Mapping Water Use and Risk: A Study on Turag River Area in Tongi

Submitted by

Shamima Prodhan

Examination Roll Number: 01

Registration Number: 29

Session: 2016-17

Master of Philosophy (MPhil)

Institute of Disaster Management and Vulnerability Studies

University of Dhaka

A thesis submitted to the Institute of Disaster Management and Vulnerability Studies (IDMVS), University of Dhaka in conformity with the requirements for the Degree of Master of Philosophy (MPhil)

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Declaration

The dissertation entitled "***Mapping Water Use and Risk: A Study on Turag River Area in Tongi***" is conducted under the supervision of **Dr. Mahbuba Nasreen**, Professor and former Director, Institute of Disaster Management and Vulnerability Studies (IDMVS), University of Dhaka (currently serving as the Pro-Vice-Chancellor on deputation at the Bangladesh Open University).

I hereby certify that the dissertation submitted to the University of Dhaka for the award of a Master of Philosophy (MPhil) degree is an original research work, that the substance of this thesis, in whole or in part, has not been previously published or quoted, and are acknowledged by a complete list of references.

Shamima Prodhan

Date: 27.10.2021

Examination Roll Number: 01
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Mapping Water Use and Risk: A Study on Turag River Area in Tongi

A Master of Philosophy (MPhil) Dissertation

By

Shamima Prodhan

Approval of the Supervisor

Dr. Mahbuba Nasreen

Professor and former Director

Institute of Disaster Management and Vulnerability Studies (IDMVS)

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DEDICATED

TO

MY ADORED

HUSBAND & DAUGHTER

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The Author

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Abstract

Safe water at home is critical for living a healthier life. Though water scarcity has never been a problem in the riverine Bangladesh, a reliable supply of water is becoming increasingly scarce. Water pollution places a greater strain on people's ability to afford water in both urban and rural areas, especially those who belong to low-income category. Unplanned urbanization, industrial expansion, and a massive population have increased interactions between various water users, altered water environment, poisoned river sources, lowered ground water tables, and modified the water regime. The present study focuses on urban water sources, their usage pattern, and the associated risks following mixed method approach- household survey using a standard semi-structured questionnaire at twelve different locations along the Turag River in the capital city Dhaka. A survey of water use behavior (observation) was held for eight days at two locations from 7 am to 5 pm. Focus Group Discussions (FGD) were also conducted at the six sites of Turag River area. The Key Informant Interviews (KII) were also conducted to get detailed information from different locations. Electric/motor tube well (73.8%), public pipe and tap water (23.3%), shallow and deep tube well (2.6%), and other open sources such as rainwater, river, lake, pond, etc. (2.8%) were documented as the primary sources of water for researched communities. In terms of their interactions with the Turag River, the community was mostly observed to gathering water for the home, washing (clothes or dishes or properties), navigation/transportation, commercial use, duck rearing, bathing, and a variety of other recreational activities with a gender variation- women (56.9%) interacting with the river more than men (43.1%). Communities also reported about suffering from different waterborne diseases such as gastric/ulcers/stomach pain (36.6%), skin disease (12.6%), dysentery (12.5%), chikungunya/dengue/malaria (11.1%), jaundice (9.2%), typhoid (6.0%), tuberculosis/pneumonia (5.4%), cholera (0.8%) and various other illness such as body pain, back pain, respiratory problem, gynecological problem, tonsil, fever (30%) in the past one year. The occurrence of these illnesses may be the result of poor water quality from sources or other reasons such as poor hygiene at home, inadequate water supply, inappropriate water storage practices, and so on. Absence from the work or forgo income due to illness has risen issues in the workplaces such as wage or pay deduction, dismissed from the job, getting verbal warnings etc. The study also revealed that women (97.1%) are more proactive than their male counterparts in collecting water for daily necessities (29.6%). Similarly, girls

(10.4 %) are more likely than boys to collect water on their own or accompanied by their mothers (5.0%). While fetching water, women face a variety of challenges along with some health-related issues. The lack of proper water management systems is cited as the primary cause of water scarcity in the country. Addressing all these issues holistically, a national policy framework to achieve sustainable development goals of ensuring universal access to water is of vital importance.

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Acronyms

BBS	Bangladesh Bureau of Statistics
BGMEA	Bangladesh Garment Manufacturers' and Exporters Association
BKMEA	Bangladesh Knitwear Manufacturers' and Exporters Association
BNHA	Bangladesh National Health Accounts
BUET	Bangladesh University of Engineering and Technology
DPHE	Department of Public Health Engineering
DoE	Department of Environment
EQS	Environmental Quality Standard
ECR	Environmental Conservation Rules
FGD	Focus Group Discussion
HHs	Households
HCR	Head Count Rate
HIES	Household Income and Expenditure Survey
KII	Key Informants Interview
LDCs	Least Developed Countries
MR	Multiple Response (Households report more than one in the same issue)
MICS	Multiple Indicator Cluster Survey
RMG	Ready Made Garment
SDGs	Sustainable Development Goals
STP	Surface-water Treatment Plants
SR	Statistical Region
SVRS	Bangladesh Sample Vital Statistics
SPSS	Statistical Package for the Social Sciences

Chapter 1: Introduction

1.1 Introduction

Water is not only essential for the existence of all species around the world but also plays a pivotal role in economic activity, as a key input to agriculture and industry. In the long term of achieving sustainability, continuing the pace of sustainable development for a nation, it is an element of crucial importance. In the case of sustaining our very own civilization water is the basic need (BIPSS, 2007). Over the past 100 years, human water demand increased almost eight-fold (Wada et al., 2016) due to the quadrupling of the global population, increase in per capita food demands, and rising standards of living (Falkenmark, 1997; Shiklomanov, 2000; Vo¨ro¨smarty et al., 2000; Flo¨rke et al., 2013; Wada et al., 2013). Our planet, which has 70 percent of its surface covered in water, is currently experiencing a severe water shortage. Even though Bangladesh is not recognized for its water scarcity, the quality of its water resources is poor, and it is deteriorating due to climate change, urbanization, and population increase. (World Bank, 2018). Despite Bangladesh being a deltaic country and surrounded by a large number of rivers and tributaries, it is also very important to mention that the unequal access to clean water in Bangladesh is taking greater shape for being heavily contaminated (World Bank, 2018) and the evidence of suffering from recent century’s water security makes it clearer. People, especially women, have to suffer and cope with the water insecurity based on their own adaptive techniques (Nasreen, 2012).

Bangladesh has recently seen significant economic growth as a result of its transition from an agricultural to a manufacturing-based economy, and it aspires to become a middle-income country by 2021 (World Bank, 2012). Bangladesh's export-oriented garments, clothing, and textile sector, known as Ready-Made Garments (RMG), has been a major driver of the country's economic progress. The sector operates about 4482 factories in Bangladesh (BGMEA, 2018), and has contributed around USD 30.61 billion to the economy in the fiscal year of 2017-18. The industry employs about 4.4 million people, the majority of whom are women, and contributes for 80 percent of the country's total export earnings (Saber, 2016; Selim, 2018). It is estimated that by 2021, the garment sector aims to double its revenue to USD 50 billion per year and employ another 2 million workers (Hossain et al., 2018). The RMG companies are mostly concentrated in three cities in Bangladesh: the capital city Dhaka, the port city Chittagong, and the industrial city Narayangonj (Ahmed, 2014). Dhaka being the capital city of Bangladesh, most of the RMG sectors are flourishing centering Dhaka (Salam, 2014). According to the Department of Inspection for Factories and Establishments' database, around 3000 garment factories are now functioning in Dhaka[1]. It attracts a high number of migrants from rural regions due to the economic prospects it provides. The urban population of Bangladesh increased from 7.9 percent in 1971 to 38.2 percent in 2020 growing at an average annual rate of 3.29 percent[2]. Bangladesh's urban population was estimated to be 64.81 million in 2020 (Statista, 2021)[3], accounting for 32.8 percent of the overall population (WORLD (WORLD DATA ATLAS, 2021)[4]. The location, as well as the social, economic, and political context of Dhaka, will continue to favour rapid growth in the city's population. Every year, about 3.5 percent of the population migrates inside the country in search of jobs provided by the garment industry's fast expansion (UNICEF, 2021)[5] and ends up living in urban slums (47.2% in 2018). More than 5,000 slums in Dhaka city are home to an estimated four million people[6] without decent housing or basic utilities. The influx of population increases the demand for everyday water resource uses in the city area. Poor people, who mostly live-in slum areas, are ignored on both the demand and supply sides, and have even less access to potable water. They face challenges in accessing water and often do not have facilities of piped or tube well water as of others.

Even though Dhaka has seen extraordinary industrial expansion, unplanned urbanization, and human development over the last decade, it has lifted many people out of poverty while placing substantial strain on its rivers' ability to supply water and absorb pollutants (REACH, 2015). Dhaka is bounded on the west by the Turag, on the south by the Buriganga, on the east by the Balu, and on the north by the Tongi khal. Only 17 percent of the city's water supply comes from surface waterways, such as river water, while the rest 83 percent is extracted from groundwater (GW) piped through a network (Nahar et al., 2014). Because of the discharge of a massive volume of untreated and municipal waste materials, surface water sources from nearby rivers and lakes have already surpassed the regulatory limits of numerous water quality criteria. Furthermore, it has been alleged that about 80 percent of the readymade garments (RMG) industry in Bangladesh is located along with a major river

[1] http://database.dife.gov.bd/index.php/factories/member-bgmea-bkmea
[2] https://knoema.com/atlas/Bangladesh/Urban-population
[3] https://www.statista.com/statistics/603402/bangladesh-urban-population/#:~:text=Urban%20population%20Bangladesh%202011%2D2020&text=In%202020%2C%20there%20were%20approximately,were%20living%20in%20urban%20areas.
[4] https://knoema.com/atlas/Bangladesh/Urban-population
[5] https://www.unicef.org/bangladesh/en/children-cities%C2%A0
[6] https://www.unicef.org/bangladesh/en/children-cities%C2%A0

system in Dhaka city (World Bank, 2005). Treatment of this water has become so expensive that water supply agencies have to depend on groundwater aquifer for production of drinking water. Rivers play a role in absorbing or transporting pollutants such as industrial and municipal wastes, manure discharges, and runoff from agricultural fields, roadways, and streets (Stroomberg et al., 1995). In Hazaribagh, there are around 149 tanneries that produce over 18,000 litres of liquid every day and approximately 115 metric tons of solid waste, virtually all of which is discharged into the river Turag through the Bashila and Katasur khals (IWM, 2007). Again, 10 percent of industries release treated effluent, while the remainder discharge wastewater into rivers or bodies of water without treatment or with limited treatment (Satter & Islam, 2005). Textile industry wastewater in Bangladesh was estimated to be at 217 million m^3 in 2016, including a wide range of contaminants, and is expected to rise to 349 million m^3 by 2021 if traditional dyeing techniques are continued (Hossain et al., 2018). Direct discharge of toxic chemicals from industries into the river results in increase pollution and deteriorates its water quality. Heavy metal-containing industrial wastes and effluents are being discharged in the vicinity of industrial regions, including vanadium, molybdenum, zinc, nickel, mercury, lead, copper, chromium, cadmium, and arsenic (Islam et al., 2013), which have significant impacts on surface water quality. Dhaka also produces over 1.65 million metric tons of solid waste each year[7]. Estimates of waste generation per inhabitant per day range from 0.29 to 0.60 kilos per day, however the Dhaka City Corporation (DCC), the principal body in charge of waste collection, transportation, and disposal, is unable to do the work adequately due to its inadequate logistics[8]. In 2018-19, per capita per day waste generation in Dhaka is found as 0.641 kilograms[9]. It is estimated that only 40–60 percent of Dhaka's waste is collected by the DNCC[10]. People who live along the riverbanks throw garbage into the waterways that is not controlled by the DNCC. Oil and other chemicals thrown into rivers by launches, steamers, and trawlers pollute river water in addition to residential and industrial trash. This deterioration is of great concern not only for the aquatic environment but also for human health due neighbouring people are continuously interacting with this water for their daily purposes such as drinking, cooking, bathing, washing, fisheries, and navigation (Rahman,

[7, 10] https://www.waste.ccacoalition.org/sites/default/files/files/city_fact_sheet/Dhaka_MSW_FactSheet_0.pdf
[8] Dhaka North City Corporation
[9] Waste Report 2018-19. Dhaka North City Corporation, Waste Management Department. https://dncc.portal.gov.bd/sites/default/files/files/dncc.portal.gov.bd/annual_reports/6693c776_0dde_49da_b85b_1928d398a7f4/2020-07-07-15-04-0388efe51e61d331efb81045a0648dd2.pdf

1994). This water also has a disproportionate impact on vulnerable livelihood systems such as agriculture, aquaculture which must otherwise endure extreme hardship or migrate.

Dhaka is Bangladesh's only city with a sewage system, to which only 20 percent of its population is connected (Mansour et al., 2017) which indicates that more than 70 percent of the city's population does not have access to adequate sanitation facilities. Only 2 percent of the population in Dhaka's low-income neighborhoods has access to properly managed sanitation (Arias-Granada et al., 2018), although no faecal excrement is deemed securely handled outside of a small proportion that goes into the sewage network (Peal et al., 2014). Release of these untreated toxic industrial effluents, municipal solid waste, direct connection of sewerage along the riverbanks results in pollution of river water. Near industrial areas this polluted river water is being used for irrigation purposes in paddy and vegetable (spinach, tomato, and cauliflower) cultivation fields (Islam et al., 2013), resulting in the penetration of such chemicals in the human body through the food chain which is dangerous to the health of the dependent community. Cholera, diarrhoea, dysentery, hepatitis, typhoid, polio, and other illnesses have been related to contaminated water[11].

As population density in Dhaka city is rising, so are housing needs, thereby increasing the pressure on the already stressed water supply services. There is a huge gap between demand and supply; therefore, households across the city face tremendous water crises, especially in summer each year. Although precise data is difficult to come by, most of Bangladesh's present water supply services are incapable of fulfilling demand. DWASA (Dhaka Water Supply and Sewerage Authority) is unable to fulfil or sustain current water requirements with their existing supply to the city dwellers (Rahman et al., 2014; Nahar et al., 2014) as the city water supply system accommodates only about two-thirds of Dhaka households (Nahar et al., 2014). Furthermore, DWASA is only capable of producing 1,500 million liters of water per day (mld), but Dhaka's daily water demand and requirement is around 2,200 mld. The current water delivery infrastructure is under strain as a result of rising population growth rates, with estimated demand exceeding 4,000 mld by 2020 (Nahar et al., 2014). According to an ADB report (2017), 1.3 million people (15% of the total population) lived in slums in the DWASA service area in 2007, with many of them having unauthorized water system connections and a significant number of the most vulnerable slum dwellers having no access to water services at all. Without intervention or changes in policy and service

[11] https://www.who.int/news-room/fact-sheets/detail/drinking-water

commitment, the number of slum dwellers in Dhaka without access to water is expected to rise to more than 4 million by 2025.

Water is one of the most important non-traditional security problems since it is necessary for human health, well-being, economic stability, and political stability (BIPSS, 2007). In the absence of adequate water supply and sanitation, many of the urban poor people depend on rivers for meeting their daily domestic needs such as bathing, laundry, and cooking (REACH, 2016) as safe water supply covering only 50–60 percent of the urban population[12] (only about one-half of the total urban population) while the other half have to depend on contaminated traditional sources of water such as ponds or rivers especially the lower income group who cannot afford the cost of supply water. It is estimated that 3 percent of Bangladesh's population, or over 4 million people, rely on unimproved water sources, such as ponds, rivers, streams, or unprotected wells and springs to get their drinking water (World Bank, 2018). Many parts of the city's rivers and canals are biologically dead because of high pollution levels, particularly during the dry season, with the majority of this water unfit for human consumption. Surface water contamination from untreated waste and industrial effluents affects all Dhaka residents, either by increased healthcare costs or reduced productivity due to waterborne disease (World Bank, 2007).

WHO/UNICEF (2010) progress on drinking water and sanitation for gender content shows that in 45 developing countries women performed 64 percent of water collection as they are considered as the primary managers of water at the household level. Similarly, in most societies, women are in charge of the water supply in the home. Having enough water to satisfy household requirements has a direct impact on women's health, education, and career opportunities. Water is connected to our health, wellbeing, culture, economy, and environment (UNESCO-IHP, 2014), however, collecting water often for hours in a day can make school going late for school[13]. Fetching water also takes time and limits the economic productivity of women.

Understanding the various accessible sources and unequal consequences of water security on the health and wellbeing of poor women, men, girls, and boys, as well as the multiple barriers to equality in Bangladesh's urban setting, are essential components of this study. To achieve the global goals (six) of sustainable development (SDG, 2016-2030) that is to ensure availability of water for all as well as for the aims of the Seventh Five Year Plan (SFYP,

[12] https://www.adb.org/sites/default/files/evaluation-document/35766/files/lc-urban-sector-wss-ban.pdf
[13] https://www.wateraid.org/uk/the-crisis/tackling-inequality/girls-and-women

2016-2020) of the Bangladesh Government 'safe drinking water to be made available for all rural and urban population', present research objectives can provide support to policy makers through indicating ways to sustainable supply and management of water for the urban water poor. Future study might be focused on government and non-governmental organization (NGO) initiatives in water security for the urban poor. To find out about the functioning of any Govt. or NGO to help the underprivileged or water-poor for ensuring their access to water-related interventions, it would be of great support. Future researchers will be able to devise interventions for inclusive members based on the findings of this study.

