16.8 m Building 3- 26.2 m Building 4- 25.9 m	**Area (m^2)** Building 1:390m^2 Building 2:118 m^2 Building 3-255 m^2 Building 4-181 m^2
Roof Width (in meter)	Building 1: 15 m Building 2: 7 m Building 3- 9.75 m Building 4- 7 m	
Roof materials	Building 1: Concrete Building 2: Tin (CI sheet) Building 3- Concrete Building 4- Tin (CI sheet)	
Roof Condition and treatment	Building 1: Good Building 2: Needs moderate treatment Building 3- Needs moderate treatment Building 4- Needs moderate treatment	
The shape of the roof (gable, lean to etc.)	Building 1: slope Building 2: slope Building 3- slope Building 4: slope	
Percent (%) of roof length with existing guttering	Building 1: 80% Building2 : No Building 3- No Building 4- No	

Volume of existing rainwater storage tanks if there are any	Building 1: 20000 liter Building 2: No Building 3- No Building 4- No
Who use the existing tanks if there are/is any	Only School students and teachers
User feedback on existing water tanks if there are any	Under constriction,
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 1: 23 ft. Building 2:10 ft. Building 3-12 ft. Building 4- 10 ft.
Roof type: Building 1 two storied building	
Roof type: building 2 tin shed semi pucca	

Roof type: building 3 one storied building	
Roof type: building 4 tin shed semi pucca	

Specific queries	Building 1	Building 2	Building 3	Building 4
Roof treatment needed for RWH	No	Yes	yes	Yes
Any obstacles on roof (tree, garbage storage, others)	No	yes	yes	yes
Roof area covered by tree/garbage storage/others.	No	30%	20%	30%
Rainfall intensity	1700mm	1700mm	1700mm	1700mm
Potentiality of rainwater volume (70% efficiency)annually	464 cubic meter	NA	309 cubic meter	NA
Existing Downpipe availability	Yes	no	yes	no
Available drawing of Building	No	No	No	No
Available drainage pipe Network	No	No	No	No
Construction completions	2015	2002	2000	2002
Evidence of leakage on existing pipe network	No	No	No	no
Number of toilets in building	8 inside, 3 outside	no	2 outside	No

Number of occupants in the building	180 students and teachers	90 students	150 students	200 person capacity hall room
Secondary catchment area	Na	118 sqm	255 sqm	181 sqm
Potentiality of rain water volume (70% efficiency)		141 cubic meter	304 sqm	216 cubic meter
Evidence of wall damping	No 			
Wet section of the top ceiling				
Existing Water Source?	Yes			
What Types?	RHW (5000×5) Liter			
When installed?	Under Construction			
How many HH uses?	No, only for school students			
Water Quality?	Till date have not started to drink water			
Users Feedback?	NA			
Any other water source	Tube-well			

Site boundary	 
More site photos	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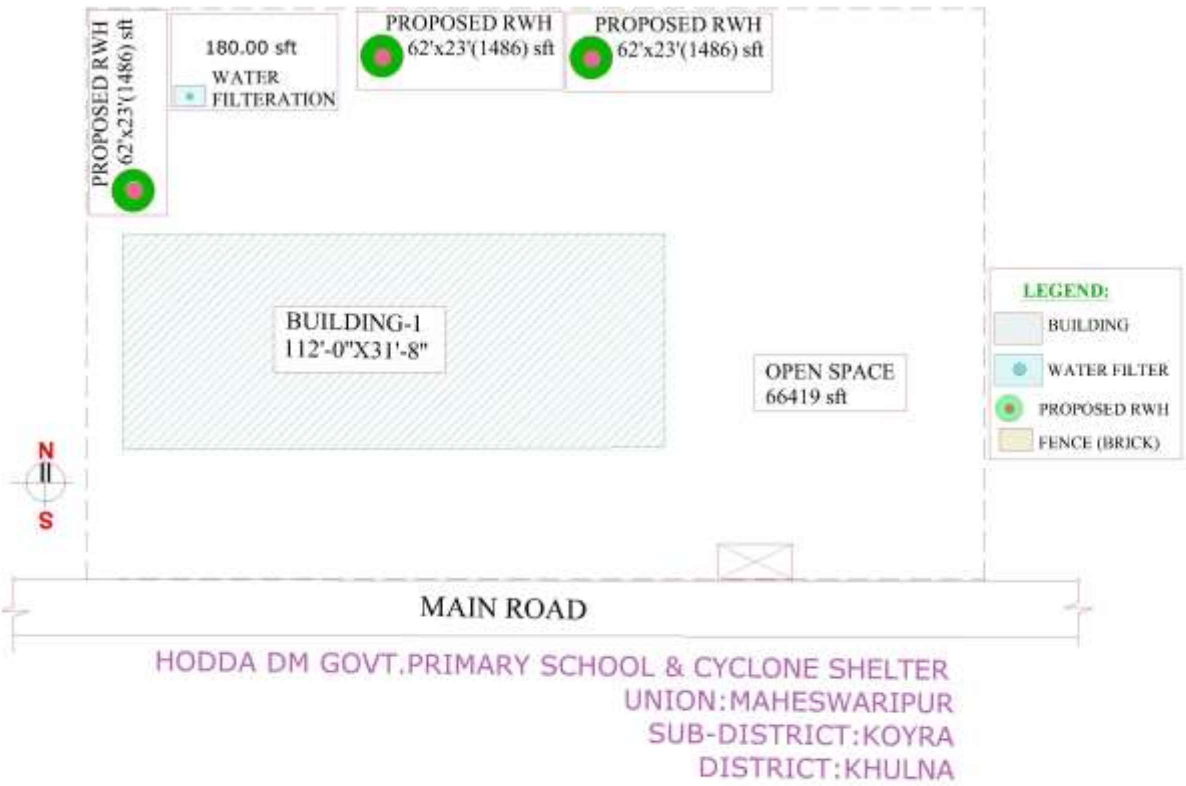
11. Model Site Profile: **Hodda DM govt. Primary school and cyclone shelter**

Site SI no: _________________, RF SI no: ______________________

Latitude: 22° 44' 47" **Longitude: 89° 38' 99"**

Site Location	**Village: Hodda** **Ward No.: 8** **Union: Maheswaripur** **Upazila: Koyra** **District: Khulna**
Details layout plan of Site	



Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Educational
Number of building	One (1)
Site Chief name /Position / Contact Number	Arun Kumar Sana Head Master 01728-229246
Assistant Chief Contact person & Number	Shyamal Kanti Mondal Assistant Teacher 01714-703238

Available space to install 522 cubic meter tank	Yes, 2900 sft.
Soil Type	Sandy clay
Area of available open space that is not used for any purpose	Around 2600sft
Space for filtration infrastructure (**minimum 100sft.**)	180 sft (12x15)
Power connectivity available and condition	REB, Good (3-4 hours load shedding daily), and Solar Panel
Total land area	0.52 acre.
Total open area	0.41 acre (average)
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	3.5 feet
Groundwater level (**ft.)**	Tub well Not Success
Nearby surface water (ponds) source and distance	Yes
Salinity in nearby Pond	Yes
Potential threats (Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	N/A
Site Boundary condition-	75% of site boundary is available which is in good condition
Availability filter materials (Coarse sand, stone)	yes
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Clinic Complex , 1.5 km
Nearby Bazar name and distance	DM School Bazar; 1/2 km