1.2 Conceptual Framework of the Study

The conceptual framework is an analytical technique for organizing research ideas in an easy-to-remember and use manner (Berlin, 1953). The present study therefore tries to focus on various available sources of water for studied communities together with their interaction with the river; gendered differential roles and responsibilities of water-related household activities; how the quality of available sources of water affects neighbouring communities' health and productivity, ultimately the relationships with reduction or increase of vulnerabilities and poverty. The conceptual framework of the study is presented below in Figure 1.1:

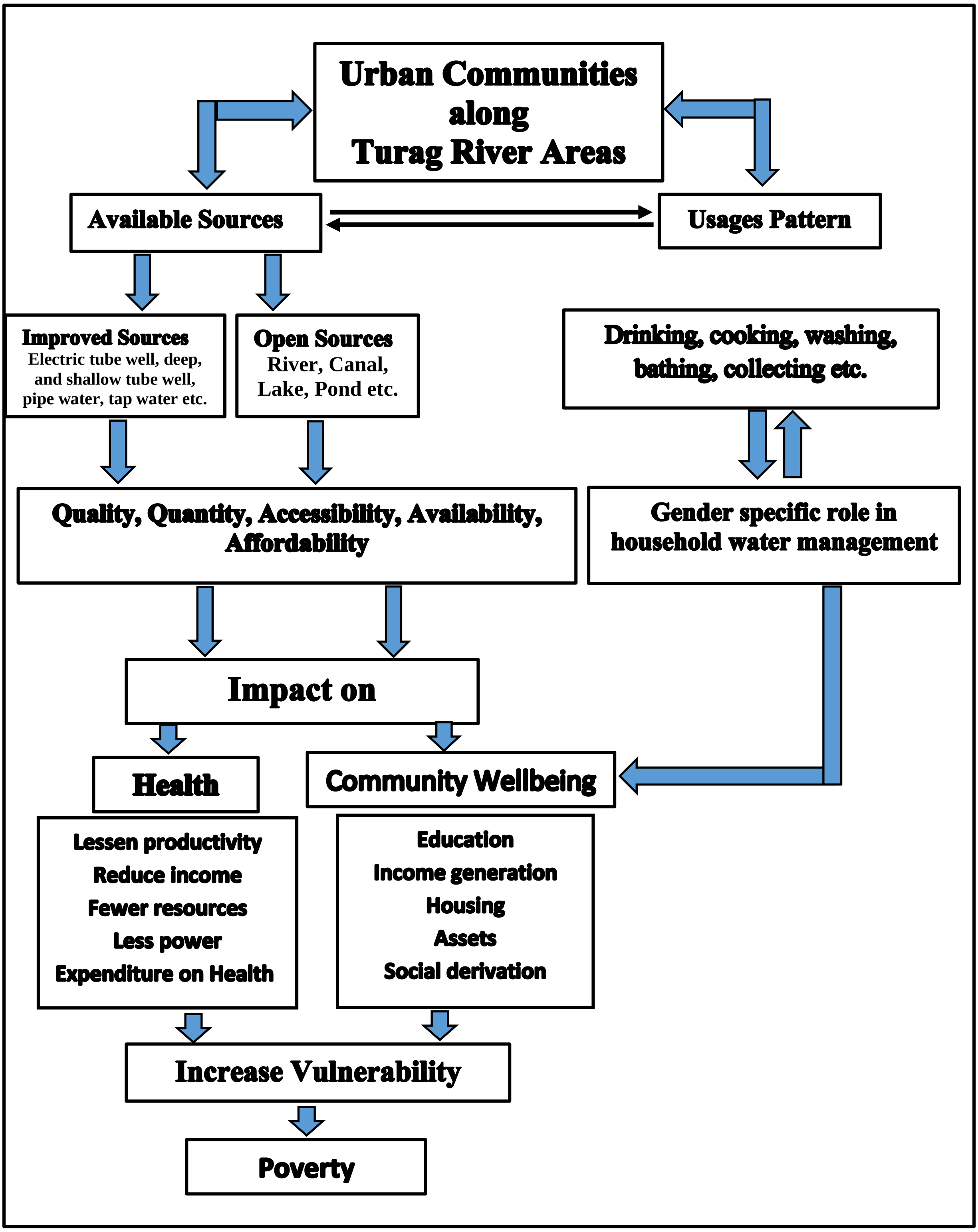

Figure 1.1: Showing the Conceptual Framework of the Study

1.3 Objectives and Research Questions of the Study

The overall goal of this research is to explore the links between urban water usage and associated risks. In line with the broad objectives the specific objectives of the research have been designed as follows:

i. To find out available sources and usages pattern of urban water;
ii. To understand how and why people of the local community continue interacting with the Turag River;
iii. To analyse gender-specific roles and behaviour in the attainment of household water security;
iv. To examine nexus between water source and community peoples' health; and
v. To point out the associated impacts of disease occurrence among studied communities.

The relevant ***research questions*** of the study are given below:

i. What are the available water sources and patterns of water usage?
ii. How do the local people interact with river water?
iii. What is the gender-specific roles and behaviour in the attainment of household water security?
iv. Is there any link between water source and community health?
v. How do they get impacted due to disease occurrence?

Table 1.1: List of broad and specific objectives of the study

Serial No.	Broad Objectives	Specific Objectives
1.	To find out available sources and usages pattern of urban water	i. to find out available drinking and domestic water sources in the survey areas; ii. to find out seasonal variation of water usages; iii. to find out the reasons for shifting from primary sources to secondary sources of water; iv. to explore the challenges faced by the people due to switching from primary to secondary sources of water; v. to find out the ownership of water sources; vi. to reveal the payment means or tariff system of water sources; vii. to know about community concerns regarding water sources and other related issues.
2.	To understand how and why members of the local community continue	i. to understand how members of the local community interact with Turag River water along with its variation in different sites at times;

	interacting with the Turag River	ii. to find out gender-disaggregated interactions with Turag River; and iii. to explain how changes in river water quality influence water use practices (welfare change) along with the Turag River system over time.
3.	To analyse gender-specific roles and behaviour in the attainment of household water security in the study area	i. to evaluate household water insecurity and gender division of labour in managing everyday water needs; ii. to find out gendered responsibility and time taken to fetch water; iii. to find out various challenges faced, and health risk associated with fetching water; and iv. to formulate policy lessons regarding the issues.
4.	To find out links between water use and community peoples' health	i. to find out prevalent diseases of the studied community in the past one year; ii. to explore the link between water sources with disease occurrence; iii. to identify other potential factors that may be responsible for disease happening; iv. to find out the measures taken to make water safe at the household level; and v. to investigate the treatment-seeking behaviour of the studied communities.
5.	To point out the associated impacts of diseases occurrence among studied communities	i. to find out productivity loss due to illness; ii. to investigate if there any reduction of income; and iii. to find out problems or issues created in the workplace due to illness.

1.4 Hypothesis of the Study

The hypothesis was formulated to serve as a guide of the study, therefore the hypothesis of this study is

> ***H_O:*** There is no connection between the sources of water on which a population relies and the occurrence of diseases
>
> ***Ha:*** There is a positive connection between the sources of water on which a population relies and the occurrence of diseases

The hypotheses will be tested based on the primary and secondary results of the present study. Besides, the study reviews a number of relevant literatures leading to the presumed hypothesis.

1.5 Operational Definitions of some key Terms

1.5.i Water Resources: are sources of usually freshwater that are useful, or potentially useful, to society; for instance, for agricultural, industrial, or recreational use. Examples include groundwater, rivers, lakes, and reservoirs. **-- Nature Portfolio, 2021**[14]

[14] https://www.nature.com/subjects/water-resources

1.5.ii Water Quality: is the suitability of water to sustain various uses or processes. **-- UNEP/WHO, 1996**[15]

1.5.iii Water Scarcity: the lack of available water resources to meet the demands of a specific population. Water scarcity can be experienced by a community, region or country and may be temporary (for example over several months of the year) or increase and decrease over time. **-- UN-Water, 2013**[16]

1.5.iv Water Security: the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments, and economies. **-- David & Claudia, 2007**[17]

1.5.v Water Availability: is the quantity of water that can be used for human purposes without significant harm to ecosystems or other users. --**Sustainable Jersey, 2013**[18]

1.5.vi Water Accessibility: implies facilities close to home that can be easily reached and used when needed. **-- UNICEF, 2016**[19]

1.5.vii Water Affordability: payment for services does not present a barrier to access or prevent people from meeting other basic human needs. **-- UNICEF, 2016**[20]

1.5.viii Community Welfare: describe as 'a community condition that conforms to our value systems, such as a presence of health, happiness, prosperity, social control, and good housing; and the absence of undesirable conditions such as illness, poverty, vice, delinquency, and crime, child neglect, ignorance, and unemployment'. – **Jonassen 1960, p.112**

1.6 Organization of the Thesis

The thesis is organized into eleven chapters.

Chapter 1: Introduction provides the background, rationale, concept, and objectives of this study.

Chapter 2: Literature Review provides an overview of existing data and previous study that is relevant to present research.

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[15] https://www.who.int/water_sanitation_health/resourcesquality/wqmchap2.pdf
[16] Water Security and the Global Water Agenda – a UN-Water Analytical Brief, 2013.
[17] David Grey & Claudia W. Sadoff. 2007. "Sink or Swim? Water security for growth and development". *Water Policy, 9* (6): 545–571. doi:10.2166/wp.2007.021
[18]https://www.sustainablejersey.com/fileadmin/media/Events_and_Trainings/Add_Event/2013/Sustainability_Summit/Sustainability_Briefs/Water_Availability_FINAL_9_10_13.pdf
[19, 20] Strategy for Water, Sanitation and Hygiene 2016-2030. https://www.unicef.org/wash/files/UNICEF_Strategy_for_WASH_2016-2030.pdf

Chapter 3: Methodology includes various data collection tools and techniques of the study have been described in this chapter.

Chapter 4: Study Area: Turag River and Selected Sites provides an overview of the origin, various physical and hydro-morphology of Turag River together with characteristics of selected survey areas along Turag River are discussed.

Chapter 5: Socio-Demographic Characteristics of Survey Community represents background and characteristics of survey households and communities have been presented in this chapter.

Chapter 6: Available sources, usages pattern, and related issues the analyses of availability of different urban water sources, water usages, seasonal variation of water use, etc. various issues have been discovered and described in this chapter.

Chapter 7: The Turag River: Uses, Water Quality and Welfare Change over Time this chapter particularly focuses on only the Turag River users, how and why they interact with this water, river water quality and changes of welfare over time due to pollution have also been discussed.

Chapter 8: Urban Water Use: A Gendered Analysis this chapter mainly focused on gendered specific roles of household water-related activities and the challenges they encountered to do so.

Chapter 9: Urban Water Use and Health Risk discuss the relation between available souses, uses, and disease prevalence of selected communities.

Chapter 10: Linking Illness with Productivity Loss discuss different issues that groups have faced because of illness-related absences from work.

Chapter 11: Conclusion recommendations and concluding remarks have been summarized in this Chapter.

A list of ***References*** that have been used in this study and various other information, questionnaire, checklist, table, photographs that have been discussed in the different sections has been kept in the ***Appendix*** and attached at the end of all the chapters mentioned here.

Chapter 2: Literature Review

A literature review was conducted to gather data relevant to the research topics that would be useful in bolstering the study's findings. The literature also aided in identifying knowledge gaps and focusing on the sorts of data required for the evaluation. Simultaneously, literature was explored to aid in the knowledge of acceptable qualitative and quantitative data analysis approaches. Government and non-government entities' documents, presented papers, articles, academic journals, books, and relevant websites were examined.

2.1 Population Growth

2.1.i Population Growth: International Scenario

Population growth rates peaked at 2.1 percent yearly between 1965 and 1970, then gradually declined to 1.4 percent annually between 1997 and 1998, with a world population of 3 billion people in 1960 doubling to 6 billion by 1999[21]. Demographers predict the world population to achieve 8 billion milestones in 2023, with the global population forecast to reach 9 billion by 2037 and 10 billion by 2056, after reaching 7 billion milestones in 2011 (Lam, 2011). The global population is now growing around 1percent per year, after peaking at 2.1 percent in 1968 (Chamie, 2020).

Currently, 61 percent of the world's population lives in Asia (4.7 billion), 17 percent in Africa (1.3 billion), 10 percent in Europe (750 million), 8 percent in Latin America and the Caribbean (650 million), and the remaining 5 percent in Northern America (370 million) and Oceania (43 million). China (1.44 billion) and India (1.39 billion) are the world's two most populous countries, each with more than 1 billion people and accounting for 19 and 18 percent of the global population, respectively. Between 2019 and 2050, India is expected to replace China as the world's most populated country around 2027, while China's population is expected to decline by 31.4 million, or approximately 2.2 percent. The global population is expected to reach 8.5 billion people in 2030, 9.7 billion in 2050, and 11.2 billion by 2100 (Figure 2.1) (World Population Prospects 2019: Data Booklet)[22].

The current yearly growth in the global population is 81 million, down from a high of 93 million in 1988. Annual additions are expected to decline further, to 48 million by 2050. The majority of the approximately 2 billion population growth projected by mid-century

[21] https://www.un.org/en/sections/issues-depth/population/
[22] https://population.un.org/wpp/Publications/Files/WPP2019_DataBooklet.pdf

will occur in less developed regions. Africa is the most populous continent, with more than 1 billion people anticipated to be added over the next three decades, followed by Asia with around 650 million. In comparison, Europe's population is expected to decline by 37 million people during this time period (Figure 2.2) (UN-Population).

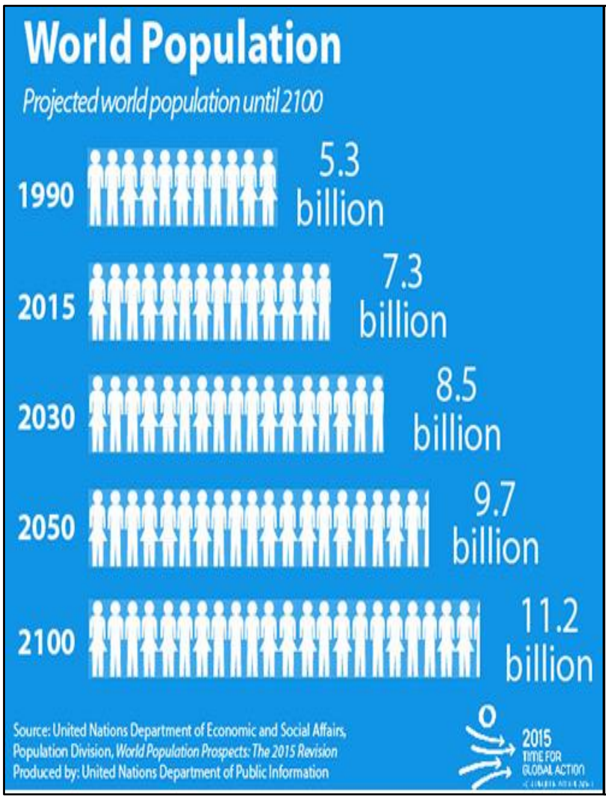

Figure 2.1: Growing World Population
(Source: UN-Population https://www.un.org/en/sections/issues-depth/population/)

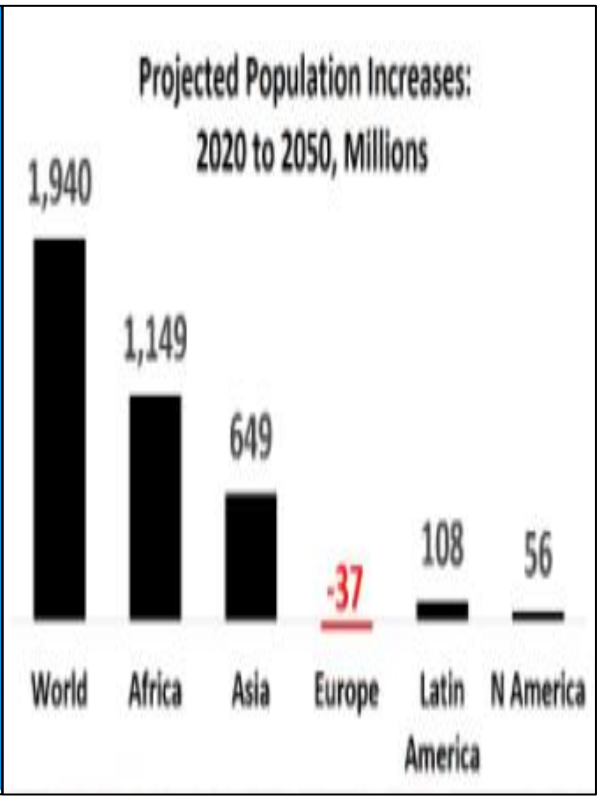

Figure 2.2: Regional differences: Asia and Africa lead in population rises through 2050
(Source: UN Population Review)

A common notion exists that water is becoming scarce as a result of inevitable trends, particularly population expansion and the associated increased demand for water for food production, residential, industrial, and municipal purposes. Furthermore, variations in food consumption impact the pace of development in residential and industrial water demand, as well as agricultural water demand. In 1995, around 37 percent of the population of developing nations lived in cities, up from 22 percent in 1960 and 30 percent in 1980 (Table 2.1) (World Bank, 2000). In the future, urbanization is expected to intensify, with the urban population of emerging nations more than doubling between 1995 and 2025, while the rural population grows by 12 percent. By 2025, urban regions will be home to 53 percent of the population in emerging nations (Rosegrant et al., 2002).

Table 2.1: Rural, urban, and total population; 1995 and 2025

Country/Region	1995 baseline estimates (millions)			2025 projections (millions)		
	Rural	Urban	Total	Rural	Urban	Total
United States	64	205	269	58	289	347
European Union 15	80	293	373	56	316	372
Japan	28	98	125	20	104	124
Australia	3	15	18	3	21	24
Other developed countries	32	59	90	27	79	106
Eastern Europe	54	83	137	33	81	114
Central Asia	31	23	54	37	35	72
Rest of the former Soviet Union	67	172	239	40	162	202
Mexico	24	67	91	25	105	130
Brazil	34	125	159	26	193	219
Argentina	4	31	35	3	44	47
Colombia	11	28	39	11	48	59
Other Latin America	53	99	152	57	177	234
Nigeria	60	39	99	79	124	203
Northern Sub-Saharan Africa	104	29	133	174	114	288
Central and western Sub-Saharan Africa	84	47	131	132	150	282
Southern Sub-Saharan Africa	55	24	80	75	80	154
Eastern Sub-Saharan Africa	70	19	89	112	73	184
Egypt	34	27	62	41	54	95
Turkey	19	43	61	12	75	87
Other West Asia/North Africa (WANA)	84	127	212	107	275	382
India	679	248	927	777	575	1,352
Pakistan	81	42	124	118	133	251
Bangladesh	97	27	124	125	85	211
Other South Asia	48	10	58	72	35	107
Indonesia	127	70	198	107	166	273
Thailand	47	12	59	50	28	77
Malaysia	9	11	20	9	22	31
Philippines	31	37	68	30	77	107
Viet Nam	59	14	73	73	32	105
Myanmar	33	11	44	34	26	60
Other Southeast Asia	14	3	16	21	10	32
China	857	369	1,226	778	702	1,480
Korea, Republic of	10	35	45	5	47	52
Other East Asia	10	14	24	9	21	29
Rest of the World	5	2	6	7	4	11
Developing countries	2,774	1,634	4,408	3,106	3,510	6,616
Developed countries	327	925	1,251	237	1,051	1,288
World	**3,101**	**2,559**	**5,659**	**3,343**	**4,561**	**7,903**

Sources: 1995 data are from FAO (2000); 2025 data are authors' projections based on UN (1998) medium scenario

2.1.ii Population Growth: National Scenario

Bangladesh, having area of 148,560 sq km (Bangladesh–Wikipedia)[23] and more than 120 million people, gained independence on March 26, 1971, with a size of population of around 70 million people. Among the various countries in Asia, Bangladesh is the eighth-largest country in terms of the world's population. Bangladesh's population is estimated to be at 167.8 million people, with a density of roughly 1252 persons per square kilometer of

[23] https://en.wikipedia.org/wiki/Bangladesh

geographical area, according to UNFPA[24] and with a growth rate of 1.20 percent (Bangladesh Statistics, 2017). Bangladesh's population has nearly doubled after 49 years of independence, to roughly 165.7 million people (worldometer, 2021)[25]. Bangladesh's population was initially estimated in 1801 to be approximately 14.5 million people. By the next 100 years, the population had more than doubled. Between 1801 and 1901, the annual growth rate was less than 0.7 percent. Between 1951 and 1974, the population expanded by over 29 million people in only 23 years[26]. From 1973 until the mid-1980s, Bangladesh's population grew at an average rate of 1.47 percent per year, but between 1986 and 2000, it grew at a pace of 2.68 percent per year, and since 2001, it has been dropping at an average rate of almost 1.76 percent per year (Ali et al., 2015). Bangladesh's population rose from 64.2 million in 1970 to 163 million in 2019, with an average yearly growth rate of 1.92 percent (WORLD DATA ATLAS)[27]. Table 2.2 shows the population growth trends in the history of Bangladesh[28].