Distance from Upazila Sadar and medium of communication from	30 km; Motor cycle; local motor van, easy bike (battery), Van
Road network condition from site to Upazila Sadar	Good
Total perimeter of the site	4863 m (560'x 200' actual Use)
Site boundary available	Yes (3 Side)
Site boundary	
% of site boundary that is fenced	75%
Type of Fence	Brick Fence
More site photos	

Building Information

Number of Building	1 (one)
Number of floor of building 1	Two Stored Building

Roof types	Building 1: Reinforcement cement Concrete (RCC) SLAB	
Roof dimension (m)	Building 1: 34.14 m x 9.65 m	
Building 1: Two Storied Building		
Roof slope **(mm)**	Building 1: 1: 1000	
Roof Length (in meter)	Building 1: 34.14 m	**Area (m^2)** Building 1: 329.45 m^2
Roof Width (in meter)	Building 1: 9.65	
Roof materials	Building 1: Reinforcement cement Concrete (RCC)	
Roof Condition and treatment	Building 1: yes 	
The shape of the roof (gable, lean to etc.)	Building 1: Plain	
Percent (%) of roof length with existing guttering	Building 1: No	
Volume of existing rainwater storage tanks if there are any	Building 1: 8000 litter	

Who use the existing tanks if there are/is any	Students and teachers		
User feedback on existing water tanks if there are any	Need more water in dry session		
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 6: 7 m		
Roof type:	Building 1: Reinforcement cement Concrete (RCC) Slab		
Specific Quarries	Building 1:	Building 2:	Building 3:
Roof treatment needed for RWH?	yes	N/A	N/A
Any obstacles on roof (tree, garbage storage, others)	yes	N/A	N/A
Roof area covered by tree /garbage storage/others.	yes	N/A	N/A
Rainfall intensity	1700 mm	N/A	N/A
Potentiality of rainwater volume (70% efficiency) annually	391 cubic meter	N/A	N/A
Existing Downpipe availability	Yes	N/A	N/A
Available drawing of Building	No	N/A	N/A
Available drainage pipe network	No	N/A	N/A
Construction completions in	2004	N/A	N/A
Evidence of leakage on existing pipe network	N/A	N/A	N/A
Number of toilets in building	4 Nos	N/A	N/A
Number of occupants in the building	142 students & teacher	N/A	N/A
Secondary catchment area,	No		
Potentiality of rain water volume (70% efficiency)annually	N/A		
Evidence of wall damping	No		
Wet section of the top ceiling	No		
Existing Water Source?	Yes		
What Types?	RWH		
When installed?	2014		
How many HH uses?	No (only students use)		
Water Quality?	Drinkable		
Users Feedback?	Not Sufficing in Dry Session		
Any other water sources?	No		
Any other RWHs	No		

Other Questioner	

The school authority will permit to install the water tank?	In a board meeting, the authority have taken the decision to install the water tank in the school premise
They will allow local community to take water from this point,? to maintain and operate the water	Yes
School committee will commit tank with nominal support from community and school authority?	Yes
Number of HH and Population located within 1 km from institution	110-120 approx.

12. Model Site Profile: Hodda high school (Building 1)

Site SI no: _________________, RF SI no: ______________________

Latitude: 22° 46' 47" **Longitude: 89° 38' 99"**

Site Location	**Village: Hodda** **Ward No.: 8** **Union: Maheswaripur** **Upazila: Koyra** **District: Khulna.**

Details layout plan of Site

Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Educational
Number of building	One (1)
Site Chief name /Position / Contact Number	Niher Ranjan Sarder Head Master 01726-581535

Assistant Chief Contact person & Number	Jogesh Chandra Halder Assistant Teacher 01714-836907
Available space to install (319.60 cubic meter)	Yes around 2800 sft
Soil Type	Sandy Clay
Area of available open space that is not used for any purpose	Around 4500 sft
Area of available space for filtration infrastructure (**minimum 100sft.**)	180 sft (12x15)
Power connectivity available and condition	REB, Good (3-4 hours load shedding daily), and Solar Panel
Total land area	2.52 acre.
Total open area	1 acre (average)
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	3.5 feet
Groundwater level (**ft.**)	Tub well Not Success
Nearby surface water (ponds) source and distance	Yes 500 m
Salinity in nearby Pond	Yes 
Potential threats (Industry/Chimney) of surface water/rainwater pollution	No

Height of nearby industry/brickfield chimney	N/A
Site Boundary condition-	70-75% boundary is brick fenced which is in good condition
Availability filter materials (Coarse sand, stone)	yes
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Clinic Complex , 1.5 km
Nearby Bazar name and distance	DM School Bazar; 600m
Distance from Upazila Sadar and medium of communication from	30 km; Motor cycle; local motor van, easy bike (battery), Van
Road network condition from site to Upazila Sadar	Good
Total perimeter of the site	4863 m (560'x 200' actual Use)
Site boundary available	Yes (3 Side)
Site boundary	

% of site boundary that is fenced	70-75%
Type of Fence	Brick Fence
More site photos	

Building Information

Number of Building	1 (one)	
Number of floor of building 1	One Storied Building	
Roof types	Building 1: Reinforcement cement Concrete (RCC) SLAB	
Roof dimension (m)	Building 1: 28.04 m x 9.45 m (Two Storied Building)	
Building 1: One Storied Building		
Roof slope **(mm)**	Building 1: 1: 1000	
Roof Length (in meter)	Building 1: 28.04 m	**Area (m^2)** Building 1: 265.01 m^2
Roof Width (in meter)	Building 1: 9.45	
Roof materials	Building 1: Reinforcement cement Concrete (RCC)	

Roof Condition and treatment	Building 1: moderate treatment needed		
The shape of the roof (gable, lean to etc.)	Building 1: Plain		
Percent (%) of roof length with existing guttering	Building 1: No		
Volume of existing rainwater storage tanks if there are any	Building 1: 8000 litter		
Who use the existing tanks if there are/is any	Students		
User feedback on existing water tanks if there are any	Need more water in dry session		
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 4: 5.7 m		
Roof type: Building 1: One storied building	Reinforcement cement Concrete (RCC) Slab		
Specific Quarries	Building 1:	Building 2:	Building 3:
Roof treatment needed for RWH?	Yes	N/A	N/A
Any obstacles on roof (tree, garbage storage, others)	No	N/A	N/A
Roof area covered by tree /garbage storage/others.	No	N/A	N/A
Rainfall intensity	1700 mm	N/A	N/A
Potentiality of rainwater volume (70% efficiency) annually	319.60 cubic meter	N/A	N/A
Existing Downpipe availability	Yes	N/A	N/A
Available drawing of Building	No	N/A	N/A
Available drainage pipe network	No	N/A	N/A
Construction completions in	2015	N/A	N/A
Evidence of leakage on existing pipe network	N/A	N/A	N/A
Number of toilets in building	2 Nos	N/A	N/A
Number of occupants in the building	208 students & teacher	N/A	N/A
Secondary catchment area,	No		
Potentiality of rain water volume (70% efficiency)annually	N/A		
Evidence of wall damping	No		
Wet section of the top ceiling	No		
Existing Water Source?	Yes		
What Types?	RWH		
When installed?	2014		
How many HH uses?	No (only students use)		
Water Quality?	Drinkable		

Users Feedback?	Not Sufficing in Dry Session
Any other water sources?	No
Any other RWHs	No

Other Questioner	
The school authority will permit to install the water tank?	In a board meeting, the authority have taken the decision to install the water tank in the school premise
They will allow local community to take water from this point,? to maintain and operate the water	Yes
School committee will commit tank with nominal support from community and school authority?	Yes
Number of HH and Population located within 1 km from the institution	100-120 approx.

13. Model Site Profile: **Hodda majher chalk govt. primary school and cyclone shelters**

Site SI no: __________________, RF SI no: _______________________

Latitude: 89° 32' 47" **Longitude: 89° 36' 55"**

Site Location	**Village: Hodda** **Ward No.: 9** **Union: Maheswaripur** **Upazila: Koyra** **District: Khulna.**
Details layout plan of Site	

Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Educational
Number of building	One (1)
Site Chief name /Position / Contact Number	Suborato Kumar Biswas Assistant Headmaster 01969-80241

Assistant Chief Contact person & Number	Bidhan Kumar Sorder Assistant Teacher 01988-974134
Available space to install 522 cubic meter	Yes around 4000sft
Soil Type	Sandy clay
Area of available open space that is not used for any purpose	Around 7500sft
Space for filtration infrastructure (**minimum 100sft.**)	180 sft (12x15)
Power connectivity available and condition	Only Solar Panel
Total land area	0.50 acre.
Total open area	0.39 acre (average)
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	2.5 feet
Groundwater level (**ft.)**	Tub well Not Success
Nearby surface water (ponds) source and distance	No
Salinity in nearby Pond	N/A
Potential threats (Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	N/A
Site Boundary condition-	50-55% is bamboo fenced which is in moderate condition
Availability filter materials (Coarse sand, stone)	yes
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Clinic Complex , 3 m

Nearby Bazar name and distance	Hodda DM Bazar; 1.8 km
Distance from Upazila Sadar and medium of communication from	25 km; Motor cycle; local motor van, easy bike (battery), Van
Road network condition from site to Upazila Sadar	Good
Total perimeter of the site	596 m (200'x 98' actual Use)
Site boundary available	Yes
Site boundary	Yes 
% of site boundary that is fenced	50-55%
Type of Fence	Bamboo and net fence

More site photos	

Building Information

Number of Building	1 (one)	
Number of floor of building 1	Two Storied Building	
Roof types	Building 1: Reinforcement cement Concrete (RCC) SLAB	
Roof dimension (m)	Building 1: 24.08 m x 8.53 m & 11.28 m x 9.58 m L-Pattern (Two Storied Building)	
Building 1: Two Storied Building		
Roof slope **(mm)**	Building 1: 1: 1000	
Roof Length (in meter)	Building 1: 24.08 m & 11.28	**Area (m^2)** Building 1: 313.07 m^2
Roof Width (in meter)	Building 1: 8.53 m & 9.58	
Roof materials	Building 1: Reinforcement cement Concrete (RCC)	
Roof Condition and treatment	Building 1: moderate treatment needed	

The shape of the roof (gable, lean to etc.)	Building 1: Slop		
Percent (%) of roof length with existing guttering	Building 1: No		
Volume of existing rainwater storage tanks if there are any	Building 1: No		
Who use the existing tanks if there are/is any	N/A		
User feedback on existing water tanks if there are any	N/A		
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 6: 9.1 m		
Roof type: Building 1: Two storied building	Reinforcement cement Concrete (RCC) Slab		
Specific Quarries	Building 1:	Building 2:	Building 3:
Roof treatment needed for RWH?	Yes	N/A	N/A
Any obstacles on roof (tree, garbage storage, others)	No	N/A	N/A
Roof area covered by tree /garbage storage/others.	No	N/A	N/A
Rainfall intensity	1700 mm	N/A	N/A
Potentiality of rainwater volume (70% efficiency) annually	372.30 cubic meter	N/A	N/A
Existing Downpipe availability	No	N/A	N/A
Available drawing of Building	No	N/A	N/A
Available drainage pipe network	No	N/A	N/A
Construction completions in	2016	N/A	N/A
Evidence of leakage on existing pipe network	N/A	N/A	N/A
Number of toilets in building	3 Nos	N/A	N/A
Number of occupants in the building	85 students & teacher	N/A	N/A
Secondary catchment area,	No		
Potentiality of rain water volume (70% efficiency)annually	N/A		
Evidence of wall damping	No		
Wet section of the top ceiling	No		
Existing Water Source?	Yes		

	
What Types?	RWH (Building)
When installed?	2015
How many HH uses?	No (only students use)
Water Quality?	Drinkable)
Users Feedback?	Not Sufficing in Dry Session
Any other water sources?	No
Any other RWHs	No (only In School Building)

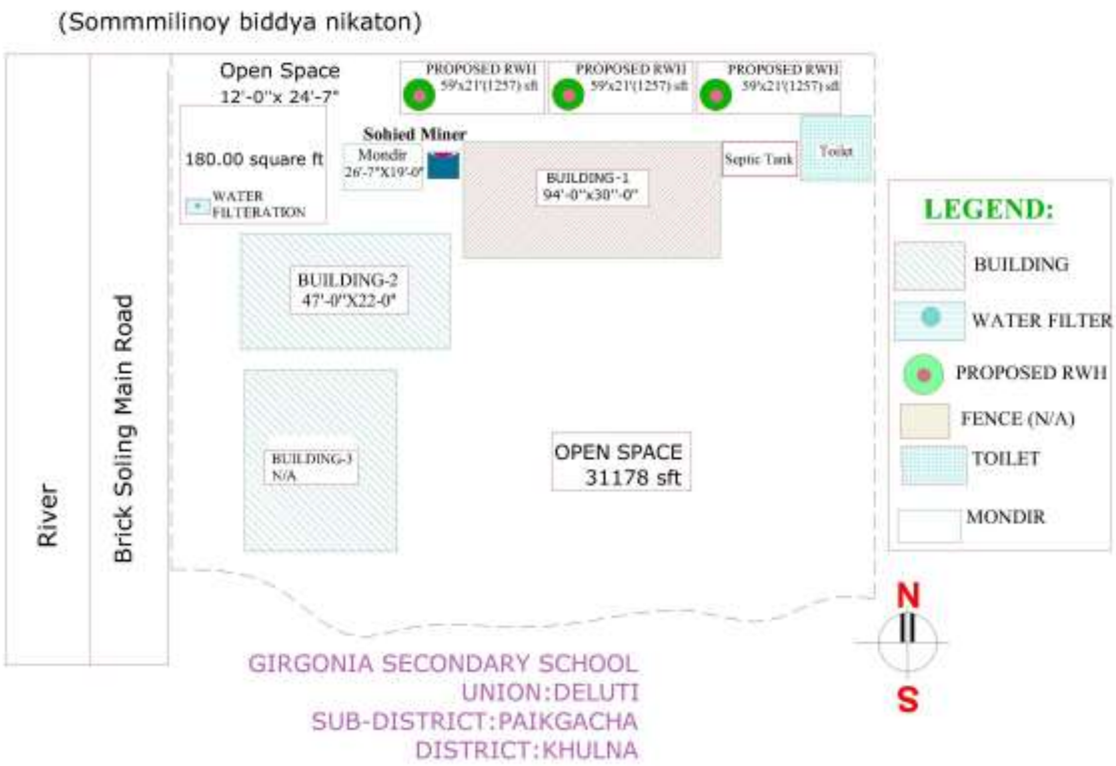
Other Questioner	
The school authority will permit to install the water tank?	In a board meeting, the authority have taken the decision to install the water tank in the school premise.
They will allow local community to take water from this point,? to maintain and operate the water	Yes
School committee will commit tank with nominal support from community and school authority?	Yes
Number of HH and Population located within 1 km from the institution	70-80 HH approx.