Table 2.2: Bangladesh Population by Year (Historical)

Year	Total Population	Growth Rate	Density	World Rank	Density Rank
2021	166303.5	0.0103	1277.587	8	10
2020	164689.4	0.0101	1265.187	8	10
2019	163046.2	0.0103	1252.563	8	10
2018	161376.7	0.0106	1239.738	8	11
2017	159685.4	0.0108	1226.745	8	11
2016	157977.2	0.011	1213.622	8	11
2015	156256.3	0.0115	1200.402	8	11
2010	147575.4	0.012	1133.713	8	11
2005	139035.5	0.0172	1068.107	8	10
2000	127657.9	0.0208	980.701	8	9
1995	115169.9	0.0222	884.7655	9	10
1990	103172	0.026	792.594	9	10
1985	90764.18	0.0265	697.2742	9	9
1980	79639.49	0.0259	611.8114	8	9
1975	70066.3	0.0175	538.2677	9	10
1970	64232.48	0.0301	493.4507	9	10
1965	55385.11	0.029	425.4829	9	10
1960	48013.5	0.0267	368.8523	11	10
1955	42086.3	0.0212	323.318	12	10

Source: World Population Review, 2021

24 UN World Population Prospects (2019 Revision) - United Nations population estimates and projections.
25 https://www.worldometers.info/world-population/bangladesh-population/
26 https://epc2010.princeton.edu/papers/100498
27 https://knoema.com/atlas/Bangladesh/Population
28 https://worldpopulationreview.com/countries/bangladesh-population

A small number of studies have been attempted population projection for Bangladesh over the past decades. Recently, Statista[29] conducted a population projection of Bangladesh using the 2011 census population as the base for the period from 2015 to 2025 and presented in Figure 2.3.

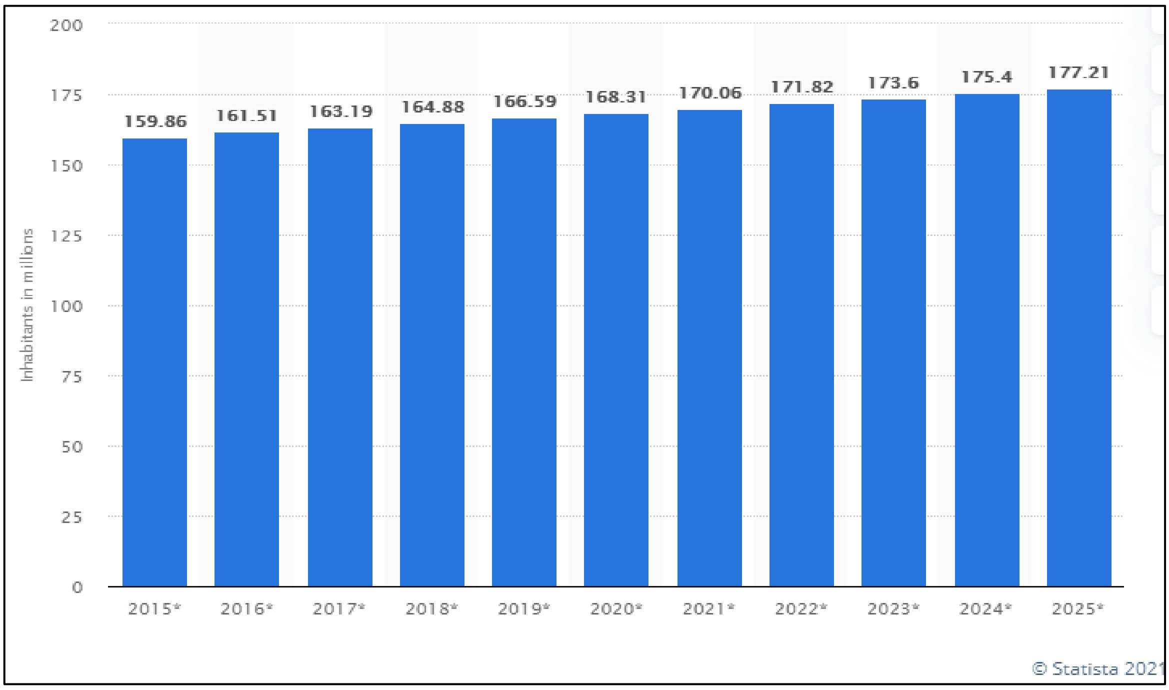

Figure 2.3: Bangladesh, total population from 2015 to 2025 (in million inhabitants)

2.2 Water Resources

97.5 percent of the water on our globe is salty ocean water, which makes up 70 percent of the total. Glaciers, snow, and permafrost make up the remaining 1.725 percent. Groundwater accounts for 0.075 percent, whereas lakes, marshes, and rivers account for 0.025 percent (Nishat, 2008).

2.2.1 Global Water Resources

The world's population is rapidly increasing, and projections suggest that by 2030, there will be a 40 percent gap between anticipated demand and available water supply if current trends continue (World Bank, 2017)[30]. Water scarcity affected around 5 percent of the world population in 2000, implying that fewer than 1000 m^3 of freshwater was available per person per year; by 2025, it is expected to impact 31 percent of the population. Many of these individuals live in nations with significant population expansion, and their water problems are rapidly worsening[31]. Several global water resources overviews based on global

29 https://www.statista.com/statistics/438167/total-population-of-bangladesh/
30 https://www.worldbank.org/en/topic/waterresourcesmanagement
31 https://www.open.edu/openlearn/ocw/mod/oucontent/view.php?printable=1&id=2399

databases, models, and observable records have been published. Gleick (1993) offered detailed evaluations of worldwide water resources, covering water supply from various sources as well as water demand from diverse sectors. Margat (1995) looked examined the worldwide water situation between 1990 and 2025, creating a collection of global maps that show regional variation in several water-related variables. The UN's Economic and Social Council (ECOSOC) presented the UN with a Comprehensive Assessment of the World's Freshwater Resources (ECOSOC, 1997). Seckler et al. (1998) created water demand and supply scenarios up to 2025, identified countries and regions that would face severe water scarcity in the next 25 years, and discussed potential solutions to eliminate water scarcity, such as improving irrigation water use effectiveness and expanding water supply (Chaturevedi, 2000). Shiklomanov (2000) offered a critical evaluation of the current state of global water resources assessment, as well as the findings of assessments for the twentieth century and forecasts for future water supply for household, industrial, and agricultural requirements. Water supply and demand data sets by nation are published by the World Resources Institute (WRI, 2000), and are updated year after year. The World Water Vision project, which included numerous international and national research and consulting agencies and institutions, also analyzed future water possibilities (Rosegrant et al., 2002).

2.2.2 Water Resources of Bangladesh

Two types of water resources that make up the bulk of Bangladesh's water sources are namely surface and groundwater[32]. Surface and groundwater are used for a number of functions on a daily basis, including drinking, cooking, and basic hygiene, as well as recreational, agricultural, and industrial operations. In Bangladesh, the natural subsystem of the water resources system (Ahmed & Roy, 2006) consists of:

i. the interlinked system of rivers, estuaries, canals, khals (smaller than rivers in size), etc.;
ii. the floodplain;
iii. wetlands;
iv. haor, baor, beel (local names of different kinds of ponds filled with stagnant rainwater), lakes, etc.;
v. ponds;
vi. intertidal lands and water; and
vii. groundwater aquifers.

[32] https://www.netherlandswaterpartnership.com/sites/nwp_corp/files/2020-06/Bangladesh-Water-Sector-Network-Study-Final-Report-2018.pdf

2.2.2.i Surface water

Bangladesh's surface water resources are derived from rainfall inside the country as well as inflows from rivers that flow into Bangladesh from both inside and outside the country. IWM (2014) calculated the average rainfall for Bangladesh excluding the eastern highlands to be 266 km^3 averaged from 1980 to 2008, whereas Kirby et al. (2014) projected it to be 284 km^3 averaged from 1985 to 2010.

The surface water system includes approximately a thousand beels and haors, which are saucer-like depression basins with a marshy nature, in addition to the network of rivers. In the southern regions of the nation, there are also ox-bow lakes, which are the remains of dead rivers (WSP, 2014). Bangladesh's rivers, streams, and canals cover around 15,000 miles (24,000 km) (Rahman et al., 1990). Flowing rivers and static sources such as ponds, beels, and haors produce a maximum inflow of 140,000 cubic meters per second (in August) and a minimum of 7,000 cubic meters per second (in February) (Nadira & Shixiang, 2018).

The entire yearly volume of water entering the nation via transboundary rivers is estimated to be around 1000 billion cubic meters (Ahmed & Roy, 2006). The flow delivered by these river systems varies greatly throughout the year, peaking during the monsoon season (July to September) (Rahman et al., 1990). In addition to these natural water features, each community has a number of ponds of varying sizes. A total of 1,288,222 ponds are predicted to exist (Bangladesh Bureau of Statistics, 2007). The entire area of the aquatic bodies is about 12,000 square kilometers, accounting for around 8 percent of Bangladesh's total land area. Table 2.3 shows the areas of the various bodies of water.

Table 2.3: Surface water bodies in Bangladesh

Type of Water Body	**Area (km^2)**
Main rivers (Padma, Meghna, and Jamuna)	2,174
Other river and canals	2,626
Dead rivers and ox-bow lakes	225
Beels/Haors/Natural Water Bodies	1,540
Estuary	5,518
Total	**12,082**

Source: SPARRSO Report, 1984

2.2.2.ii Groundwater

Surface water recharge is the primary source of groundwater. The majority of Bangladesh's land was created by three major rivers' sedimentary alluvial and deltaic deposits (Ahmed & Roy, 2006). For the most part of the nation, these alluvial deposits have produced an unconfined aquifer. Except for adequate drinking water supplies, groundwater was intended to be one of the country's primary natural resources. Because of the comparatively uncontaminated quality of groundwater compared to surface water, which is generally polluted and often bears waterborne illnesses, it is the primary source of water for household, industrial, and agricultural supplies. In Bangladesh, groundwater ranging from the quaternary to recent sediments is the primary supply of water for residential, industrial, and agricultural purposes (WSP, 2014). Furthermore, nearly 90 percent of Bangladeshis rely on groundwater for their drinking water. A body of groundwater, varying in depth from 1 m to 1000 m, runs across the whole country of Bangladesh (Khan, 1990). According to several scientific research on the city's groundwater, the aquifer piezometric level has dropped substantially in recent years owing to excessive groundwater removal (Akther et al., 2009). Groundwater withdrawals account for 35 percent of total yearly water withdrawals (World Bank, 2006). Groundwater is rapidly decreasing due to overexploitation in agriculture and widespread usage by homes, towns, and enterprises. The water table is dropping, and saltwater intrusion is growing. The coastal region's shallow aquifers get more salinized as the water table drops. Groundwater is sensitive to seawater intrusion in coastal regions, as well as dissolved iron in some local areas; nevertheless, arsenic poisoning is the most serious groundwater concern (Khan & Siddique, 2000). It also causes land subsidence. Arsenic pollution of shallow groundwater tables on a large scale is another issue. The water table has dropped below the tube wells' suction level in several locations. The groundwater table in Dhaka has dropped by 20 meters in the previous decade (World Bank, 1998).

According to a series of studies (World Bank, 2000; Ahmad et al., 2001), nearly 95 percent of drinking water and 68.5 percent of irrigation water are derived from groundwater sources, whereas Gupta et al. (2005) found that 95 percent of domestic and industrial water supplies and 70 percent of irrigation supplies are derived from groundwater, and WSP (2014) found that only 8.8 percent of groundwater is used for water supply, 11.9 percent for transportation, and 79.3 percent for agriculture in Bangladesh. In the dry season (October to May) groundwater forms the major source of water available for agricultural production in many areas of the country. According to the Master Plan Organisation (MPO, 1987), the national estimate of groundwater abstraction for agriculture was 6912 million m3/year, whereas it was roughly 900 million m^3/year for potable water supply and industrial usage. Because surface water availability varies seasonally and geographically, the use of tube wells to elevate shallow groundwater was advocated in rural and urban areas to enable intensive agriculture and supply clean drinking water. Thousands of hand, shallow, and deep tube wells have been drilled around the nation in the last 20 years, and they are widely utilized for both household and agricultural reasons (Rahman et al., 1990). Bangladesh now has 35,322 deep tube wells, 1,523,322 shallow tube wells, and 170,570 low lift pumps providing water for agriculture (Qureshi et al., 2014). In Bangladesh, groundwater irrigates around 79 percent of the entire agricultural land, while surface water irrigates the rest (Qureshi et al., 2014).

The aquifer systems in the country are as follows (WSP, 2014):

(i) An upper or main aquifer, extending to about 150 meters, 5 meters being the source of "shallow" groundwater in this report;

(ii) A deep aquifer, extending from 150 meters to about 350 meters; and

(iii) A very deep or lower aquifer, extending below 350 meters to as much as 1,600 meters, about which very little is known.

Table 2.4 summarizes the possible recharge for shallow aquifers, as well as the various sources of demand (water supply, environment, and agriculture) and their balance for different hydrogeological areas up to 2025.

Table 2.4: Organization involved in Groundwater Management

Ministry	**Department**	
	Major Role	**Minor Role**
Water Resources	WARPO, BWDB	
Local Government	DPHE, WASAs	LGIs, LGED, RDA
Agriculture	BADC, BMDA	DAE
Environment		DOE
Science & Technology		BAEC
Energy & Minerals		GSB
Private Sector		IWM, CEGIS, consulting firms

Source: WSP, 2014

2.3 Water Use

2.3.1 Global Water Use

Agricultural (including irrigation, livestock, and aquaculture), municipal (including household), and industrial water withdrawal are the three categories of water extraction (FAO-AQUASTAT)[33]. Agricultural applications, such as irrigation, livestock, and aquaculture, are by far the biggest water users on a worldwide scale, accounting for 69 percent of all yearly water withdrawals. Industry and electricity generating account for 19 percent, while home usage accounts for 12 percent (Figure 2.4).

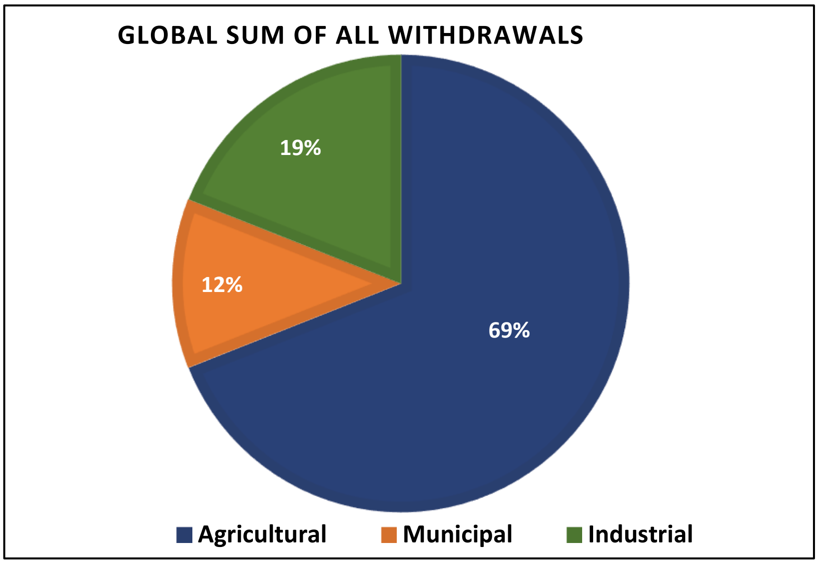

Figure 2.4: Global sum of all withdrawals (%) (Source: AQUASTAT, 2020)

Around 40 percent of the world's irrigated land is presently supplied by groundwater. It permits 13 percent of overall food production, with groundwater accounting for 44 percent of irrigated food production globally (Villholth et al., 2017). Because of their huge populations and extensive agricultural operations, Asia accounts for eight of the ten nations with the highest groundwater extraction. India, China, Nepal, Bangladesh, and Pakistan alone account for over half of the world's total groundwater usage. Saudi Arabia, the United Arab Emirates, Oman, Kuwait, Bahrain, and Qatar are among the Western Asian nations that rely nearly entirely on groundwater for their renewable water supply. In Asia, groundwater resources are critical for meeting water demands. Groundwater is utilized for crop irrigation, food production, industrial, and residential use throughout Asia, accounting for roughly 25 percent of total water consumption (FAO, 2016). Indeed, Asia's groundwater withdrawals account for the vast majority (72%) of worldwide consumption value. This is

[33] AQUASTAT - FAO's Global Information System on Water and Agriculture. http://www.fao.org/aquastat/en/overview/methodology/water-use

due to Asia's extensive agricultural operations as well as its big population and rapid population growth rates (Shah, 2007; Gleeson et al., 2012; FAO, 2016). In Asia, groundwater extraction has risen dramatically, especially since the 1970s. Global assessments of groundwater sustainability clearly suggest that present groundwater use in several Asian regions, such as the upper Ganges River Basin or the North China Plain, is likely to lead to aquifer depletion and water scarcity (Gleeson et al., 2012).

Groundwater also serves as a vital source of water for rivers, lakes, and wetlands, which are separate ecosystems that are flooded by water on a regular or periodic basis. Groundwater has important socio-economic consequences in addition to its ecological role. For example, it is estimated that groundwater irrigation contributes between $10 billion and $30 billion to Asia's economy each year (Shah et al., 2003; WWAP, 2016).

The water extraction ratios per continent are shown in Figures 2.5 and 2.6, with the agricultural portion ranging from more than 80% in Africa and Asia to just over 20 percent in Europe. Agriculture (including irrigation, livestock watering and cleaning, and aquaculture), industry, and towns all withdraw water globally through time, as seen in Figure 2.7.