14. Model Site Profile: Girgonia Secondary School (Sommalony Biddya Nikaton)

Site SI no: __________________, RF SI no: _______________________

Latitude: 22° 61' 95" **Longitude: 89° 40' 29"**

Site Location	**Village: Gilbunia.** **Union: Deluti Paikgacha** **Ward no: 1** **Upazila: Paikgacha** **District: Khulna.**
Details layout plan of Site	



Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Educational
Number of building	Two (2)
Site Chief name /Position / Contact Number	Khogandra Nath Mondal Head Master 01712-334150
Assistant Chief Contact person & Number	Anindo Mondal Librarian 01942-423342

Available space to install 483 cubic meter	Yes, around 3700 sft
Soil type	Sandy
Area of available open space that is not used for any purpose	Yes, around 4000 sft
Space for filtration infrastructure (**minimum 100sft.**)	180 sft (12 x 15)
Power connectivity available and condition	REB, Good (3-4 hours load shedding daily), and Solar Panel
Total land area	1.5 acre.
Total open area	1 acre (average)
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	3.5 feet
Groundwater level (**ft.)**	100 feet (according to informant) , Saline
Nearby surface water (ponds) source and distance	No
Salinity in nearby Pond	N/A
Potential threats (Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	N/A
Site Boundary condition-	N/A
Availability filter materials (Coarse sand, stone)	yes
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Deluti Family Planning Center, 5 km Community Clinic Complex , 7 km
Nearby Bazar name and distance	Gilbunia Bazar; ½ km

Distance from Upazila Sadar and medium of communication from	18 km; Motor cycle; local motor van, easy bike (battery), Van with by Boat
Road network condition from site to Upazila Sadar	Bad
Total perimeter of the site	906 m (253'x 200' actual Use)
Site boundary available	No
Site boundary	N/A
More site photos	

Building Information

Number of Building	2
Number of floor of building 1	One Storied Building
Number of floor of building 2	CI Sheet Building
Roof types	Building 1: Reinforcement cement Concrete (RCC) SLAB Building 2: CI Sheet (Tin)
Roof dimension (m)	Building 1: 29.26m x 9.15 m (One Storied Building) Building 2: 14.32 m x 6.70 m (CI Sheet Building)

Building 1: One Storied Building		
Building 2: CI Sheet Building		
Building 3:	N/A	
Roof slope **(mm)**	Building 1: 1: 1000 Building 2: 1:1.5	
Roof Length (in meter)	Building 1: 29.26 m Building 2: 14.32 m	**Area (m^2)** Building 1: 267.72 m^2 Building 2: 95.94 m^2
Roof Width (in meter)	Building 1: 9.15 m Building 2: 6.70 m	
Roof materials	Building 1: Reinforcement cement Concrete (RCC) Building 2: CI Sheet	
Roof Condition and treatment	Building 1: Moderate treatment needed Building 2: Moderate treatment needed	
The shape of the roof (gable, lean to etc.)	Building 1: Slope Building 2: slope	
Percent (%) of roof length with existing guttering	Building 1: No Building 2: No	
Volume of existing rainwater storage tanks if there are any	Building 1: No Building 2: No	

Who use the existing tanks if there are/is any	N/A
User feedback on existing water tanks if there are any	N/A
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 1: 03 m Building 2: 1.82 m
Roof type: Building 1: one storied building	
Roof type: Building 2:	
Roof type: Building 3:	N/A

Specific Quarries	Building 1:	Building 2:
Roof treatment needed for RWH?	Yes	Yes
Any obstacles on roof (tree, garbage storage, others)	No	No
Roof area covered by tree /garbage storage/others.	No	No
Rainfall intensity	1700 mm	1700 mm
Potentiality of rainwater volume (70% efficiency) annually	319.60 cubic meter	105 cubic meter

Existing Downpipe availability	No	No
Available drawing of Building	No	No
Available drainage pipe network	No	No
Construction completions in	2015	2015
Evidence of leakage on existing pipe network	N/A	N/A
Number of toilets in building	2	No
Number of occupants in the building	90 students & teacher	30 students
Secondary catchment area,	No	
Potentiality of rain water volume (70% efficiency)annually	N/A	
Evidence of wall damping	Yes 	
Wet section of the top ceiling	No	
Existing Water Source?	Yes	

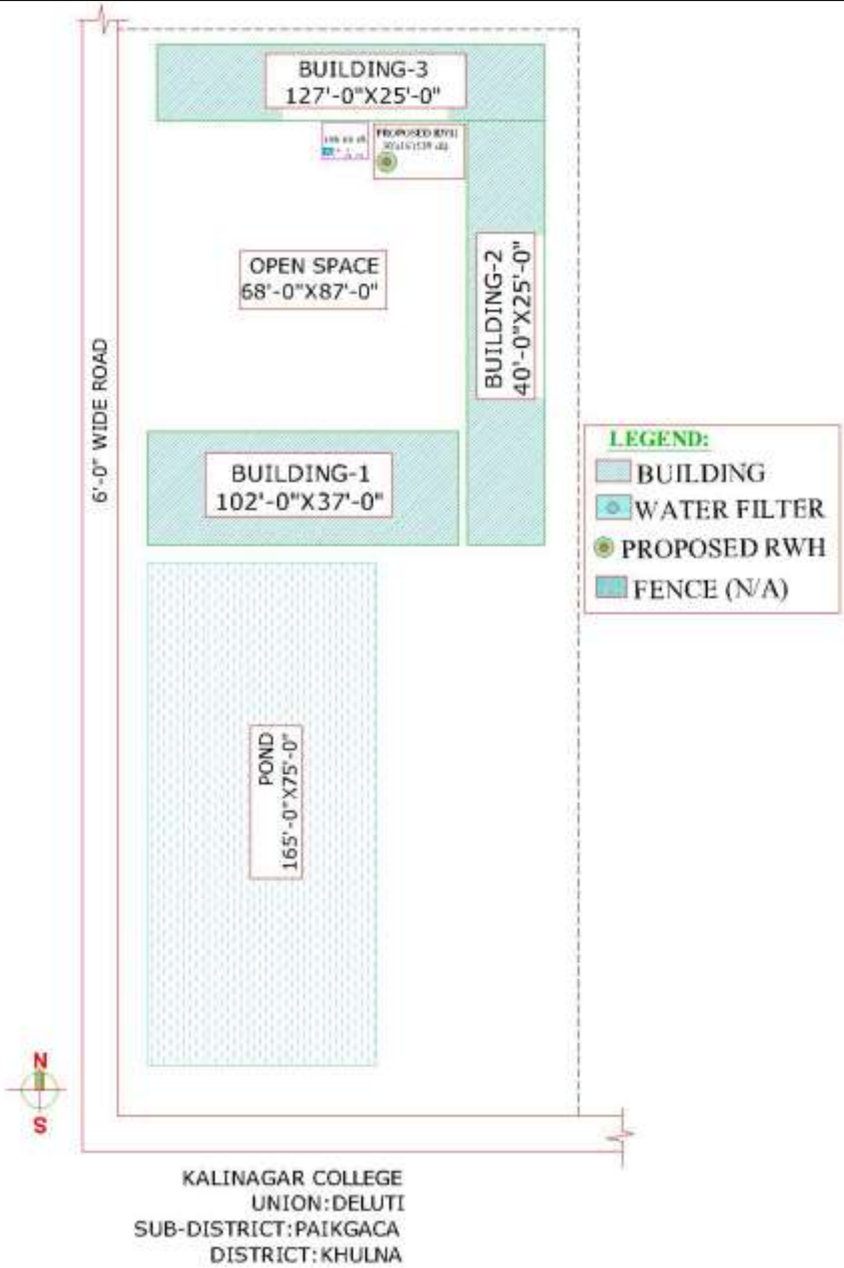
	
What Types?	Motor (Tube well)
When installed?	2015
How many HH uses?	No (only students use)
Water Quality?	Saline (not drinkable)
Users Feedback?	Only use for bathroom and others
Any other water sources?	No
Any other RWHs	No

Other Questioner	
The school authority will permit to install the water tank?	Yes, need permission from the SMC
They will allow local community to take water from this point,? to maintain and operate the water	Yes
School committee will commit tank with nominal support from community and school authority?	Yes
Number of HH and Population located within 1 km	200-250 approx

15. Model Site Profile: Kalinagor College, Deluti Paikgacha

Site SI no: __________________, RF SI no: _______________________

Site Location	**Village: Kalinagar** **Union: Deluti Paikgacha** **Ward no: 6** **Upazila: Paikgacha** **District: Khulna.**
Details layout plan of Site	



Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Educational
Number of building	3

Site Chief name /Position / Contact Number	Dibakar Mondal Principal, Cell: 01716252501
Assistant Chief Contact person & Number	Poritosh Mondal, Math Teacher,
Available space to install 626 cubic meter	11730 sq. ft
Soil type	Sandy
Area of available open space that is not used for any purpose	11730 sq. ft
Space for filtration infrastructure (**minimum 100sft.**)	Yes
Power connectivity available and condition	N/A
Total land area	47964 sq. ft.
Total open area	11730 sq. ft
Land elevation **(Mean Sea Level)**	6-7 feet
Highest Flooding Depth	4 ft
Groundwater level (**ft.)**	10-15 feet
Nearby surface water (ponds) source and distance	24feet
Salinity in nearby Pond	No
Potential threats (Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	N/A
Site Boundary condition-	Not Found
Availability filter materials (Coarse sand, stone)	Yes
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Hatbari Community Clinic and about distance about 3km from the college.

Nearby Bazar name and distance	Fulbari bazar and 8km from the college.
Distance from Upazila Sadar and medium of communication from	40 km and medium of communication is motorbike, auto rickshaw, boat.
Road network condition from site to Upazila Sadar	Very Poor
Total perimeter of the site	2 (343+ 137) feet = 960feet
Site boundary available	No
Site boundary	N/A
More site photos	

Building Information

Number of Building		3
Number of floor of building 1		4
Number of floor of building 2		1
Number of floor of building 3		1
Roof types		Building 1- RCC Building 2- Tin shed Building 3- Tin shed
Roof dimension (m)		Building 1: 102 x 37 feet Building 2: 139 x 25 feet Building 3: 127 x 25 feet

Building 1: Four Storied Building			
Building 2: CI Sheet Building			
Building 3: CI Sheet Building			
Roof slope **(mm)**		Building 1: 1: 1000 Building 2: 1: 2 Building 3: 1: 2	
Roof Length (in meter)		Building 1: 102 ft Building 2: 139 ft Building 3: 127 ft	**Area (m^2)** Building 1: Building 2:
Roof Width (in meter)		Building 1: 37 ft Building 2: 25 ft Building 3: 25 ft	
Roof materials		Building 1: RCC Building 2: CI Sheet Building 3: CI Sheet	
Roof Condition and treatment		Building 1: Moderate Treatment Needed Building 2: NA Building 3: NA	
The shape of the roof (gable, lean to etc.)		Building 1: Slope Building 2: Slope Building 3: Slope	
Percent (%) of roof length with existing guttering		Building 1: Building 2:	
Volume of existing rainwater storage tanks if there are any		Building 1: N/A Building 2: N/A	
Who use the existing tanks if there are/is any		N/A	
User feedback on existing water tanks if there are any		N/A	
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)		Building 1: 10 ft Building 2: Building 3:	
Roof type: Building 1: Four storied building		RCC	
Roof type: Building 2: CI sheet		CI sheet	

Roof type: Building 3: CI sheet	CI sheet		
Specific Quarries	Building 1:	Building 2:	Building 3:
Roof treatment needed for RWH?	Yes	No	No
Any obstacles on roof (tree, garbage storage, others)	No	No	No
Roof area covered by tree /garbage storage/others.	No	No	No
Rainfall intensity	1700 mm	1700 mm	1700 mm
Potentiality of rainwater volume (70% efficiency) annually	1190mm	1190mm	1190mm
Existing Downpipe availability	Yes	No	No
Available drawing of Building	No	No	No
Available drainage pipe network	Yes	Yes	Yes
Construction completions in	Under Construction		
Evidence of leakage on existing pipe network	No	No	No
Number of toilets in building	12	N/A	2
Number of occupants in the building			
Secondary catchment area,	No		
Potentiality of rain water volume (70% efficiency)annually	1190mm		
Evidence of wall damping	No		
Wet section of the top ceiling	No		
Existing Water Source?	Yes		
What Types?	Motor		
When installed?	2016		
How many HH uses?	Only Students		
Water Quality?	Saline		
Users Feedback?	Other uses only		
Any other water sources?	Pond		
Any other RWHs	No		

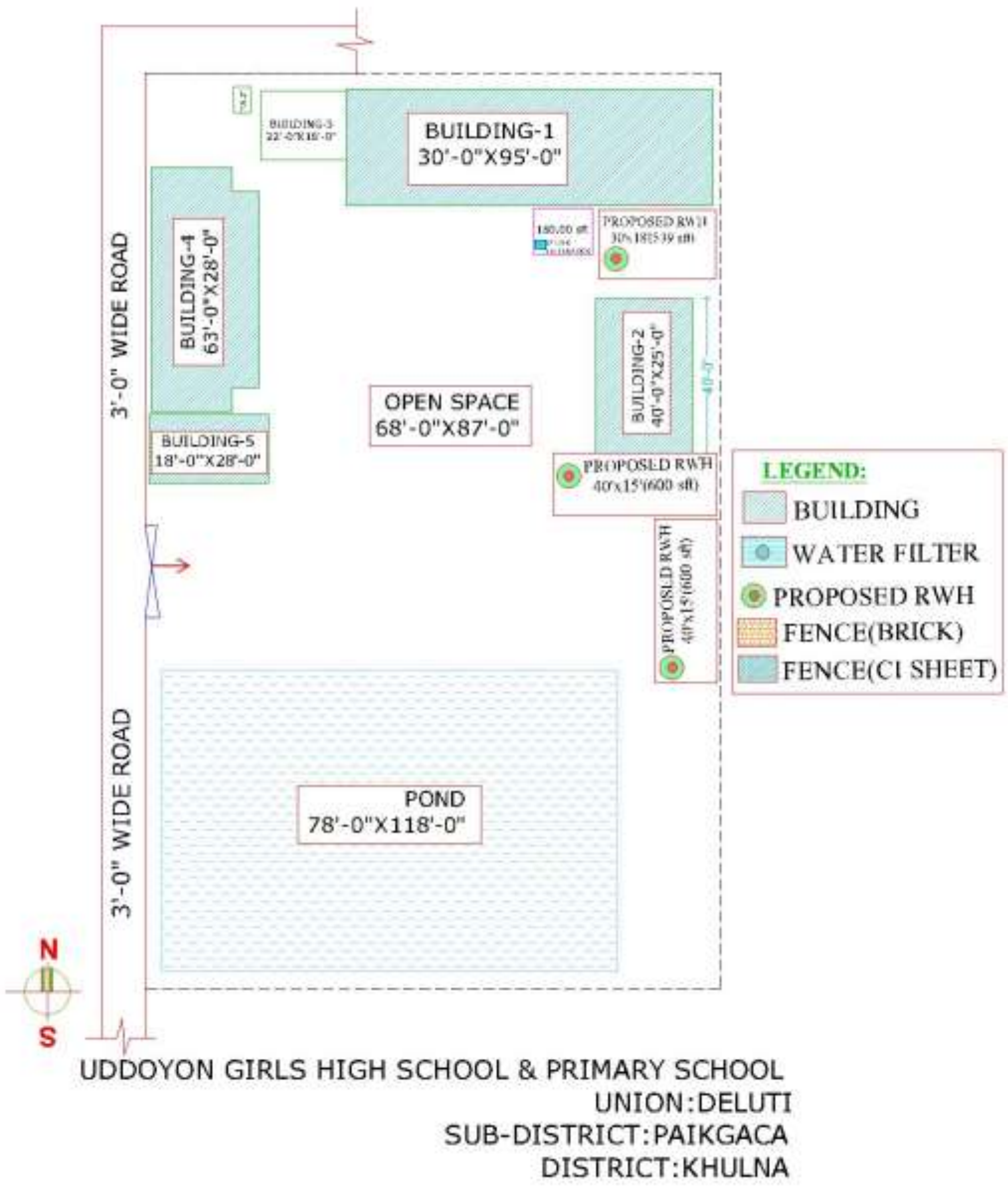
Other Questioner	
The school authority will permit to install the water tank?	Yes
They will allow local community to take water from this point,? to maintain and operate the water	Yes
School committee will commit tank with nominal support from community and school authority?	Yes