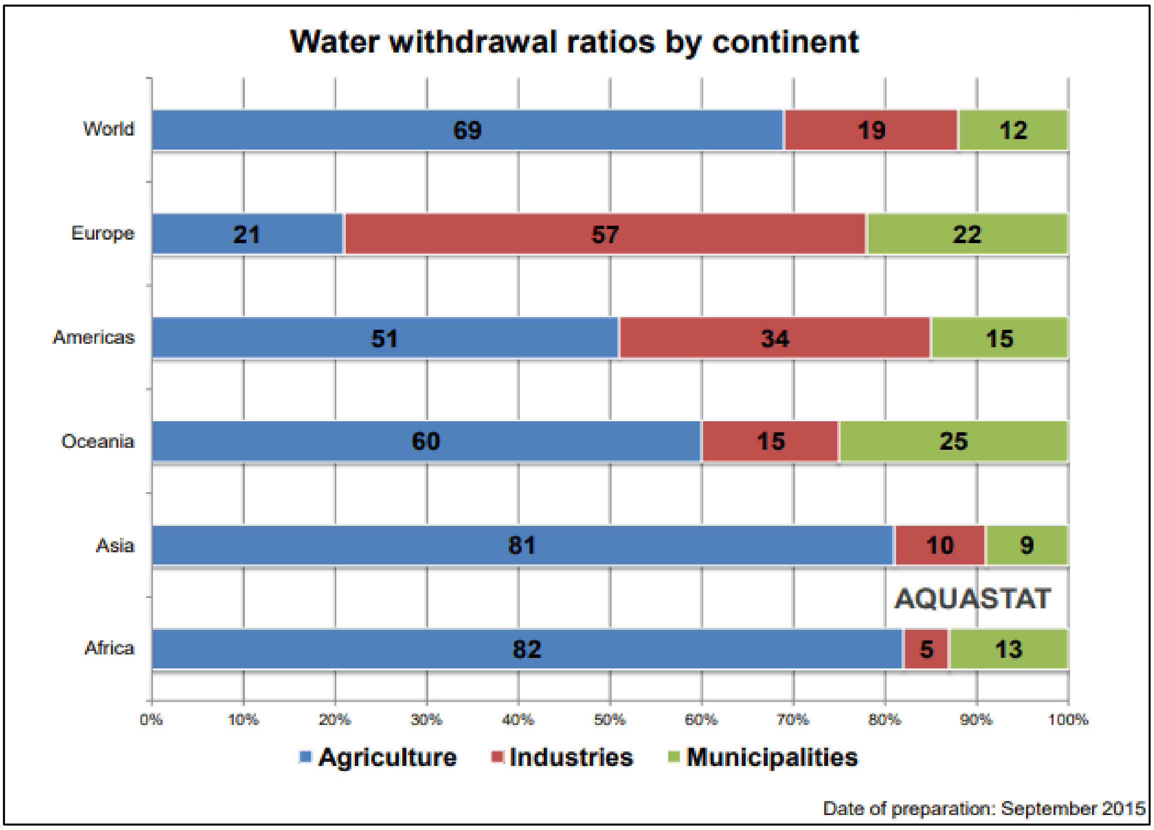

Figure 2.5: Water withdrawals ratios by continent (Source: FAO-AQUASTAT, 2020)

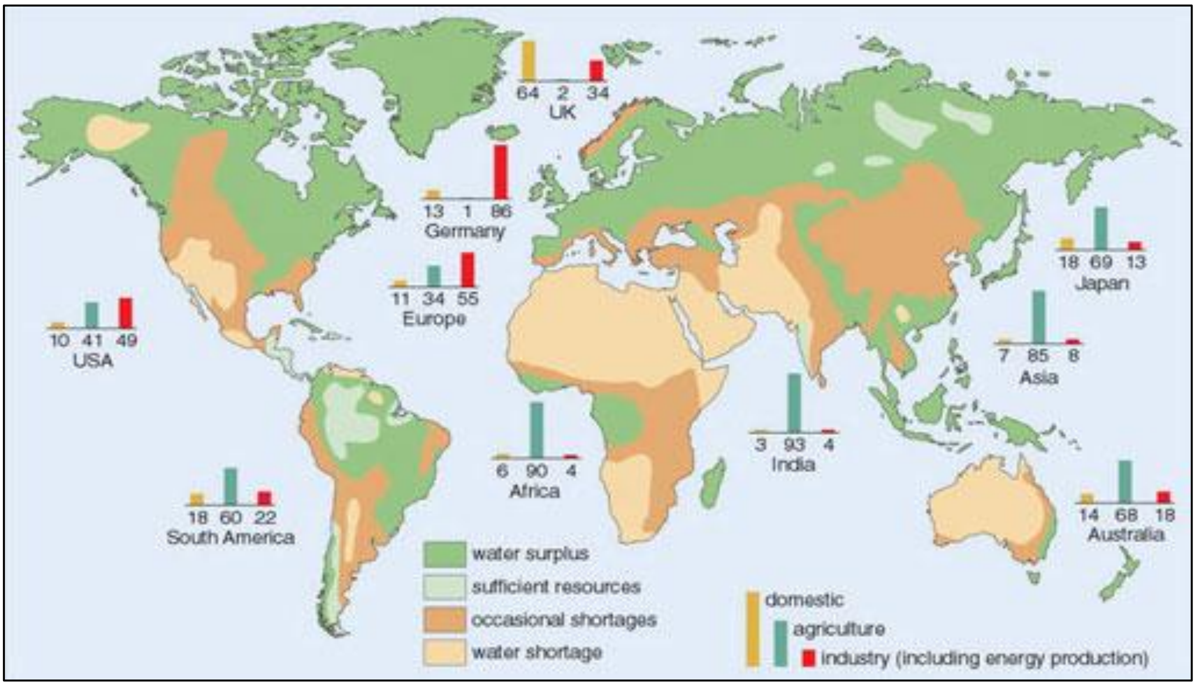

Figure 2.6: Charting the global water situation, global water uses and distribution. The bar charts show percentage use by category

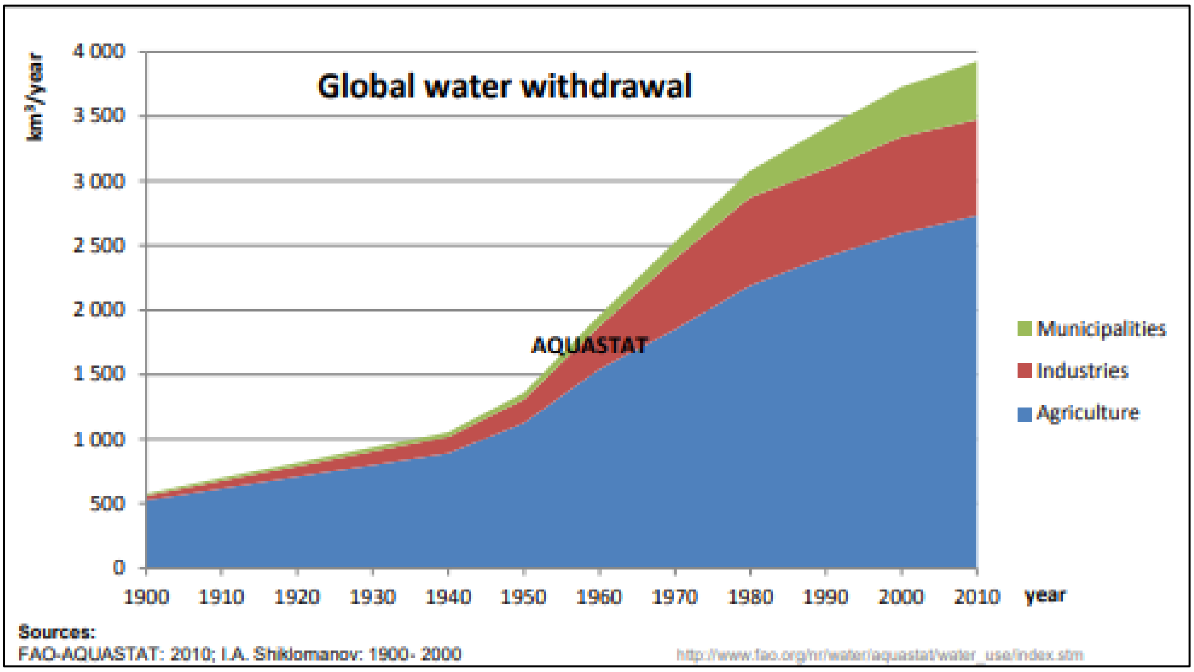

Figure 2.7: Global water withdrawals by km^2/year

Figure 2.8 depicts the distribution of freshwater extraction consumption in key water use industries throughout the world in 2010. The agriculture sector consumes roughly 38 percent of this water during this period. According to the UN's Food and Agriculture Organization (FAO), worldwide freshwater withdrawals totaled 3,928 cubic kilometers per year.

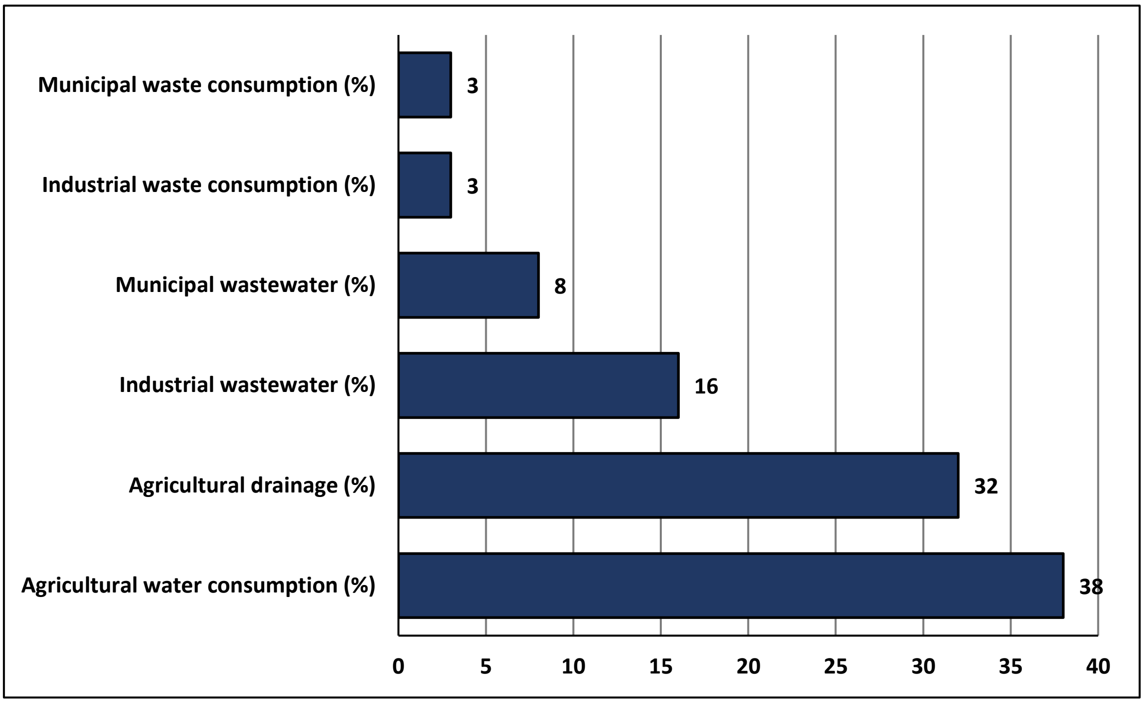

Figure 2.8: Distribution of freshwater withdrawals worldwide in 2010 by the major water use sector (Source: Statista, 2021)

Global water demands are anticipated to expand at a comparable rate through 2050, accounting for a 20–30 percent increase above current levels of water usage (UN, 2019). Although predictions vary, the study shows that an increase in demand from the industrial and residential sectors will account for much of the rise. Agriculture's proportion of overall water use is expected to drop in contrast to other sectors, but it will continue to be the greatest user in terms of both water withdrawal and consumption in the near future, as shown in Figure 2.9 (UN, 2019).

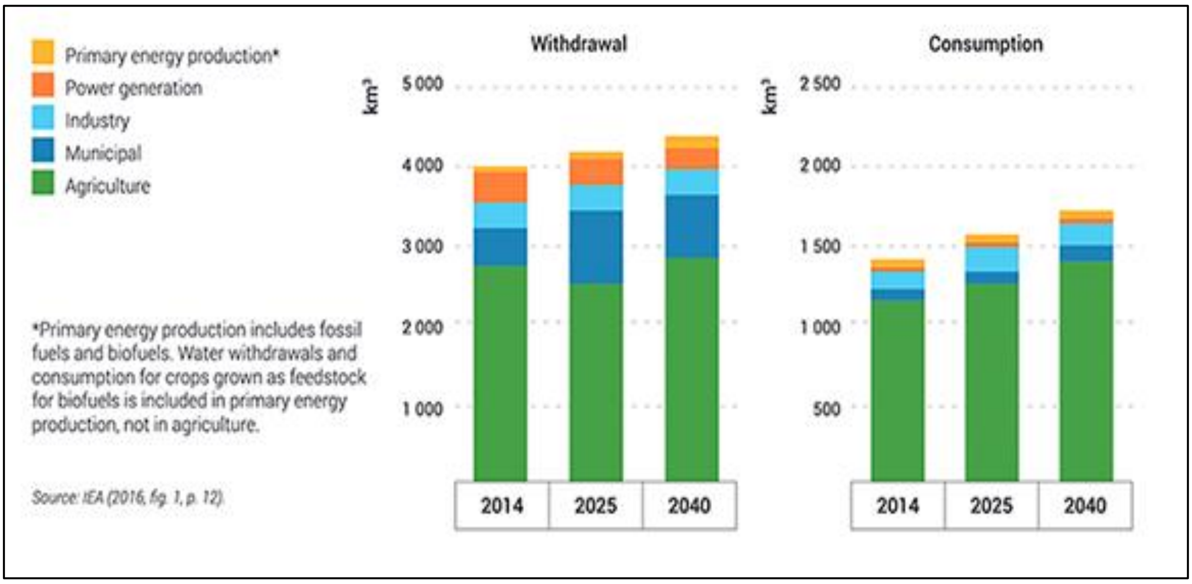

Figure 2.9: Global water demand by sector to 2040 (UN, 2019)

2.3.2 National Water Use

Consumptive needs, such as agricultural, household, and industrial usage, require water, as do non-consumptive demands, such as in-stream use (navigation, fisheries, salinity management, and pollution dilution), as well as ecological conservation and wetland preservation (Nadira et al., 2018). To satisfy its irrigation demands, Bangladesh has become more reliant on groundwater supplies. Irrigation dominates water usage in Bangladesh, with estimated annual use ranging from 25 to 33 km^3 of which 80 percent comes from groundwater. Domestic and industrial demand is estimated at 2.7 km^3 per year, which is projected to increase to about 4.1 km^3 by 2050[34]. In the winter, when there is minimal rainfall and local rivers and water supply channels dry up, farmers must rely on groundwater to cultivate *Boro* rice (Khalequzzaman, 2015). The textile sector in and around Dhaka has contributed to the increase in groundwater extraction, which is expected to continue. The sector, which generates more than 85 percent of Bangladesh's export revenues and is worth more than $15 billion in 2010, plans to reach $50 billion by 2021 and $82.5 billion by 2030. By 2030, the predicted water demand from the textile industry (approximately 6,800 megalitres per day) is expected to be nearly three times the home water consumption[35]. Table 2.5 shows sectoral withdrawal in Bangladesh.

[34] http://old.warpo.gov.bd/index.php/home/catdetails/19/51
[35] Shamsuddha et al., 2011

Table 2.5: Sector-wise water withdrawal in Bangladesh

Sectoral water withdrawal	1988-1992	1993-1997	1998-2002	2003-2007	2008-2012	2013-2017
Agricultural water withdrawal (10^9 m^3/year)					31.5 (2012)	31.5 (2017)
Industrial water withdrawal (km^3/year or $10^9 m^3$/year)	0.3789 (1992)	0.5011 (1997)	0.6233 (2002)	0.7456 (2007)	0.77 (2012)	0.77 (2017)
Municipal water withdrawal (km^3/year or 10^9 m^3/year)	1.911 (1992)	2.439 (1997)	2.967 (2002)	3.494 (2007)	3.6 (2012)	3.6 (2017)
Total water withdrawal (10^9 m^3/yr)					35.87 (2012)	35.87 (2017)
Irrigation water requirement (km^3/year or 10^9 m^3/year)					24.56 (2012)	24.56 (2017)
Agricultural water withdrawal as % of total water withdrawal (%)					87.82 (2012)	87.82 (2017)
Industrial water withdrawal as % of total water withdrawal (%)					2.147 (2012)	2.147 (2017)
Municipal water withdrawal as % of total withdrawal (%)					10.04 (2012)	10.04 (2017)
Total water withdrawal per capita (m^3/year per inhabitant)					237.5 (2012)	224.6 (2017)
Environmental Flow Requirements (10^9 m^3/year)	600.3 (1992)	600.3 (1997)	600.3 (2002)	600.3 (2007)	600.3 (2012)	600.3 (2017)

Source: AQUASTAT-FAO[36]

2.4 Water Usage in Socio-economic Activities

[37]Irrigation dominates water usage in Bangladesh, with estimated annual use ranging from 25 to 33 km^3 of which 80 percent comes from groundwater. Domestic and industrial demand is estimated to be 2.7 km^3 per year, with a forecast of 4.1 km^3 by 2050. Irrigation in the months causes an increase in demand for both surface and groundwater. It accounts for 58.6 percent of the total water demand. However, when it comes to allocating water during critical periods, the National Water Policy prioritizes domestic and municipal uses, non-consumptive uses (such as navigation, fisheries, and wildlife), river regime sustenance, and other consumptive and non-consumptive uses such as irrigation, industry, environment, and salinity management (WARPO, 1999). Fisheries, navigation, and the environment account for 40.7 percent of total demand, whereas household and industrial usage account for just 0.7 percent. As a result, the following are the top water-consuming industries:

[36] AQUASTAT Main Database - Food and Agriculture Organization of the United Nations (FAO) http://www.fao.org/aquastat/statistics/query/results.html
[37] Nasima Tanveer Chowdhury. 2010. Water management in Bangladesh: an analytical review. *Water Policy, 12*, 32–51. https://iwaponline.com/wp/article/12/1/32/19565/Water-management-in-Bangladesh-an-analytical

2.4.i Agriculture Agriculture accounts for 22 Percent of GDP and employs almost two-thirds of the country's workforce (Government of Bangladesh, 2005). Rice farming is the single most significant activity in the economy, and agriculture is the primary water-consuming industry for surface and groundwater irrigation. The pre-monsoon variety is *Aus*, while the rain-fed monsoon (wet season) rice is *Aman*, and the dry season rice is *Boro*. *Aman* rice is the most popular rice crop, accounting for roughly 56 percent of all rice farmed land, followed by *Boro* (27) and *Aus* (22) (WARPO, 1999; Ahmad et al., 2001). The growing share of irrigated HYV (High Yielding Variety) *Boro* rice in the rice development pattern is notable. Currently, irrigation is appropriate for 7.6 million hectares of the 9.03 million ha of cultivable land utilized in agriculture, and around 4.5 million ha are irrigated (World Bank, 2006). About 90 percent of this irrigation, which is mostly based on groundwater, is provided by the private sector. By 2020, the irrigated area will have grown to 6.9 million hectares (World Bank, 1998).

2.4.ii Fisheries Bangladesh has one of the most extensive and productive inland fisheries in South Asia. Fish is the most important source of protein in a Bangladeshi diet, accounting for about 65 percent of all animal protein (World Bank, 2006). Fisheries employ around 9 percent of the entire workforce and generate 6 percent of overall GDP (World Bank, 2006). Capture and cultural fisheries are the two types of fisheries. Rivers and estuaries, Kaptai lake, Sundarbans mangrove forests, floodplains, haors, baors, and beels are all sources of inland capture fisheries. Closed water bodies, such as shrimp farms, saltwater enclosures, ponds, and tanks, are used for cultured fishing. Coastal fisheries include a completely inland freshwater fishery, shrimp, and brackish water fisheries, as well as a marine fishery in the Bay of Bengal. Shrimp farming has emerged as the most important activity in coastal brackish aquaculture, and it is one of Bangladesh's fastest-growing export businesses. Aquaculture in the inland generates an estimated 8,50,000 million tons of fish each year (World Bank, 2006). Coastal aquaculture produced 95,000 million tons in 2002, whereas inland capture fisheries generated 7,50,000 million tons and coastal/marine capture fisheries produced 5,90,000 million tons. Overfishing in the catch fishery has been exacerbated by open access. The needs for estuary and floodplain capture fisheries, freshwater aquaculture, and brackish water shrimp production all require water.

2.4.iii Navigation Water transport accounts for roughly 15 percent of overall transport GDP and accounts for around 8 percent of total transport GDP (World Bank, 2006). Inland waterways carry around 30 percent of all national freight and 14 percent of all people (World

Bank, 2006). A major portion of the rural water traffic is carried by traditional, tiny, privately owned country boats. In Bangladesh, there are approximately 8,50,000 country boats with a carrying capacity of 3 million metric tons (World Bank, 2000), which is 20 times that of vehicles. It's worth noting that shipping bulk items via water is less costly than shipping by road. In the southwest of the country, it is the most cost-effective (World Bank, 2006). In rural regions and, particularly during the monsoon season in low-lying places, additional roads and highways are insufficient; many roads are in bad shape. The Bangladesh Inland Water Transport Authority (BIWTA) compiled a large list of possible navigation routes and calculated the needed draft or water depth for some of them (Master Plan Organization, 1986). While many of the channels are not passable all year, bigger motorized vessels may presently navigate roughly 8,000 km during the rainy season and about 3,800 km during the dry season (World Bank, 2006).

2.4.iv Industry Water demand for the residential and industrial sectors accounts for less than one percent of overall demand, according to MPO (1991) estimates. Because of the low level of industrialization, the demand for water in the household and industrial sectors is limited. The water situation in Dhaka (the capital), on the other hand, demands special care. Dhaka's population growth rate is the highest in the world, with a demand for 700 million m^3 of water per year compared to a supply of 300 million m^3 per year (World Bank, 2006). Groundwater accounts for 98 percent of current supplies, with surface water accounting for the remaining 2 percent.