Number of HH and Population located within 1 km	100- 150 households approx

16.-17. Model Site Profile: Uddyon Girls High School and Uddoyon Govt. Primary School

Site SI no: __________________, RF SI no: _______________________

Site Location	**Village: Kalinagar** **Union: Deluti Paikgacha** **Ward no: 6** **Upazila: Paikgacha** **District: Khulna.**
Details layout plan of Site	



Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Educational

Number of building	Total 5 (Building 1, 2 and 3 for Uddyon Girls High School Building 4 and 5 for Uddoyon Govt. Primary School
Site Chief name /Position / Contact Number	Gopal Chandra Mondal (Uddyon Girls High School) Headmaster Cell- 01739923307
Assistant Chief Contact person & Number	Parimal Kanti Sardar (Uddoyon Govt. Primary School) Headmaster Cell-01725358475
Available space to install 1018 cubic meter	11040 sq ft
Soil type	Sandy
Area of available open space that is not used for any purpose	1400 sq ft (56 x 25)
Space for filtration infrastructure (**minimum 100sft.**)	1400 sq ft (56 x 25)
Power connectivity available and condition	Electricity Not available, Solar Panel
Total land area	34177 sq ft (239 x 143)
Total open area	12440 sq ft
Land elevation **(Mean Sea Level)**	6-7 feet
Highest Flooding Depth	3 feet
Groundwater level (**ft.)**	10-15 feet
Nearby surface water (ponds) source and distance	140 feet
Salinity in nearby Pond	No
Potential threats (Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	No industry/ brickfield
Site Boundary condition-	Very poor fencing system, Front gate with RCC Wall 10%, CI Sheet fence 25%, bamboo fence 45% side and No Fence on other 20%
Availability filter materials (Coarse sand, stone)	No
Skilled construction manpower availability	Yes

Nearby Hospital/community clinic name and distance	Hatbari Community Clinic (2km distance)
Nearby Bazar name and distance	Fulbari Bazar (6-7 km)
Distance from Upazila Sadar and medium of communication from	15 km Medium of communication is Motor Cycle, Auto Rickshaw, Boat Motorcycle/ local vehicles Trawler (13 km)-
Road network condition from site to Upazila Sadar	Very Poor
Total perimeter of the site	764 ft
Site boundary available	Yes, 10% covered by brick wall and 70% with bamboo and ci sheet fence and rest 20% is open and adjacent to a pond.
Site boundary	
More site photos	

Building Information

Number of Building	5
Number of floor of building 1	1- Uddyon Girls High School (Main Building)

Number of floor of building 2 Number of floor of building 3	1- Uddyon Girls High School (Annex 1CI Sheet Building) 1- Uddyon Girls High School (Annex 2 CI Sheet Building)
Number of floor of building 4 Number of floor of building 5	1- Uddoyon Govt. Primary School (Main Building) 1- Uddoyon Govt. Primary School (Annex CI Sheet Building)
Roof types	Building 1: Reinforcement cement concrete (RCC) SLAB Building 2: Annex 1CI Sheet Building Building 3: Annex 2 CI Sheet Building Building 4: Reinforcement cement concrete (RCC) SLAB Building 5: Annex 2 CI Sheet Building
Roof dimension (m)	Building 1: 95.10 x 30.09 ft Building 2: 40.7 x 23 ft Building 3: 18.10 x 22 ft Building 4: 63.10 x 28.10 ft Building 5: 28 x 18.5 ft
Building 1: One Storied Building	
Building 2: CI Sheet Building	
Building 3:	

Building 4:		
Roof slope **(mm)**	Building 1: 1:1000 Building 2: 1:2 Building 3: 1:2 Building 4: 1:1000 Building 5: 1:2	
Roof Length (in meter)	Building 1: 95.10 ft Building 2: 40.7 ft Building 3: 18.10 ft Building 4: 63.10 ft Building 5: 28 ft	**Area (ft^2)** Building 1: 2861.60 Building 2: 936.1 Building 3: 398.2 Building 4: 1773.11 Building 5: 518
Roof Width (in meter)	Building 1: 30.09 ft Building 2: 23 ft Building 3: 22 ft Building 4: 28.10 ft Building 5: 18.5 ft	
Roof materials	Building 1: Reinforcement cement concrete (RCC) SLAB Building 2: Annex 1CI Sheet Building Building 3: Annex 2 CI Sheet Building Building 4: Reinforcement cement concrete (RCC) SLAB Building 5: Annex 2 CI Sheet Building	
Roof Condition and treatment	Building 1: Minimum treatment needed Building 2: Moderate Treatment needed Building 3: Moderate Treatment needed Building 4: Moderate Treatment needed Building 5: Moderate Treatment needed	
The shape of the roof (gable, lean to etc.)	Building 1: Slope Building 2: Slope Building 3: Slope Building 4: Slope Building 5: Slope	
Percent (%) of roof length with existing guttering	Building 1: 100 Building 2: 100 Building 3: 100 Building 4: 100 Building 5: 100	
Volume of existing rainwater storage tanks if there are any	Building 1: 1000 litre Building 2: No Building 3: No Building 4: No Building 5: No	
Who use the existing tanks if there are/is any	N/A	
User feedback on existing water tanks if there are any	No water just a blank Water Tank, Not yet used	

Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 1: 10ft Building 2: 8ft Building 3:8 ft Building 4: 10ft Building 5: 8ft				
Roof type: Building 1: one storied building	Reinforcement cement concrete (RCC) SLAB				
Roof type: Building 2:	CI Sheet				
Roof type: Building 3:	CI Sheet				
Roof type: Building 4:	Reinforcement cement concrete (RCC) SLAB				
Roof type: Building 5: one storied building	CI Sheet				
Specific Quarries	Building: 1	Building: 2	Building: 3	Building 4:	Building 5
Roof treatment needed for RWH?	Yes	Yes	Yes	Yes	Yes
Any obstacles on roof (tree, garbage storage, others)	No	No	No	No	No
Roof area covered by tree /garbage storage/others.	No	No	No	No	No
Rainfall intensity	1700mm	1700mm	1700mm	1700mm	1700mm
Potentiality of rainwater volume (70% efficiency) annually	1190			1190	
Existing Downpipe availability	No	No	No	No	No
Available drawing of Building	No	No	No	No	No
Available drainage pipe network	No			No	No
Construction completions in	2015	2015	1992	1995	1995
Evidence of leakage on existing pipe network	No	No	No	No	No
Number of toilets in building	3	1	1	1	1
Number of occupants in the building	3	1	1	2	1
Secondary catchment area,	No				
Potentiality of rain water volume (70% efficiency)annually	1190				
Evidence of wall damping					
Wet section of the top ceiling	No				

Existing Water Source?	Shallow Tube well (Saline)
What Types?	Shallow
When installed?	1995
How many HH uses?	Students (150), around 1500-2000 people
Water Quality?	Saline
Users Feedback?	Not drinkable
Any other water sources?	No, Poor drinking water availability
Any other RWHs	No

Other Questioner	
The school authority will permit to install the water tank?	Yes
They will allow local community to take water from this point,? to maintain and operate the water	Yes
School committee will commit tank with nominal support from community and school authority?	Yes
Number of HH and population located within 1 km	350-400 households

18. **Model Site Profile: 47 No. Padmapukur Govt. Primary School**

Latitude: 22°.21' 2" N	**Longitude: 89°.13′ 0″ E**
Site Location	**Village:** Pakhimara (Ward No. 03) **Union:** Padmapukur ▪ **Ward no: 3** **Upazila:** Shyamnagar **District:** Satkhira

Details layout plan of Site	
	
Proposed Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Primary School cum Cyclone Shelter

Number of building	2
Site Chief name /Position / Contact Number	Mostafa Kamal, Head Teacher Cell No: 01714515360
Assistant Chief Contact person & Number	Washim Kumar, Assistant Head Teacher Cell No. 01715072368
Available space to install 600 cubic meter	Yes, around 800 sft
Soil Type	Sandy Clay
Area of available open space that is not used for any purpose	Around 1500 sft
Space for filtration Infrastructure (**minimum 100sft.**)	180 sft
Power connectivity available and condition	**REB, 18 hours power supply available**
Total land area	1 bigha (0.33 acre)
Total open area	0.5 bigha (0.16 acre)
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	**4 feet (During Ail**a)
Groundwater level (**ft.)**	**500-600 feet** (Local opinion)
Nearby surface water(ponds) source and distance	Yes, Adjacent to the building. (**150x120**) **feet** 
Salinity in nearby Pond	Yes, slightly
Potential threats(Industry/Chimney) of surface water/rainwater pollution	No
Height of nearby industry/brickfield chimney	N/A
Site Boundary condition	No boundary wall or fence was available
Availability filter materials (Coarse sand, stone)	Yes
Skilled construction manpower availability	Yes

Nearby Hospital/community clinic name and distance	Community Health Complex; **4 km**
Nearby Bazar name and distance	Noabeki Bazar; **1.5 km** (Transport: **van and boat**)
Distance from Upazila Sadar and medium of communication from	**10 km;** Boat and Motor cycle/ local motor van/easy bike (battery)/Bus.
Road network condition from site to Upazila Sadar	Moderate (pacca, river, pacca)
Total perimeter of the site	**160 m**
Site Boundary Available	No boundary wall or fence was available
Site Boundary	N/A
School authority will permit to install the water tank?	Yes, permission needed from the SMC
They will allow local community to take water from this point?	Yes
School committee will commit to maintain and operate the water tank with nominal support from community and school authority?	Yes
Number of HH within 1km from the institution	200-250 approx.

Building Information

Number of building	2
Number of floor of Building: 1	Two storied Building
Number of floor of Building: 2	N/A (Damaged building)
Roof type	Concrete
Roof dimension (m)	Two storied building **(34x10)m**
Building 1: two storied building	

		
Building 2 : Damaged building	N/A	
Roof slope **(mm)**	Building 1- Two storied building (1:1000)**mm**	
Roof Length (in meter)	Building 1: 35**m**	**Area (m^2)**
Roof Width (in meter)	Building 1: 10**m**	Building 1: 350**m^2**
Roof materials	Building 1: Two storied building **concrete**	
Roof Condition and treatment	Building 1: **Moderate treatment required**	
The shape of the roof (gable, lean to etc.)	Building 1: Slope	
Percent (%) of roof length with existing guttering	Building 1: Two storied building (**95 %**)	
Volume of existing rainwater storage tanks if there are any	Building 1: N/A	
Who use the existing tanks if there are/is any	N/A	
User feedback on existing water tanks if there are any	N/A	
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Building 1: Two storied building (**20 feet**)	

Roof type: Building 1 two storied building	RCC  
Roof type: building 2	N/A
Specific queries	**Building 1**
Roof treatment needed for RWH	Yes, plaster treatment may require
Any obstacles on roof (tree, garbage storage, others)	Yes
Roof area covered by tree/garbage storage/others.	Two storied building (**10 Percent**)

Rainfall intensity	1700 mm annually
Potentiality of rainwater volume (70% efficiency)annually	**416**
Existing Downpipe availability	Yes
Available drawing of Building	No
Available drainage pipe Network	No
Construction completions	2009-10
Evidence of leakage on existing pipe network	No
Number of toilets in building	03 inside
Number of occupants in the building	**220 (students & teachers)**
Secondary catchment area	N/A
Potentiality of rain water volume (70% efficiency)	N/A
Evidence of wall damping	There was no wall damping
Wet section of the top ceiling	No
Existing Water Source?	Yes
What Types?	**Pipeline drinking water supply** provided by Muslim Aid in collaboration with BD Govt. and WHO. Solar Pumping Drinking Water Plant (**2 km far from the site**). 

The next tap is 200 meter away from sites

	
When installed?	2012
How many HH uses?	**220 students and teachers** and **30-40 households** depends on that water supply
Water Quality?	The pipeline supply water is good for drinking. Tube well water gets iron even after installing **500-600 feet deep pipe.**
Users Feedback?	The people of the locality do not get water all the time when they needed.
Any other water source	No
Site boundary	No boundary wall/fence was available
More site photos	**Mosque (Two storied building) 30 yards far from the main site with dimension of (13x11)** 