2.5 Dhaka: Urbanization and Industrialization

Urbanization around the world has developed mostly centred on water resources. Water resources played important role in the development of human civilization over the past centuries (Choudhury et al., 2014). [38]For centuries, riverbanks have been the prime support for establishing settlements, trade, commerce, transportation, and recreation. The waterfront was usually the focal point of urban activities (Hoyle, 2002). Urbanization brought needs that used more and more water. Dhaka flourished as a centre of river-based trade, being closed to the Bay of Bengal then, Dhaka attracted merchants from China to Europe. This also attracts pirates at selected locations on the rivers surrounding Dhaka (Rahman et al., 2016). The Mughals established Dhaka city at the beginning of the 16th century. Dhaka first grew east-west along the river Buriganga, and then started to expand northward. As the

[38] Rahman, A & Ara, Y. 2016. Structuring Dhaka through Water Urbanism: Visions, Challenges and Prospects, pp. 195-210.

riverfront was already built up, European traders put up factories in the north of Dhaka, connected to the Eastside rivers, in the early 17th century (Karim, 1991). However, Dhaka was the capital of the newly created provinces of East Bengal and Assam in 1905-1911, then the capital of East Pakistan after the partition of British India (1947) and later the capital of sovereign Bangladesh in 1971 (Rahman et al., 2016). Since independence, the city has been succumbing to population increase and has now become a megacity. Dhaka had one of the fastest rates of urbanization in the world in the 1980s; it grew at a rate of nearly 7.1 percent annually over 1961-1974 and at 10 percent in the next decade. Due to its geographical and administrative centrality, the city enjoyed the most physical, economic, and social advantages and thus received primary impulses for its steady growth. Dhaka as a megacity with more than 400 years of history, is home to around 15 million people and serving a million others who come and go daily (Zaman, 2017). Rapid urbanization through the growth of exceptionally large cities has become a peculiarly Least Developed Country (LDC) phenomenon. Bangladesh is no exception. Dhaka Metropolitan area grew from an urban conglomeration of 1.4 million persons in 1947 to a megacity of 11 million in 2010 (Rashid, 2014). Dhaka is one of the world's fastest-growing cities, with an estimated annual population growth rate of 4.2 percent, one of the highest among Asian cities. The continued expansion reflects the increasing movement of people from rural regions to the Dhaka metropolitan area. In the 1960s and 1970s, such development accounted for about 60 percent of the city's growth, but more recently, the city's population has risen due to the extension of its administrative limits, which brought 1 million people to the city in the 1980s[39]. In 1951 and 1961, the city's population was just 0.41 million and 0.71 million, respectively. It had grown to 2.06 million by 1974, with an annual growth rate of 11.15 percent (BBS, 2008). The population rose to 3.44 million in 1981, and by 1991 and 2001, it had risen to about 6.48 million and 9.67 million, respectively (BBS, 2001 & 2003).

The population of the megacity has grown to almost 14 million people, with an average annual growth rate of 4.08 percent between 1991 and 2001, much exceeding the country's annual growth rate of 1.3 percent. Dhaka would surpass Beijing in size by 2025 if present population growth rates continue, with a predicted population of 22.9 million (UN, 2012).

During the period 1974-1981, Bangladesh had a higher urban population growth rate of 10.03 percent due to both pull and push forces (BBS, 2001). As a result, migration is the

[39] https://www.prb.org/urbanizationtakesonnewdimensionsinasiaspopulationgiants/

most crucial element driving Dhaka's rapid urban population increase (up to 70%) (Islam, 2001). World Bank (2007)[40] showed that in Dhaka city, new poor migrants are about 3,00,000 to 40,00, 000 in a year.

The Dhaka metropolitan region, for example, is home to more than 75 percent of Bangladesh's approximately 4,000 export-oriented textile companies. Dhaka also boasts more than 80 percent of the national companies in a number of other important industrial sectors. Bangladesh's national GDP is expected to reach 324.24 billion dollars in 2020 (World Bank, 2020)[41] and the city of Dhaka contributes 40 percent of the country's GDP.

2.6 Changes in Dhaka's Growth and Water Demand

The city became the capital of East Pakistan after the partition of British India (1947), later (1971) it emerged as the capital of sovereign Bangladesh. The sources of drinking water supply throughout East Pakistan were various. In the towns of Dacca, Narayanganj, Pabna, Jessore, Faridpur, Rajshahi, Chittagong, etc., the public water supply comes from tube wells for the whole or part of the town. In parts of Dacca, Narayanganj, and Khulna, the water supply wholly or partly sourced from filtered and treated river water (Rashid & Rahman, 2010). In the villages, water is frequently taken from nearby rivers, khals, or local tanks usually without any purification. But with time an important and rapidly increasing source of water is numerous small tube wells provided by Government in larger villages. Sewage and filth were the main sources of contamination of water then. Apart from domestic sewage, no great problem of industrial pollution of rivers exists as there is not much industry and a large volume of trade waste in East Pakistan (Rashid & Rahman, 2010). Water pollution takes various forms, ranging from the recently discovered and little understood occurrence of arsenic poisoning to industrial discharges from tanneries, distilleries, pulp and paper mills, and textile dyeing and chemical companies (World Bank, 1998). The tannery factories in Hazaribag in Dhaka are responsible for very hazardous Chromium effluents (BEN, 1996). Untreated sewage quickly became the most severe source of water contamination as the world's population grew exponentially over the following few decades. Shortage of clean and uncontaminated water for non-domestic uses such as agriculture and industry are already the problem for Bangladesh. As the population moves to urban centres problem of safe drinking water has become more acute (World Bank, 1998). Even though

[40]http://documents1.worldbank.org/curated/en/938981468013830990/pdf/404240BD0Dhaka10ALSO03582401PUBLIC1.pdf

[41] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=BD

the water supply to the larger Dhaka has risen ten-folds since now, the quantity of water generated per capita has not kept pace with the fast population expansion of the metropolis. The potable drinking water service was begun in Dhaka City in the year 1874, and same year Nabab Khaja Abdul Ghani constructed a water treatment facility in Chadnighat along the bank of the river Buriganga. After that time, city residents were only given access to piped water on a restricted basis[42].

Bangladesh's metropolis, Dhaka, has become one of the world's most densely inhabited cities, housing 36 percent of the country's urban population. During the 1960s and 1970s, rural migration accounted for 60 percent of population increase. While this development has moderated since then, Dhaka continues to expand steadily, with projections putting the population of the city at almost 21 million by 2020, and as many as 27.4 million by 2030 (UNFPA, 2018).

The city's rapidly expanding population has already put great strain on it, as demonstrated by its high poverty rates, and future worries include more traffic, higher unemployment, and insufficient infrastructure. The city of Dhaka's population expansion will result in increasing demand for water. Unplanned urbanization causes towns to expand haphazardly or irregularly, resulting in the loss of green spaces and water bodies, lowering water quality (Ramachandra & Kumar, 2009).

DWASA now supplies 2.9 million cubic meters of water through 760 deep tube wells, with that number anticipated to increase by 2030. With the current abstraction capacity, an additional 350 bore-wells will be required. However, based on the present population growth rate of the greater Dhaka region (3.6%), the population for the years 2021 and 2030 is expected to be 21.5 million and 27.4 million, respectively (Figure 2.10).

[42] http://app.dwasa.org.bd/admin/news/Dhaka%20WASA%20Article-for%20BOOK.pdf

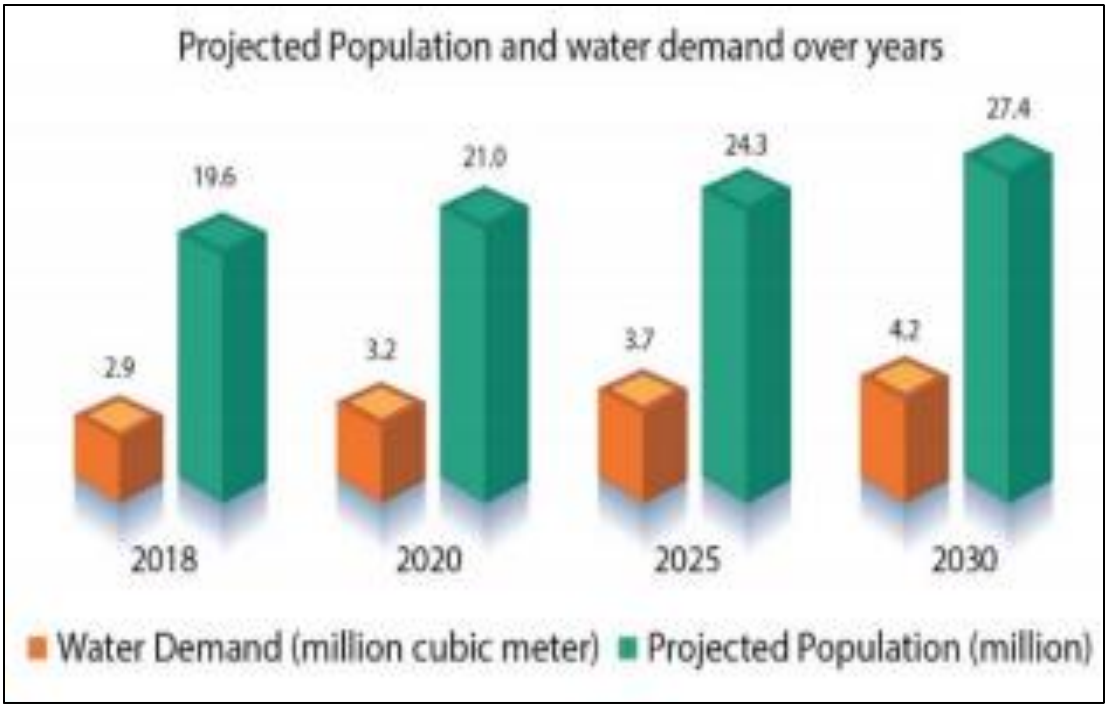

Figure 2.10: Projected population and water demand
(Calculated based on UNFPA projection)

2.7 Dhaka's Water Supply

[43]DWASA presently serves about 70 percent of the population of Dhaka City Corporation (DCC) and its suburbs (the Dhaka Metropolitan Area) (DMA). The quality and quantity of services provided in the region are not evenly distributed. In slum regions, where the majority of the impoverished live, service provision is basic. Even though urban slums represent for 37 percent of the population of DMA, there are no piped distribution networks accessible (about 4 million people). To provide potable water to city inhabitants, Dhaka WASA has around 2600 km of water line and approximately 3 lac water connections. It serves a 360-square-kilometer service region with a population of 12.5 million people and produces over 2110 million litres per day (mld). Groundwater is the primary source of water for Dhaka WASA. Dhaka WASA operates around 600 deep tube wells throughout the city, which provide roughly 87 percent of the city's water. Dhaka WASA has nearly 100 percent water coverage, and Dhaka city's water demand is 2.25 million cubic meters per day (2250 mld), slightly above the current supply of nearly 2.11 million cubic meters per day (2110 mld). Currently, groundwater abstraction from Dhaka WASA's 605 deep tube wells provides 87 percent of the provided water. Surface water treatment accounts for the

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[43] Dhaka Water Supply and Sewerage Authority. 2016. Master Plan Report. http://dwasa.portal.gov.bd/sites/default/files/files/dwasa.portal.gov.bd/page/071726be_2cac_41f0_9412_be8936c47d2c/Drainage%20master%20Plan.pdf

remaining 13 percent of water. The pace of groundwater depletion is rapidly increasing. DWASA has already begun the process of switching from groundwater to surface water as a source of water. Table 2.6 provides an overview of Dhaka WASA's water supply system.

Table 2.6: Water Supply System of Dhaka WASA

SL	Structures	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2012-2013
1	Deep Tube well	465	490	519	560	599	644
2	Water Treatment Plant	4	4	4	4	4	4
3	Water Production/day	1700 MLD	1760 MLD	1880 MLD	1990 MLD	2150 MLD	2420 MLD
4	Water Line	2533.73 km	2600 km	2600 km	2600 km	2600 km	3040 km
5	Water Connection	2,43,477	2,56,477	2,74,368	2,86,911	3,02,132	325717
6	Hydrant (active)	38	38	38	38	38	38
7	Roadside Tap	1643	1643	1643	1727	1727	1727

(Source: DWASA, 2012-13)

2.8 State of Water in Dhaka city

Water usage in Dhaka city has increased dramatically as a result of rapid urbanization and migration from rural regions (Khan, 2011). Bathing, washing, flushing toilets, and cleaning, for example, account for a significant part of overall water use. Groundwater extraction in Dhaka began at a depth of 100 meters, and in certain severe cases, the well went up to 300 meters to reach the main aquifer. The rate of depletion varies by area; for example, between 1991 and 2008, the groundwater level in Mirpur fell 53.75 meters at a rate of 3.2 m/yr, while it fell 1.1 m/yr in Mohammadpur, 2.2 m/yr in Sabujbagh, 0.5 m/yr in Sutrapur, and 0.8 m/yr in Dhaka Cantonment (Yeazdani, 2016). The city's groundwater level has plummeted around 20 meters at a pace of 2.81 meters per year during the previous seven years, and the rate has been growing since 2000. Given the present rate of groundwater depletion of 2.81 m/yr, a prediction has been produced that predicts the groundwater table will drop to 120 m by 2050 from its current level (Yeazdani, 2016). As a result of the depletion, several of the operating deep wells may have to shut down owing to water constraint. Water recharging must be maintained to provide arsenic-free drinking water. Direct recharging of water from several rivers in the Dhaka area contributes to the aquifer, although vertical recharge is limited owing to dense urbanization. To maintain a suitable water level in Dhaka, the government should take the required steps to avoid the ongoing loss of wetlands.

Water supply in Dhaka and Narayanganj is administered by the Dhaka Water Supply and Sewerage Government (DWASA), while water supply in Savar and Gazipur is managed by the relevant municipal authority (Municipality). The total expected abstraction for the entire Dhaka region was roughly 5.9 million cubic meters per day, with DWASA supplying over 2.4 million cubic meters per day from approximately 760 deep tube wells (DTW) via a 3,040 km pipeline network, with a system loss of around 25 percent (DWASA, 2017)[44]. The second-largest abstraction came from private abstractions, which account for roughly 1.67 million cubic meters per day and mostly involve industrial and commercial abstraction (Islam et al., 2017). In the Barind area around Dhaka, groundwater is overused, and there are worries about water consumption elsewhere (WARPO, 2020). [45]Dhaka Water and Sanitation Authority (DWASA, 2012) now gets 83 percent of its drinking water from groundwater sources via 627 deep tube wells in Dhaka City and Narayangonj, and 17 percent from three main surface water treatment plants. Because of overexploitation and the increasing demand from urbanization, Dhaka's groundwater has been substantially depleted, and the rate of water level decline in the city region has been estimated to be around 2.5 m/yr in recent years.

[46]Groundwater abstraction in the Greater Dhaka Area is about 5.9 million cubic meters per day, with DWASA supplying around 2.4 million cubic meters per day, or around 40 percent of the total. DWASA employs roughly 760 deep tube wells (DTW) and a 3,040 km pipeline network, with a system loss of around 25 percent. Report from the management information system (MIS). Institute of Water Modelling and Dhaka Water Supply and Sewerage Authority (DWASA) (IWM, Dhaka, Bangladesh). The industrial and commercial sectors are the second greatest users of water, accounting for around 1.67 million m^3/d, or nearly 28 percent of total abstraction (Figure 2.11).

[44] https://www.2030wrg.org/wp-content/uploads/2019/11/GW-Report-Final-Peer-Reviewed.pdf
[45] http://www.basin-info.net/river-basins/bangladeshi-river-basin-bangladesh/hydrology
[46] DWASA, 2017

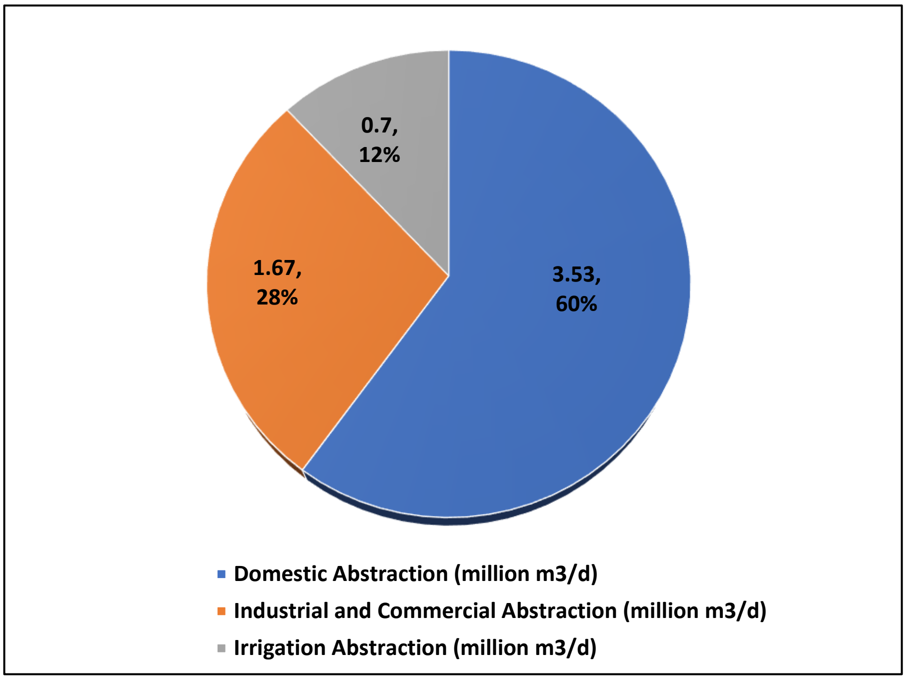


Figure 2.11: Current ground water abstraction by sector (DWASA, 2017)

2.9 Peripheral River System and Water Hydrology in Bangladesh

Bangladesh, at 1,47,610 sq km in size, is the largest delta in the world with an extensive hydraulic system of huge rivers, tributaries, branches, khals (canals), and other water bodies. All of Bangladesh's main rivers originate beyond the country's boundaries. Bangladesh has just 7 percent of the catchment area of its three main rivers, leaving it largely reliant on upstream nations to discharge sufficient flows (ADB, 2007). Bangladesh has 230 rivers, tributaries, and distributaries that crisscross the nation, producing a web-like structure that originates both inside and outside the country, with 57 of them transboundary, with fifty-four (54) from India and three (03) from Myanmar (BBS, 1997; Ahmad, 2001). The GBM basins (Figure 2.12), which include the Ganges (G), Brahmaputra (B), and Meghna (M) rivers and its distributaries, drain a total area of roughly 1.72 million km^2 in Bangladesh (Ahmad et al., 2001), and the combined flow is discharged into the Bay of Bengal. China shares the Brahmaputra and the Ganges, Nepal only the Ganges, and Bhutan only the Brahmaputra; Bangladesh and India share all three river systems (Faisal, 2002). In the three river systems, discharges are highest in July-August and lowest in April-May. Bangladesh drains 92 percent of the water produced yearly in the Ganges-Brahmaputra-Meghna (GBM) basins. Bangladesh has a water shortage during the lean season (January-May) due to reduced flows across transboundary rivers caused by huge upstream obstacles. As a result, Bangladesh's water regime is defined by excessive rainfall during the rainy season and insufficient rainfall during the dry season (Ahmad, 2001).

Bangladesh is a downstream country that receives many of these common rivers at a mature state, when the velocity drops, sedimentation rates increase, and the river changes its course, braiding into multiple channels (Bandyopadhyay & Perveen, 2008), where Bangladesh is a downstream country that receives many of these common rivers at a mature state, when the velocity drops, sedimentation rates increase, and the river changes its course, braiding into multiple channels. During the peak season, these rivers release 1.5 million cubic meters of water per second (m^3 s-1), while the runoff is only around 61,000 m^3 s-1 during the lean period (Hasan & Mulamoottil, 1994). The Brahmaputra and Ganges rivers account for 80 percent of the flow measured within Bangladesh, whereas the Meghna provides just 2 percent of total measured discharge in Bangladesh between March–April (World Bank, 2000).

The Ganges, Brahmaputra, and Meghna River Basins: Profile

[47]The Ganges begins its journey in the Gangotri glaciers in the Himalayas, near the Indo-China border, at a height of around 7,010 meters. It runs in a south-easterly direction, with the lower portions flowing eastward, eventually entering Bangladesh at Rajshahi in western Bangladesh. The river is approximately 2,520 km. It runs south-east for roughly 257 km after entering Bangladesh before joining the Brahmaputra. The Ganges catchment region spans 10,87,300 sq km across India (8,60,000 sq km), Nepal (1,47,480 sq km), China (33,520 sq km), and Bangladesh (46,300 sq km) (Khan, 1994).

The entire catchment area of the Brahmaputra-Jamuna is 552,000 sq km with China (270,900 sq km), Bhutan (47,000 sq km), India (1,95,000 sq km), and Bangladesh (39,100 sq km). The Brahmaputra is roughly 2,900 kilometers long, with an average discharge of nearly 19,000 m^3/s (Table 2.7). The rivers gather snowmelt and runoff from high-elevation catchments in China, Bhutan, and India before entering Bangladesh's Rangpur region. After entering Bangladesh, the Brahmaputra flows south, merging with the Ganges (Padma) near Aricha Ghat, before merging with the Meghna River in the south-east.

The Meghna River's headstream, the Barak, begins in the hills of Manipur, India. Near the Indo-Bangladesh border, the Barak splits into two rivers, the Surma and the Kushiyara, which eventually merge near Ajmiriganj to form the Meghna. The river travels in a south-

[47] https://assets.publishing.service.gov.uk/media/57a08da6e5274a31e000199a/R6755rev.pdf

westerly direction till it reaches Chandpur, where it meets the Padma. The river stretches for about 900 km, including 403 kms in Bangladesh.

More than 80 percent of stream flows are accounted for by two major rivers, the Brahmaputra, and the Ganges. The greatest flood discharge of the Ganges was 76,000 m^3/s at Hardinge Bridge in 1987, while the highest flood discharge of the Brahmaputra was 98,600 m^3/s at Bahadurabad in 1988. The rivers' minimum discharges are 261 and 2800 m^3/s, respectively. The Ganges has an average daily flow of 10,874 m^3/s, which drops to 1366 m^3/s during the season and rises to 32,00 m^3/s during the summer. The greatest flow, over 44,000 m^3/s, is generally experienced in August. The Meghna's annual average discharge in Bhairab Bazar is roughly 4,800 m^3/s, with the greatest flow occurring around mid-August (Nadira & Shixiang, 2018). River inflows are also decreasing dramatically as a result of gradually rising withdrawal in the higher riparian nations (Khalequzzaman, 2015).

Table 2.7: The GBM Rivers' average discharge in Bangladesh

River	Average Discharge m^3/sec	Average Annual Silt Runoff (tonnes/sq km)
The Ganges	11,610	492
The Brahmaputra-Jamuna (Brahmaputra)	19,200	1,370
The Meghna	3,515	-

Source: Chowdhury, 1990

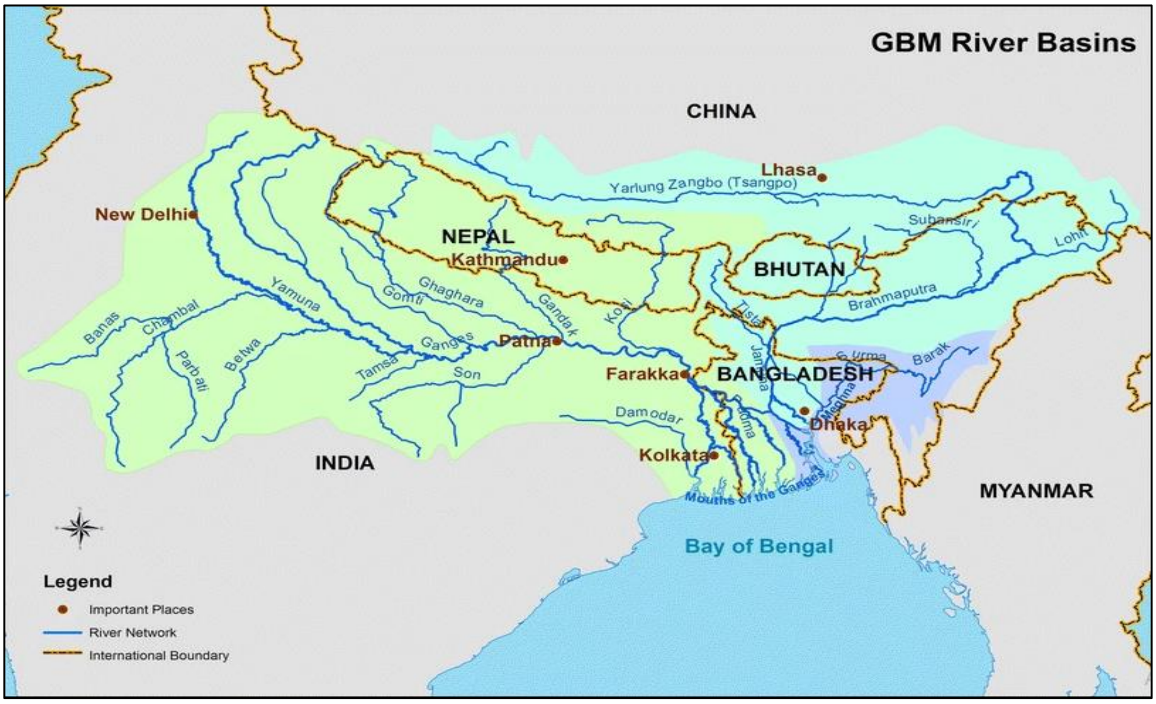


Figure 2.12: The Ganges–Brahmaputra–Meghna (GBM) Basins (Source: Baten & Titumir, 2016)

2.10 Dhaka's Peripheral River and Water Hydrology

[48]Dhaka is the epicenter of ambitions and progress. Dhaka, Bangladesh's capital, is one of the world's most populous megacities. It is a historic settlement on the banks of the Buriganga, north of the confluence of the River Padma (combined Ganga and Brahmaputra) and the Meghna, founded by the Mughal Empire in the 16th century. Dhaka is bounded on the east by the Balu and Sitalakhya rivers, on the west by the Turag and Buriganga rivers, on the north by the Tongi Khal river, and on the south by the Dhaleswari river (Figure 2.13). The Dhaleswari River, a tributary of the Jamuna River, runs through the south-eastern section of Bangladesh's North Central Region, near to the Padma River (Ganges) and Upper Meghna River confluence. At 11 km downstream of the Buriganga confluence, the Lakhya River enters Dhaleswari. The Dhaleswari River, a tributary of the Jamuna River, flows through the south-eastern portion of Bangladesh's North Central Region, near to the confluence of the Padma River (Ganges) and Upper Meghna River, about 5 km below the Dhaleswari-Lakhya confluence. At 11 km downstream of the Buriganga confluence, the Lakhya River enters Dhaleswari. The Dhaleswari River meets the Meghna River around 5 km downstream of the Dhaleswari-Lakhya confluence, and then flows into the Padma River 20 km downstream. The Turag River, which collects local rainfall and spill flows from the Jamuna River's left bank, is the major source of water for the Buriganga. Between the middle-wooded areas and the Old Brahmaputra, the Lakhya River drains a vast watershed. The Balu, which drains a minor catchment to the west of the Lakhya, provides additional inputs to the system. The Dhaleswari-Buriganga-Lakhya-Balu River system is tidal during the dry season when upstream inputs are restricted. During the rainy season, these rivers receive water from the Jamuna (Brahmaputra River), while during the dry season, the higher sections of these rivers are progressively supplied by groundwater discharge (Zaman, 2017). Buriganga, Turag, and Balu Rivers were internally connected by a network of more than 40 khals of over 250 km length until recently (Nurrunnabi, 2002). All the chrome-polluted waste of the tanneries at Hazaribagh (western edge of Dhaka city) is discharged into this river. Other pollution hotspots are Mouchak, Konabari, and Tongi towns north of Dhaka. Their wastes go into the Turag and then into Sitalakhya (Rashid, 2014). A summary of the peripheral rivers and distances from Dhaka has been shown in Tables 2.8 and 2.9.

[48] River Master Plan. 2019. Report of the Technical Committee on the prevention of Pollution and Increasing Navigability of Rivers surrounding Dhaka

Table 2.8: Summary of peripheral rivers surrounding Dhaka

River Name	Length (km)[a, b, c, d]	Width (m)	Average depth (m)	Originates	Outfall
Turag	21[a], 75[b], 71[d]	218	13.5	Bansi River (Kaliakair)	Buriganga (Mirpur)
Tongi	14.4[a], 15[b]	60		Branch of Turag	Balu River (Trimohoni)
Balu	110[a], 30[b], 45[d]	300	9.63	Turag (Amin Bazar)	Shtilakhya (Demra)
Buriganga	45[a], 27[c]	265	14	Dhaleswari (North)	Turag
Shitalakhya	110[a], 120[b], 52[d]	113	10	Distributary of old Brahmaputra	Dhaleswari (Kalagachhiya)
Dhaleswari	160[a], 178[b], 61[d]	300	37	Jamuna (Tangail)	Upper Meghna
Sources	Haque, 2018[a]; DWASA, 2019[b]; Banglapedia, 2015[c]; DWASA, 2006[d]	Haque, 2018	DWASA, 2006	Haque, 2018; DWASA, 2019; Banglapedia, 2015	Haque, 2018; DWASA, 2019; Banglapedia, 2015

Table 2.9: Distance from Dhaka to all surrounding rivers

Name of Rivers	Distance from Dhaka City (km)	Remarks
Padma	40.13	
Megna	33.5	
Jamuna	38.8	Farthest away
Balu	13.3	
Tongi Khal	9.8	
Turag	7.9	
Shitalakhya	13.9	
Buriganga	10.3	
Dhaleswari	21.9	

Source: Haque, 2018

The hydrological environment of Dhaka city comprises these six rivers (Figure 2.14) connected to large rivers, relatively low depth groundwater aquifer, wetlands around the city, and about 2400 mm average annual rainfall between 2001-2008 (NWRD, 2011). The surface water sources are rivers around the city and groundwater sources are the DTWs installed in different zones of DWASA. In recent years, it was observed that the surface water flow through the Turag and Sitalakhya Rivers around Dhaka is reduced together with permanent disappearing of wetlands due to encroachment or landfilling for residential and commercial uses (Choudhury et al., 2014). Already about 73 percent of permanent wetlands were lost from 1967 to 2010 (from 207 km^2 to 55 km^2), which were either dried out or converted to other land use (CEGIS, 2011). Reduction of surface water flow in rivers and declining wetlands are consequently affecting the water production by STPs and groundwater recharge in Dhaka city. Although the STPs are still running, the groundwater table is declining at an alarming rate (2-3 m/year). Furthermore, both surface water and groundwater sources are being polluted by the wastewater dumping from industries in the city. Hence, the sources of water for the water supply system are at great risk, creating havoc to ensure safe drinking water for city dwellers as well as reducing potential water availability in the future. With the present trends and present state of the hydrological environment around Dhaka city, it can be easily foreseen that the freshwater availability in Dhaka city would be limited in the future where this limited source of water, water supply networks do not cover the whole city adequately to provide water to all its citizens (Choudhury et al., 2014). Given the geographical location of the country, Bangladesh is highly vulnerable to both flooding in the rainy season and scarcity of water in lean season.

Figure 2.13: The Turag River and other rivers at the surroundings of the Dhaka city (Source: Rahman et al., 2013)

Figure 2.14: Dhaka Hydrological Plot. Source: http://www.basin-info.net/river-basins/bangladeshi-river-basin-bangladesh/hydrology

Chapter 3: Methodology

The methodology describes the procedure to be followed for the collection and analysis of the data in confirmation with the research to fulfil the objectives. This section describes in detail the research processes used in the present study. It elucidates how the stated research objectives can be achieved following a suitable research methodology. This section aims to develop a comprehensive research methodology that fits the research questions.

This part covers the methodology in depth, but each chapter of this thesis, which is focused on a distinct research topic, contains the relevant data collecting methods, data collection sites, number of respondents, data analysis techniques, and theoretical approaches.

3.1 Data Sources and Collection Techniques

The present study utilizes both primary and secondary sources of information. Primary sources involved a household questionnaire survey and three methods of qualitative research for data collection. Secondary sources involved the review of existing literature. These data collection tools have been selected based on the research questions and the points to be discussed (Table 3.1). The quantitative and qualitative methodology of the research gets significant attention as they help to understand the problems in static as well as in the dynamic settings, that is, comprehensively and holistically. In essence, the study aims to decipher the link between urban water use, health risk, and gendered role in the riparian areas of Dhaka city.

3.1.1 Primary Sources of Information

Data collection tools have been decided based on the research question (Table 3.1) which involve the combination of both quantitative and qualitative approaches. The quantitative and qualitative integration help to triangulate the nature of the problem and the way forward.

3.1.1.a Quantitative method has been systemically applied across study sites following a scientific approach where surveys include intra-household interviews.

- ***Household Interviews****:* The information related to the study questions was collected primarily from the household, and the respective community through a structured questionnaire (Appendix A1). An in-depth interview has been conducted at the household level (Intra-household). The researcher visited each of the respondents more than once to explore the interaction of water use, gendered role, and health risk.

3.1.1.b Qualitative data collection tools have been developed based on health risk, gender, and equity issues following participatory tools such as water use behaviour survey (Observation), Key Informants' Interview (KII), and Focus Group Discussion (FGD) to understand daily interactions with the water system.

- ***Key informant interviews:*** Different people who have a good understanding of the linkage of environment, risk, and household welfare are the key informants of the study.
- ***Group discussions:*** Several group discussions were arranged in various sample areas and included diverse people like male, female, and adult from different households in the community.
- ***Participatory Observation:*** In this water use survey researcher visited the study area several times. It helps the researcher to understand the purposes and gender dimensions of Turag River interactions. It will be a deeper understanding and analysis of information from interviews.

Table 3.1: Research questions, data collection tools, and points to discuss

Research Question	Data collection tools	Discussion points
1. What are the available water sources and usages patterns?	Questionnaire survey, FGD, KII, Observation	Available sources, water usage, seasonal variation of water usages, ownership of source, payment type, intervention, and maintenance
2. How do the local people interact with river water?	Observation, FGD, Questionnaire survey	**<u>Observation</u>** • Types of domestic water-use (Bradley & White, 1968): **Consumption** (Drinking, Cooking, Water collection); **Washing** (Vegetable, Dish, Cloth washing etc.); **Hygiene** (Bathing, Personal washing, Open defecation); **Amenities (**Boating, Angling, Swimming/recreation, Other non-essential tasks); **Productivity** (Navigation/Transport, Fishing, Commerce, Watering, and bathing of Livestock) **<u>Survey</u>** • Main sources of water, the purpose of river water use, source during the scarce period

Table 3.1: Cont…………

Research Question	Data collection tools	Discussion points
3. What are the differential gender-specific roles and behaviour in the attainment of household water security?	Questionnaire survey, FGD, KII	Family member's responsible to manage water, hours spent, challenges they face to collect water
4. Is there any links between water use and community health?	Questionnaire survey, FGD, KII	Health risk focus on understanding the behavioural side of exposure pathways, types of diseases, frequency of occurrence, measures taken to recover
5. How community gets impacted due to illness?	Questionnaire survey, FGD	Productivity loss, increase in working hours, loss of work, the problem in the workplace due to illness food insecurity

3.1.2 Secondary Sources of Information

Secondary literatures consist of books, journals, annual reviews, periodicals, other publications, etc. The study uses diverse secondary sources of data to analyses the issues such as the population and household census, Zilla series and Community series of the latest population census 2011, latest agricultural census, statistical yearbook, various reports such as household income and expenditure survey produced by Bangladesh Bureau of Statistics (BBS), policy documents from relevant ministries, related documents produced by international organizations/institutions like FAO or World Bank. Some relevant and cross-country evidence has also drawn from other countries.

Demographic data can be found both from national and international data sources. Both national and international data sources have been used in this study, as:

3.1.2.i National Data Sources

• ***Census***

Census is considered as the official count of the population of a country at a given period. In our country, the Bangladesh Bureau of Statistics (BBS) is responsible for the nationwide census. Census Wing is one of BBS's eight wings, and it's in charge of conducting three decennial censuses: the Population and Housing Census, the Agriculture Census, and the Economic Census. The first Population and Housing Census was conducted in 1974, the first Agriculture Census was conducted in 1977, and the first Economic Census was conducted in 1986, following the country's freedom in 1971. There have been five Population and Housing Censuses since independence, the most recent of which was performed in 2011, making it Bangladesh's final official census. Bangladesh, like many other nations, lacks continuous statistics on births, deaths, and other critical population data since censuses are done every ten years.

• ***Sample survey***

Sample survey is one of the important sources of demographic data in Bangladesh. Different surveys like demographic and health surveys, household and expenditure surveys are conducted under the sample surveys. Sample surveys provide a wide variety of data which includes data like age, sex, residence, education, income level, etc. Sample surveys can provide misleading information or faulty interpretation of data due to lack of proper representativeness.

• ***Demographic surveillance system***

In the 1960s, the Demographic Surveillance System (DSS) was established to collect data on family planning, child nutrition, epidemiology, child and maternal health, and other topics. This system provides demographic data on a narrow basis and the data provided are not regular.

3.1.2.ii International Data Sources

• ***United Nations***

Bangladesh is included in the United Nations' population and statistics division, which gathers and distributes worldwide population data. The United Nations Population Fund (UNFPA), which oversees the UN's demographic division, produces World Population Prospects, which contains population statistics from all around the world. The most current release includes demographic data from 1950 as well as projections for the years 2050. Population density, population by five-year age group and sex, sex ratio, sex ratio at birth, population growth rate, number of births and deaths, and other demographic statistics are all included in the database. This study heavily relies on this data source.

• ***Demographic and Health surveys***

Household surveys that are nationally representative are known as Demographic and Health Surveys (DHS). The DHS collects statistics on a wide range of population, health, and nutrition indices. DHS has provided Bangladesh with accurate demographic statistics since 1994. The survey gathered extensive information on fertility levels, marriage, fertility desires, awareness and use of family planning techniques, nursing habits, women's and children's nutritional status, childhood mortality, maternal and child health, and the reliability of the data.

• ***US Census bureau- International database***

The US Census Bureau's worldwide database contains estimates of population, births, deaths, and migration statistics from all around the country. It shows population growth patterns and compares Bangladesh's demographic situation to the world average. It contains information on population numbers, fertility indicators and measurements, mortality, and migration.