	
Damaged Building	

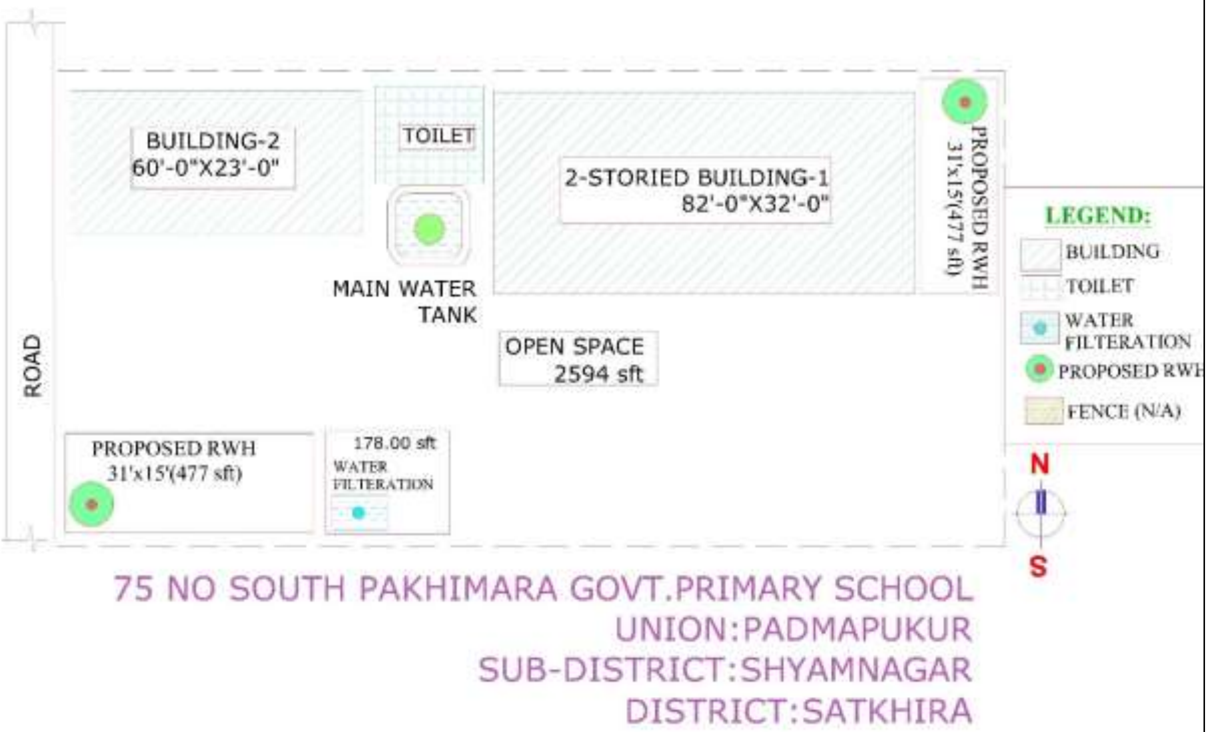
19. Model Site Profile: 75 No. South Pakhimara Govt. Primary School

UNDP Site Sl no: ________________, RF Sl no: ______________________

Latitude: **22°.21′ 2″ N** Longitude **89°.13′0″ E**

Site Location	▪ **Village:** Pakhimara (Ward No. 03 ▪ **Union:** Padmapukur ▪ **Ward no: 3** ▪ **Upazila:** Shyamnagar ▪ **District:** Satkhira

Details layout plan of Site



Proposed Main Drinking Water Source	Rain Water Harvesting System
Proposed Building Type	Cyclone Shelter cum Primary School
Number of building	2
Site Chief name /Position / Contact Number	G.M. Mijanur Rahman, Head Teacher Cell No: 01914772432
Assistant Chief Contact person & Number	B. M. Anowarul Haque, Assistant Head Teacher Cell No. 01944485460
Available space to install **383** cubic meter	Yes, around 950 sft

Soil type	Sandy Clay
Area of available open space that is not used for any purpose	Around 2000 sft
Space for filtration infrastructure (**minimum 100sft.**)	178 sft
Power connectivity available and condition	REB, 18 hours power supply available
Total land area	1 bigha (0.33 acre)
Total open area	0.7 bigha (0.2 acre)
Land elevation **(Mean Sea Level)**	5 meter
Highest Flooding Depth	**4 feet** (During Aila)
Groundwater level (**ft.)**	**480-510 feet** (Local opinion)
Nearby surface water (ponds) source and distance	**200 yards due north.** 
Salinity in nearby Pond	No

Potential threats (Industry/Chimney) of surface water/rainwater pollution	Yes, On the other side of the river (Picture taken from the roof of the site building) 
Site Boundary condition	No boundary wall or fence was available
Availability filter materials (Coarse sand, stone)	Yes
Skilled construction manpower availability	Yes
Nearby Hospital/community clinic name and distance	Community Health Complex; **3km**
Nearby Bazar name and distance	**Noyabeki Bazar; 1 km** (Transport: Van and Boat)
Distance from Upazila Sadar and medium of communication from	**10km**; Boat andMotor cycle/ local motor van/easy bike (battery)/Bus.
Road network condition from site to Upazila Sadar	Moderate (brick road, river, pacca)
Total perimeter of the site	180 m
Site boundary available	No boundary wall or fence were available

Building Information

Number of floor	Two storied Building, Single
Roof dimension (m)	Building 1: Two storied building (**25×9.5**)**m** Building 2: Semi pacca building (**18x6.5**)**m**

Two storied building **(25×9.5)**	
Semi pacca building (**18x6.5**)	
Roof slope **(mm)**	Two storied building (1:1000) Tin shed building (1:1000)
Roof Area (m^2)	Two storied building (**237**)**m^2** Semi pacca building (**104**)**m^2**
Roof materials	**Building 1: concrete** Building 2: **Tin shed** (CI Sheet)
Roof Condition and treatment	Building 1: **Moderate treatment required** Building 2: Tin need to be replaced with new Tins
The shape of the roof (gable, lean to etc.)	Building 1: Slope Building 2: Slope

Percent (%) of roof length with existing guttering	Two storied building (**70 %**) Semi pacca building (**No guttering**)
Volume of existing rainwater storage tanks if there are any	Rain Water Harvest Plant (**2 cum**)  Plastic tank (**1000 litre**) 
Height of the wall under the eaves of roof (to ensure that the tank can fit under the guttering)	Two storied building (**20 feet**)
Roof type: two storied building	RCC

Roof treatment needed for RWH	Yes, plaster treatment may required
Any obstacles on roof (tree, garbage storage, others)	Yes
Roof area covered by tree/garbage storage/others.	Two storied building (**10 Percent**) Semi pacca building (**20 percent**)
Rainfall intensity	1700 mm annually
Catchment Area (excluding the area covered by tree/garbage storage/others)	Two storied building (**210 m^2**) Semi pacca (**95 m^2**)
Potentiality of rainwater volume (70% efficiency)annually for According to ToR guidelines building structure	**268cubic meter**
Available open space that is not used for any purpose	Yes
Space for filtration infrastructure (**minimum 100sft.**)	Yes
Construction completions	2013
Existing pipe network	Yes
Evidence of leakage on existing pipe network	No
Number of toilets in building	03
Number of occupants in the building	**90 (students & teachers)**
Evidence of wall damping	No
Wet section of the top ceiling	No
Existing Water Source?	Yes
What Types?	RWHs (are being used only for wash and toilet purposes not for drinking)
When installed?	2013
How many HH uses?	**90 students and teachers**
Water Quality?	Not refined
Users Feedback?	The people of this locality mostly used tubewell water for drinking. But the ground water level was highly deep (480-510 feet). That's why most of the tubewell was in no use and damaged. There was also a **Water Tank near (150 yard)**the school which was installed by **GIZ in 2011** for the purpose of supplying drinking water for the locality but as the ground water level was so deep it couldn't pump water from the ground. The local people said it remained useless from time of its installment. The school had a potentiality to catch

	more than 160there was also a two water tank to store rain water but this water only used for the toilets. Students brings water from their own or neighbor home for drinking. If there were an arrangement/water treatment plant to refine this rain water the students could drink pure rain water moreover nearby people could also use it for their safe drinking.
Any other water sources?	No
Broken PSF	**Yes** 
Damaged tubewell	03 (in the school compound)

	 
Site boundary	No boundary wall or fence was available
Existing RWHs	Yes

Solar Pumping Water Supply Tank installed by **GIZ** (not in work since time its installment because of the ground water level is too deep to pump iron and salinity free drinking water)