• ***World Bank-Open Database***

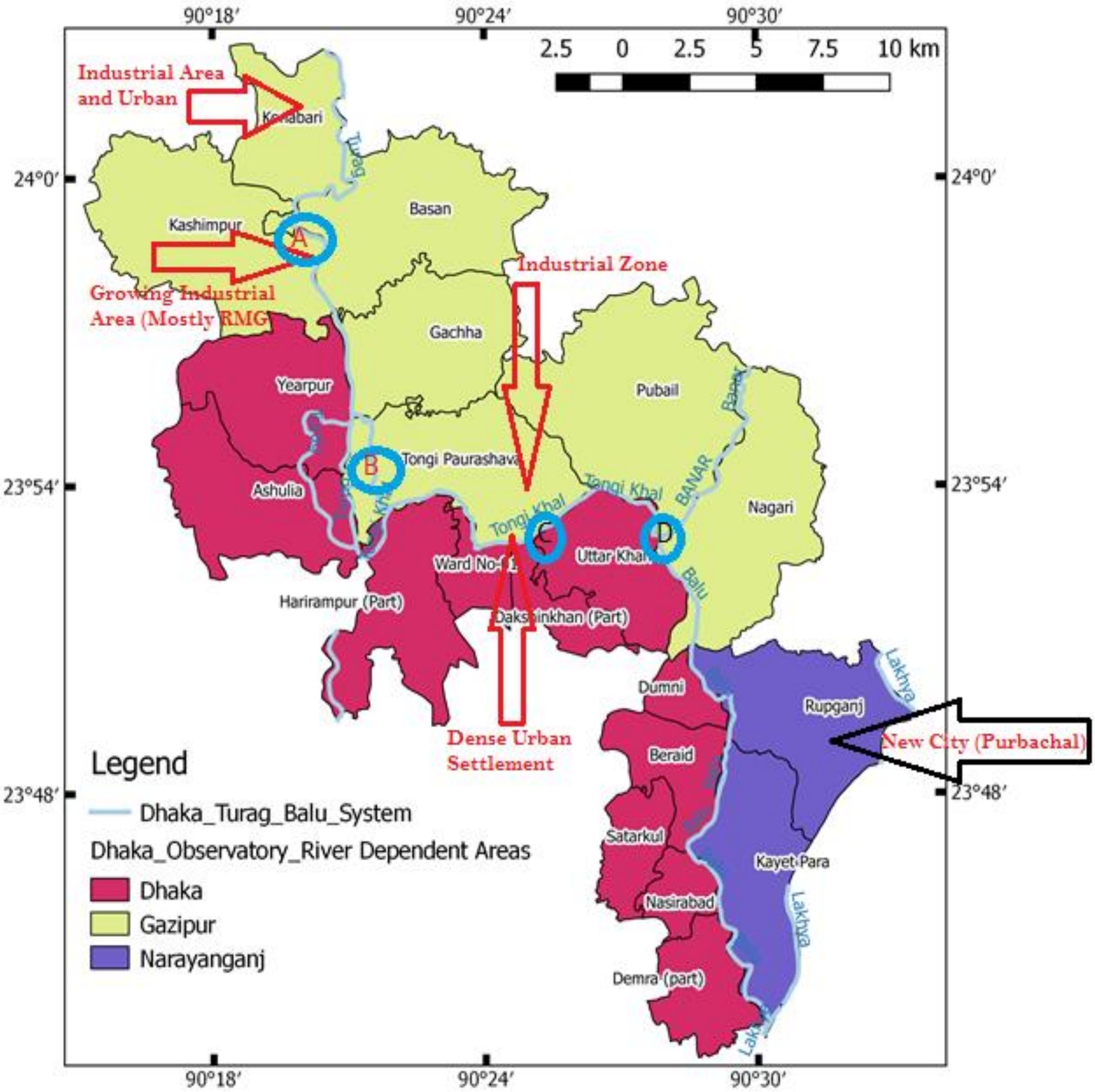
The Data Group's purpose is to offer high-quality national and international statistics both inside and outside the World Bank, as well as to strengthen member nations' capacity to create and use statistical data. The World Bank publishes a variety of data products in print and electronic media that address a wide range of development topics. The extent of the data effort and the vast spectrum of user interests are reflected in these publications. They also make data more visible and accessible, particularly via the use of maps, charts, and graphs.

3.2 Selection of Study Area

The water survey points of REACH-BUET cover the areas between the endpoint of Bongshai river and the connection points of Turag and Balu River, a distance is of around 49 kilometers by road (Joydevpur-Tangail Highway to Dhaka-Sylhet Highway to *Tarabo* to *Rupganj*). The areas in between those points have some distinct characteristics: at the Bongshai-Turag points, mostly in the part of Konabari and Kashimpur areas, there are industrial settlements on one side and the other side, there is low land which mostly floods during monsoon, and dwellers live mostly in scattered formation but are mostly attached with the river. Few people live on the banks of the river.

The survey areas have some features which will deal with the issue of industrial growth, industrial waste, urbanization, and municipal waste (***Map 1***). The areas, Kashimpur-Konabari, as labeled by **A** in the figure represent the zones of industrial waste (IW) from the newly growing industrial zone; the areas, Bhadam and Bhakral, represent zones near to core urban periphery, some natural part, and some parts affected by the municipal waste (MW). Areas, located broadly near Abdullahpur, labeled by **C** represent a mix of heavy industrial waste and municipal waste. Areas, near to point **D**, represent the pollution plume.

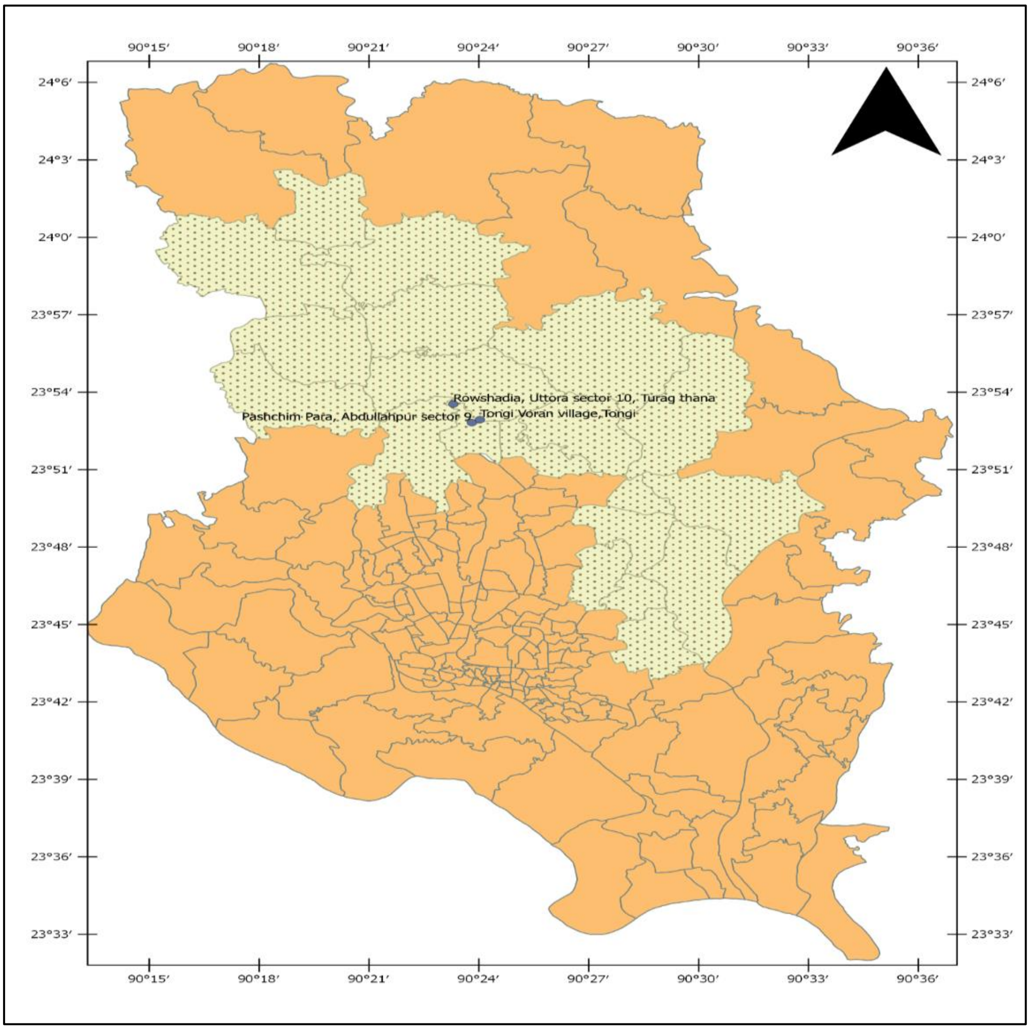
Therefore, the areas labeled **A** and **B** represent the newly growing industrial zones and growing industries that are concentrating on RMG expansion whereas areas **C** and **D** are the range of downstream areas: **C** is semi-downstream, and **D**, up to now is relatively downstream (***Map 1***). Besides, the REACH team has made multiple scoping visits to identify the diverse water security challenges in different areas. Information from the urban water risk characterization and scoping visits were used to design the household survey questionnaire and sampling strategy.



Map 1: Showing Project Survey Points (Source: BUET, The survey areas in the map are indicated by blue circles)

3.2.1 Reconnaissance, Scoping Visit and Primary Scenarios

Before selecting the survey areas, reconnaissance and scoping visits had been made to understand the survey areas, nature of major problems there, and characteristics of the analytical units including the understanding of local institutes, and local knowledge. Several reconnaissance visits were made to be familiar with the survey areas and potential samples. The visits enabled us to formulate research problems, research questions, and to find possible ways to collect the data in the targeted areas. We collected photos and videos of river water usages in the riparian areas of the Turag River. Since environment and industry have a broader sense, the analysis has been concentrated on water, the key element of the environment, and garment industries, the most flourishing industry of Bangladesh. The very first visit was made to three sites namely Rashadia, Voran, and Abdullahpur close to the Bishwa Ijtema grounds along the Tongi Khal[49] (***Map 2***).



Map 2: Showing location of sites visited

[49] Sonia Ferdous Hoque, Postdoctoral Researcher in Water Security and Society; Observations from field visits to Matlab, Khulna and Dhaka Observatories, Bangladesh; 08 February 2017

The first site (**Rashadia**) visited was a small community of about 15–20 households, comprising garment factory workers, construction workers, and small businessmen. All households are tenants, paying monthly rents to the landlord who also lives within the same community. Households receive water supply from Dhaka Water Supply and Sewerage Authority (DWASA) and their tariffs are incorporated in their house rents. There is a shared storage tank and women collect water from the tank for their domestic needs. They do not have any significant problem with their water supply, except for periodic shortages due to intermittent electricity supply, especially during the summer. In such cases, they collect water from a shallow tube well located in the neighborhood. Despite being close to the river, they do not use the river water for any purpose, even during the wet season when the water level increases considerably.

The second site **(Tongi Voran)**, located close to the first one, uses water from a deep borehole (350 ft) constructed by an NGO about 7-8 years ago. The borehole is equipped with a pump and storage tank. Water is released to taps within the yard two times a day. Every household pays a monthly tariff of Tk. 80 per room for the electricity bill, which is collected by the landlord along with the rent. The pump has been repaired about 5 times since installation, with the last one being done about 2 months ago. All households contribute to the repair cost, which can be around Tk. 2000. The landlord constructed a separate borehole, like the shared one, within his own gated compound about two years ago. Women in the community reported that they do not use the river water for any purposes during the dry season due to pollution and foul smell. Some people use the river water for 3-4 months during the monsoon, mainly for washing, laundry, and bathing. Similar to the first site, intermittent electricity supply causes disruption in water supply during the summer months. A private shallow tube well across the road is used as an alternative source during crisis periods; however, the women reported that the well owner is quite hostile.

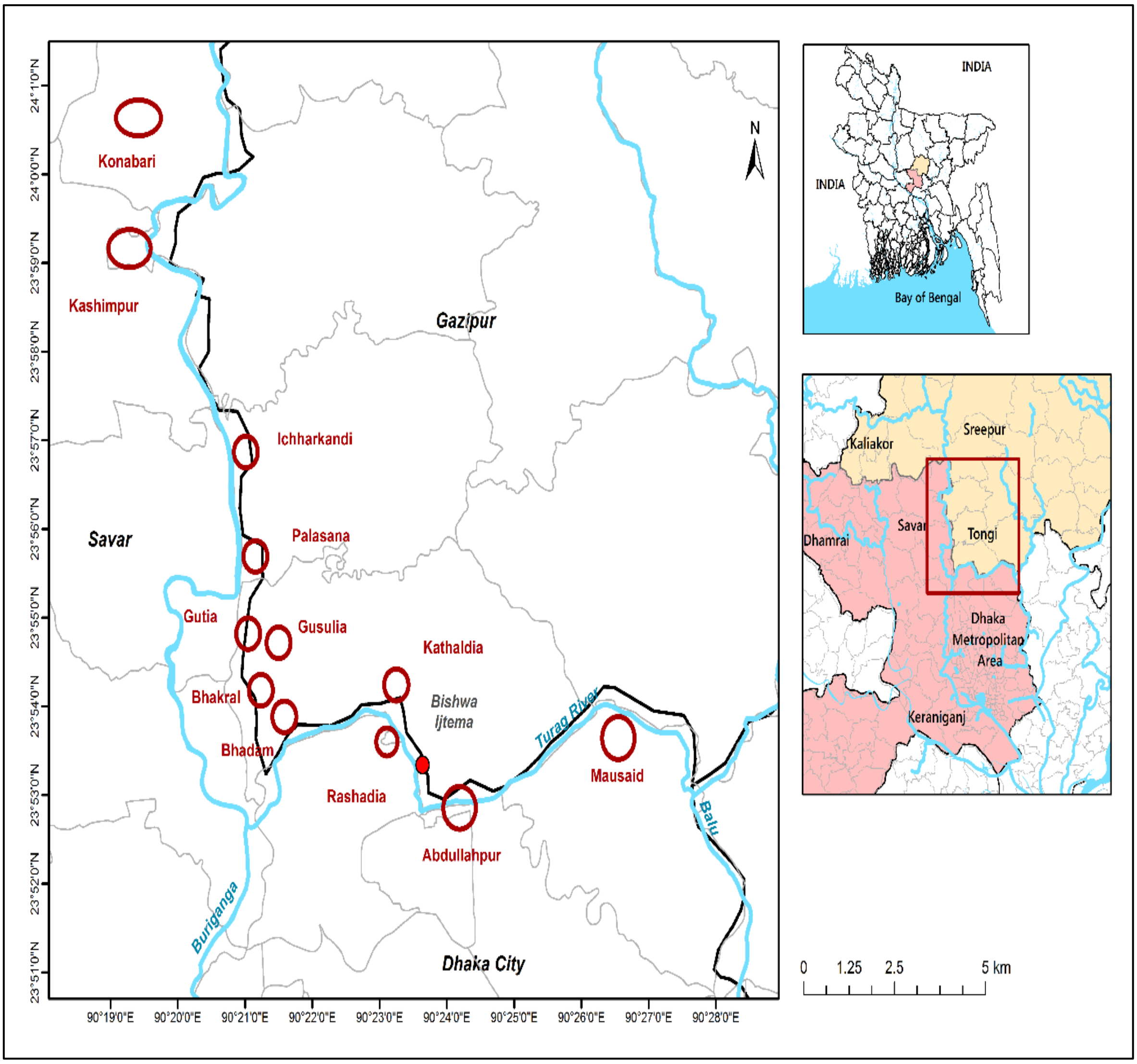
The third site **(West Abdullahpur)** is a very dense settlement, and all households own the dwellings they live in. There are a couple of deep boreholes with pumps and tanks provided by the local government, along with few individual tube wells as well. The government TWs are the main source of drinking water and are shared by hundreds of households within the community. During our visit, we observed many women and children using the polluted river water for washing clothes and dishes (Photograph 1). They reported that they do the main washing in the river and later rinse the dishes/clothes with the water from the TW. Otherwise, they would have to waste a lot of time just queuing at the government TWs.

Despite the noticeably poor quality of the river water, residents mentioned that they hardly suffer from any water-related diseases as they have become ‘immune’ to it. Apart from pollution from untreated effluent discharge, there was widespread littering of plastic bags and household waste in the river (Photograph 1). Alarmingly, we also observed hanging toilets on the bank of the river (Photograph 1), close to the place where people were washing dishes/clothes. River water use increases in the wet season as an increase in water level reduces the perceived concentration of pollutants. dishes/clothes. River water use increases in the wet season as an increase in water level reduces the perceived concentration of pollutants.

Photograph 1: (Clockwise from top-left) Low-income settlement along the bank of the Turag River; Plastics and household waste dumped near the river; Hanging toilets along the river; Women and children washing dishes and laundry using river water

3.2.2 Finalization of Study Areas

Considering the sources of drinking water and proportion of households adjacent to the river, the research team proposes the following twelve areas for the survey: four areas from the upstream (having low pollution level), six areas from the midstream (moderately polluted area), and two areas from the downstream areas (where the pollution level is comparatively high). The Twelve sites include- Konabari, Kashimpur, Ichharkandi, Palasana, Gutia, Gusulia, Bhakral, Bhadam, Rashadia, Kathaldia, Abdullahpur, and Mausaid (***Map 3***). A preliminary perception is that the availability and low polluted water during the monsoon will increase the probability of using the river water for various purposes of the households. In each sample area, it is expected that a certain percentage of the households will be exposed to river water.



Map 3: Showing study sites along Turag River area (Source: REACH, Oxford)

3.3 Selection of Study Population

[50]The survey will help to assess the study questions. The questions will be tested using the household level, institutional level, and community-level data. The population of the study, therefore, will be those who live in riparian areas, areas adjacent to the river, physically or economically.

- ***Household-level:*** the households living near the river within a specific distance i.e., half a kilometer will be the study population. To capture the intra-household water resource usage, the survey will focus on individual data within the households.
- ***Local medical institutes:*** local medical institutes will be visited to understand the extent of waterborne diseases in the survey areas.
- ***Industry:*** some industries will be visited to know about the sick leaves of the workers and their expected productivity loss.

3.4 Data Collection

3.4.1 Intra-household Questionnaire Survey

The household survey aimed to collect quantitative data on various indicators of multidimensional poverty and water security risks, in terms of drinking/domestic water services and the impacts of water-related hazards on livelihoods and wellbeing. The household heads or their spouses were the target respondents; however, since the survey contained detailed questions on agricultural activities, the presence of male respondents proved to be necessary at times. The survey questionnaire (Appendix A1) comprised of four core sections (sections 2–5), which were observatory specific sections designed to aid comparison across the REACH observatories with a question addressing the specific research from fellow researchers. Also, there were introductory and concluding sections, leading to a total of six sections.

3.4.1.i Sampling Design: Selection of Primary and Secondary Sampling Units

The study focuses on urban water security at the household level and so households are the sampling units. The households in Turag riparian areas constitute the population of the study. The study population, therefore, includes households located within given areas who are more likely to be exposed to river water and river water-related risks and households living a little bit away from the river and less likely to be exposed to the risks. The study

[50] Eusuf, A. and Khaleque, M. A. 2017. Research Questions, Survey Instruments and Sampling Strategies. Dhaka Observatory

aims to incorporate systematic random sampling strategies to avoid the researcher's biases in selecting primary sampling units and sample elements. The strategy keenly considers representativeness, accuracy, sample size, time, and budget constraints. In determining the sample size, the team considers the nature of the samples, the degree of homogeneity, and the level of analysis. Since the statistical method of sample selection depends on the nature of the expected outcome, namely proportions, means, and ratio (Chadha, 2006), the team is also aware of the selection of the statistical method in drawing samples.

The study follows a probability sampling technique in drawing the sample household, the unit of analysis. The samples from the listed households in the sampling frame and households near to river within a given distance having the chance of being exposed to river water-related risks have been treated as the target population. The households living a little bit away from the river and having less chance to be exposed to river water-related risks treated as the control population. The study population covered the households living within half a kilometer of the banks or canals of Turag River with the samples from the newly growing industrial zones, the upstream of the Turag River, as well as from the downstream areas. A preliminary perception is that the availability and low polluted water during monsoon will increase the probability of river water use in various purposes of the households, and therefore, increase the chance of being users becoming infected by waterborne diseases compared to the dry season when the households have a low likelihood of using river water due to highly polluted water.

3.4.1.ii Sampling Frame

The sampling frame has been developed based on a short baseline survey in the survey areas. Some basic questions were added to the baseline survey. Households within half a kilometer have been considered as the elements of the baseline survey.

3.4.1.iii Sample Size

3.4.1.iii.a Determination of Sample Size

Determination of appropriate sample size, a well-discussed topic in statistics, is a key to the success of any field operation. As the survey is involved with the estimation of many parameters, the determination of a single sample covering all the parameters is a difficult task. In this situation, the determination of sample size should be based on the estimation of a parameter of interest, which is a relatively rare event among other parameters so that the sample size adequate for that rare event will automatically be adequate for all other parameters.

According to Daniel (1999), the sample size can be simply calculated using the following formula:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

where $n =$ sample size, $Z = Z$ statistic for a level of confidence, $P =$ expected prevalence or proportion, and $d =$ precision or the desired margin of error.

Since the prevalence of health risks upstream and downstream is unknown to us, following the convention that $\hat{P} = 0.5$, so that the standard error $\sqrt{\frac{\hat{P}(1-\hat{P})}{n}}$ yield the highest standard deviation. Such consideration, in a budget-constrained sampling, will suggest a low level of samples but with relatively better sampling distribution.

Table 3.2: Parameter values and respective sampling outcome

Input Values		
Parameter		**Value**
Predicted value of indicator (in target/base population)	*r*	0.500
Design effect	*deff*	1.5
Relative margin of error at 95% confidence	*RME*	0.0996
Proportion of target/base population in total population	*pb*	0.08
Average household size	*AveSize*	4.2
Household response (or completion) rate[A]	*RR*	0.90

Output Values	
Estimate	**Value**
Predicted *r*	0.5
Confidence limits (at 95% confidence)	
Upper	0.5498
Lower	0.4502
Number of households (Sample size): *n*	2000
Standard error (*se*)	0.0249

(Note: The sample size is determined following the sample size determination template of MICS)

Under the presumption of a 90 percent response rate of the households with a predicted value of 50 percent of the indicator, the total number of sample households becomes 2000. The estimated standard error is 2.5 percent.

To estimate the sample size, the following formula has been used:

$$^{51}n = \frac{4 * r * (1 - r) * deff}{(RME * r)^2 * pb * AveSize * RR}$$

The standard error (se) has been estimated using the following formula:

$$\frac{r * RME}{2}$$

3.4.1.iii.b Selection of Sample Size

The total samples of 2000 have divided into two groups, the target samples, samples living near to river, and the controlled samples defined control households, households living away from the river. Of the total 2000 samples, 1400 samples will be from the upstream and the remaining from the downstream. In each sample area, it is expected that a certain percentage of the households will be exposed to river water.

We assumed that the chance of exposure to river water by the households adjacent to the river is at best 50 percent. In designing the sample size, the design effect was set at 1.5. The relative margin of error at 95 percent confidence (RME) was kept at around 1 percent. The average proportion of the target population in the total population is expected to be nearly 8 percent and the average household size is 4.2. In calculating the samples in the survey areas, the proportion of households who are adjacent to the river and exposed to other types of drinking water source are kept in mind. Some areas are remarkably close to the river/lakes while a part of some areas is adjacent to the river and a part of the population has the chance to expose to river water. Therefore, the low percentage of the samples in the areas suggests either a low chance of being exposed to river and river water or a low percentage of the population is adjacent to the river or both. On the other hand, the high percentage of the samples in the areas suggests the inverse to the preceding.

Considering the sources of drinking water and the proportion of households adjacent to the river, the research team proposes the following sample distribution by areas.

[51] Sample size determination template of MICS

Table 3.3: Proposed sample distribution and HHs weight

Selected sites	HHs	Population	Water Source other than tap and tube well	Proposed Samples	% of total samples	% of HHs of the areas	HHs weig ht
1. Konabari	7976	30176	0.2	335	45.0	4.2	901
2. Kashimpur	4065	13957	1.2	211	22.9	5.2	459
3. Ichharkandi	423	1845	14.2	166	2.4	39.2	48
4. Palasana	471	2038	0.0	118	2.7	25.0	53
5. Gutia	372	1818	5.4	113	2.1	30.4	42
6. Gusulia	172	789	15.7	70	1.0	40.7	19
7. Bhakral	239	1068	11.5	87	1.3	36.5	27
8. Bhadam	863	2850	0.6	221	4.9	25.6	97
9. Kathaldia	613	2640	14.6	243	3.5	39.6	69
10. Rashadia	193	705	12.1	72	1.1	37.1	22
11. Abdullahpur	1860	8289	0.0	225	10.5	12.1	210
12. Mausaid	466	2332	4.9	139	2.6	29.9	53
Total	**17713**	**68507**	---	**2000**	---	---	---

Source: REACH Survey Data, Dhaka Observatory (December 2017-February 2018)

3.4.1.iv Data Cleaning

The raw data collected through ONA software has been converted into an SPSS dataset. The data has been investigated to know its quality. The quality check has been done based on the understanding of the questions of the survey by the respondents. The poorly understood filled-in questionnaires have been removed to enhance the data quality. Moreover, some entry errors have also been removed. After all corrections, the final sample size becomes 1,826. The distribution of the final samples by survey areas is shown below:

Table 3.4: Distribution of samples by areas

Areas	**Proposed Samples**		**Final Samples**	
	n	**%**	**n**	**%**
1. Konabari	335	16.75	242	13.25
2. Kasimpur	211	10.55	204	11.17
3. Ichharkandi	166	8.30	164	8.98
4. Palasana	118	5.90	110	6.02
5. Gutia	113	5.65	107	5.86
6. Gusulia	70	3.50	65	3.56
7. Bhakral	87	4.35	85	4.65
8. Bhadam	221	11.05	199	10.90
9. Kathaldia	243	12.15	222	12.16
10. Rashadia	72	3.60	68	3.72
11. Abdullahpur	225	11.25	220	12.05
12. Mausaid	139	6.95	140	7.67
Total	**2000**	**100.00**	**1826**	**100.00**

Source: REACH Survey Data, Dhaka Observatory (December 2017-February 2018)

3.4.1.v Instrumentation of the Survey[52, 53]

This section summarizes the purpose and the specific questions within each module. The household head or his/her spouse will be the target respondents. While most of the modules require information at the household level, some are applicable to all individuals within the household or to children under the age of 5 only. To understand intra-household differences in water security, certain questions will have to be asked for the adult male and female separately. The survey questionnaire (Appendix A1) comprised of four core sections (sections 2–5), which were designed to aid comparison across the REACH observatories, with the specific question of researcher's objectives were drawn from the specific section. Besides, there were introductory and concluding sections, leading to a total of six sections. A seventeen-page (17) standard structured household survey questionnaire has been developed (Appendix A1) and applied for collecting data from the respondents. The questionnaire was pre-tested through eight interviews during scoping and revised following the pre-test. Although the questionnaire was written in English, the interviews were performed in Bangla, the local language.

Section 1: Introduction and identifiers

This contained the consent and confidentiality agreement, which were read out to all respondents before commencing the survey; and the identification information, which includes the enumerator ID, the names of the union and the *mouza*[54] where the household is located, and the duration for which the household has been residing in that area. The GPS coordinates of the household were also included as part of this section, ensuring that the accuracy level was at least 20 m. However, as this process required a few minutes, this question was moved to the end of the survey so that the respondents were not kept waiting.

Section 2: Household demographics

Demographic information on all household members will be collected, including questions on name, age, sex, relation to household head, education, and possession of personal mobile phone. The household head and his/her spouse will respond to questions about their main occupation, frequency, and seasonality of this activity and the type of payment received. While the total number of mobile phones possessed by the household is an important

[52] Sonia Ferdous Hoque, REACH Methods Manual, Household Survey, Bangladesh Coastal Observatory; 2017
[53] Katrina Charles, Methods Manual, Dhaka; 2017
[54] Mauza is the lowest administrative unit having a separate jurisdiction list number (J.L. No.) in revenue records. Every mauza has its well-demarcated cadastral map

indicator of wealth, individual ownership reflects gender dimensions of resource use and control.

Section 3: Water and Sanitation

Comprised of five sub-sections: ***a) 3.1 Drinking water- Source and Payments****:* The respondent was first asked to mention all the sources of drinking water used by the household in the last one year. If more than one source was mentioned, separate sets of questions were asked about the main and the secondary sources of drinking water. These questions focused on the time taken for collection, the mode of transportation, the gender and age of the person(s) responsible for the collection, any challenges faced in fetching water, the amount and frequency of payments made (if any), and the reasons for using the secondary source (if applicable). If any type of tube well (deep/shallow tube well with handpump or motor pumps) was mentioned, the respondent was asked to specify who owned the tube well and whether the tube well was located.

b) 3.2 Drinking water- Intervention and maintenance*:* This sub-section included questions on the types of drinking water interventions made by the government/development organizations in the past 5 years and whether the household has contributed any cash/labour for this purpose. This is followed by questions on private investments made by the household for installing new water-related infrastructures, such as new tube wells, pipes, and motors to existing hand pumps, and storage tanks.

c) 3.3 Drinking-water- Quality and storage*:* Assessment of the water quality involved questions on the respondent's perception about the safety of their drinking water and whether the household treated the water in any way to make it safer to drink. Where the community stores water, how long it is stored, and the hygiene of the storage container.

d) 3.4 Water for cooking and domestic uses: The respondent was then asked to mention all the sources of water used by the household for cooking, bathing, and laundry/ dishwashing in the past one year.

e) 3.5 Sanitation and hygiene: This sub-section focused on the types of toilet facilities used by adults and children of the household, whether the toilet was shared with other households, and the place and cleansing materials used for handwashing purposes. Questions on sharing the toilet with other households were included to assess the extent of contamination and disease spreading, as well as the household's wealth status. If the respondent mentioned soap or other cleansing material, the enumerator asked him/her to show it for validation.

Section 4: Poverty

This section aims to assess the wellbeing status of household members through objective indicators such as possession of durable assets, land, and livestock, sources of energy for lighting and cooking, and building materials for the roof, walls, and floor, and through the subjective perception of wellbeing at present and about five years before the survey. Subjective metrics include the perception of the respondent of this/her wellbeing situation in comparison with people of his/her village and an overall assessment of how he/she describe his household situation. Though previous experience suggests that housing materials may not always reflect wealth adequately, and it is often necessary to judge the condition of the house as well. Hence, the enumerators were asked to take an image of the exterior of the house, such that the roof, wall, and floor were clearly visible.

Section 5: Priority Concerns

The general concerns related to the socio-economic development of the area were identified including the concerns related to water used for drinking/domestic needs and the natural environment. The respondents were first asked to rank the top three concerns that they think the government could help to solve. The enumerators were instructed to read out a few examples from the list if needed, but not mention anything regarding water. The purpose was to understand how people prioritized water security in relation to other development agendas. The respondents were then asked to rank the top three concerns (if any) regarding the water they drink and use for domestic needs, followed by concerns regarding the natural environment. For this section, enumerators were instructed to use their judgment whether a response was a genuine concern or whether it was just mentioned for the sake of giving a response.

Section 6: Closing Questions

Included: ***6.1 Images*** – At the end of the survey, the enumerators took photos of the respondent's house; and the toilet both from outside and inside. These pictures helped to cross-check the accuracy of data in previous sections and provide a subjective understanding of the wealth status of the household. ***6.2 Enumerator feedback and contact information -*** This sub-section was for the enumerators only, where they rated their overall satisfaction with the interview process, the respondents' understanding of the questions, and the accuracy of the responses. In the end, the enumerators collected the mobile numbers for contacting the respondent or the household head for further questions/clarification if needed. The enumerators also provided their perception of the wealth status of the household so that this subjective data can be used to validate the quantitative wealth indices derived from the asset data collected by the survey.

3.4.1.vi Validity of Instruments

The validity of the instrument is frequently defined as the degree to which an instrument measures what it purposed to measure (Kimberlin & Winterstein, 2008). An initial questionnaire was tested during piloting to twelve (12) respondents' households on the subject, to check the depth of the items under constructed. The response from these respondents was used to enhance the content and eliminate ambiguity and duplication of tests.

3.4.1.vii Analytical Approach

The study follows both descriptive and arithmetic techniques to analyses the survey data. The summary statistics include the standard measures of statistics like the measures of central tendency (mean, median, quartiles, deciles, percentiles, etc.), measures of dispersion (variance, standard deviation), and pairwise cross-tabulation of the respective variables in the analysis. Chi-square and Spearman's correlation has also been used to investigate the relationship between the dependent variable (disease incidence, associated challenges, and impacts) and independent variables (water sources) and to test the hypotheses of the study that have been described in the specified chapter.

3.4.1.viii Tools of Analysis

The data has been collected using tablets. The questionnaires have been transformed into online version and made suitable for ONA. The primary level of analysis is being done using ONA and further statistical analysis has been done using the Statistical Package for Social Sciences (SPSS) version 23, Pivot table, and Microsoft Excel 365. Firstly, for cleaning, the data has been transformed from ONA to Excel. For statistical analysis, the cleaned data has been transformed from Excel to SPSS and then reorganized and processed through SPSS.

3.4.1.ix Data presentation

Collected data will be presented in the following three ways-

a) **Textual presentation:** a narrative description of the data gathered
b) **Tabular presentation:** systematic arrangement of information into column and rows
c) **Graphical presentation:** an illustrative description of the data using Microsoft Excel 365

d) **Photographical presentation:** relevant photographs of respective issues

3.4.1.x Ethical considerations

[55]The research follows the ethical guidelines set by the Central University Research Ethics Committee (CUREC) of the University of Oxford, as well as any additional requirements specific to the local partners in the individual observatories. There are three key principles for our research:

- **Respect for all participants**: We appreciate and value the contribution of people in our study observatories. As one of our key principles, we specify that all members of the research team, including enumerators, are responsible for ensuring that any person involved in the research is always treated with respect. This means respecting the opinions and contributions of all participants.
- **Respect for fieldworkers**: We appreciate the contribution that enumerators make to the project, and we respect their well-being and safety in the field. This includes making sure that they have a safe work environment and are not put at any risk through your involvement in the research.
- **Non-judgment**: Researchers/Enumerators should not judge the opinions, decisions, or actions of people involved in the research. Their role is to document their perspectives through systematic, scientifically sound methods.

Before commencing the survey, all selected participants have been informed about the purpose of the study (Appendix A2), the nature of the information sought, the degree of commitment required, and any possible risks and benefits associated with their participation. Once the participants are clear about their roles, they have been asked to sign a consent form (written in the local language). As many of the participants are likely to be illiterate, the information in the consent form can be read out and verbal consent can be obtained. These can be integrated into the ODK platform for household surveys.

All our research is voluntary and REACH enormously values the contributions made by participants to our research. It is important that participants take part of their own free will and do not feel pressured by enumerators or others into taking part in the research. Participants are free to withdraw at any stage of the research process and no explanations will be sought.

[55] Charles, K. 2017. REACH Methods Manual, Dhaka

The study involves the collection of personal identification information, including the names of participants and the location of their residence. Participants' contributions must be kept confidential and not discussed with anyone apart from fellow enumerators, facilitators or translators, or the University of Oxford team. Any further discussion of the content of any research must be in the appropriate context, such as clarification for translation, and through secure channels. The data collected will be stored in password-protected files on personal computers and the university's server. All researchers/enumerators recruited for this study must abide by these rules and sign an agreement document for this purpose.

3.4.2 Focus Group Discussion (FGD)

One of the most utilized participative approaches in PRA is focus group discussion (FGD). [56]The primary purpose of the FGDs in the Universal Methodology is to understand the local perception and distribution of multi-dimensional poverty and water security. FGDs give significant insight into the social character of knowledge in social science research, allowing the researcher to extract information about the community's history, collective experiences, and common concerns (Goss & Leinbach, 1996). In focus groups, the group is synergistic, and members' contributions are refined by what they hear from others (Finch & Lewis, 2003). Participants can achieve a representative agreement on pertinent subjects through interjections and debates during conversations, which enriches the information acquired.

In this study, FGDs had been conducted in selected sites of the study areas with different sex groups and collect information relating to issues associated with water use and its' impact on public health with prioritizing some gender issues (Appendix A3). Six FGDs, each involving 6–8 participants were carried out for 1-2 hours in community settings. In totality, forty-two (42) participants were attended six FGDs, where audio recordings were also been made. Each team was made up of three members: an FGD facilitator, a note-taker/recorder, and an observer. Teams conducting FGDs with women included at least one female team member, usually two. Following introductions and explanations, FGD teams were facilitated discussions and recorded the discussion in writing and using electronic recorders (Appendix Photographs I1, I2, I3, I4 & I5).

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[56] Charles, K. 2017. REACH Methods Manual, Dhaka. Based on Young Lives' "Ethics of Research with Children" page 22-24. http://www.younglives.org.uk/sites/www.younglives.org.uk/files/YL-WP53-Morrow-EthicsOfResearchWithChildren.pdf

3.4.2.i Site selection: Six areas have been selected for the study where four from the upstream (having low pollution level) and two from the downstream (moderately polluted area) part of the Turag River.

Table 3.5: Sites of conducting Focus Group Discussion

	Upstream	Downstream
Sites of FGDs	Kashimpur, Konabari, Bhadam, Bhakral	Abdullahpur, Mausaid

3.4.2.ii Participants selection criteria: The participants should be residents of the communities as identified in "Research Questions, Survey Instruments, and Sampling Strategies". The following criteria were used to select participants for the FGDs:

- Male, resident in identified slum neighbourhoods adjacent to the Turag. Two male groups FGDs one in Kashimpur and another one in Bhakral;
- Female, resident in identified slum neighbourhoods adjacent to the Turag. Two female groups FGDs one in Konabari and another one in Abdullahpur; and
- The mixed group was identified in the slum neighbourhoods adjacent to the Turag. Two mixed groups FGDs one in Bhadam and another one in Mausaid.

3.4.2.iii Instrumentation of FGD

Table 3.6 outlines the questions under each of the three themes (Appendix A6). The FGD facilitator is advised to ask these questions (translated to local language), in the order outlined (Appendix A3 & A6). The facilitator may need to ask additional questions for obtaining detailed data or providing further clarification. The objective of this survey is to better understand the dimensions of water use behaviour by gathering information on three broad themes: 1. Sources and usages; 2. Perception of health risk; 3. Gendered roles to manage everyday water needs as appropriate for the local context.

Table 3.6: Major themes and points to discuss

Main questions for discussion	Prompting and follow-on question
Themes 1: Sources and usages of water	
1. What are the available sources of water?	i. What are the main sources of household water? ii. What other supplies of water do you have access to? iii. How do you access these supplies i.e., do you pay for the services or is it provide by the Government?
2. How do the local people use river water?	iv. How do you use the river? v. What are the purposes of river water use? vi. Reason for river water use vii. Have you always used the river irrespective of year or season? a. Do you use this water in the wet season? What are its purposes? b. Do you use river water in Dry season? What are the main purposes? viii. If you change your behaviour, between the wet and the dry, c. When do you change it? d. Why? ix. When do you collect water or use water from the river? e. If the uses have been altered, what has influenced this change (i.e., climatic events, new industry development, population boom, access to other sources of water, etc.)? x. Who are the people that use the river? xi. Why do you specifically use this water? Or Are there any specific reasons for using this water?
Theme 2: Perception of health risks	
3. Is there any link between water use and public health?	xii. Do you think there is relation between water sources and diseases occurrence? If yes, xiii. Please explain the sources that cause diseases most xiv. Do you think that river affects your health? a. In which ways do you think the river affects your health? b. Is this the same for other members of your family? xv. Among the Turag River water uses (discussed in Part 1) a. What is the greatest health risk to you? b. Is this the same for other members of your family? xvi. What type of diseases do you and your family suffer from?

	xvii. Is there any gender variation of the diseases? If yes, xviii. Please explain the variation.
Theme 3: Gender issues	
4. What are the differential roles of men and women to manage their everyday water? **5. How they get impacted by doing so?**	xix. What are the main water-related household activities? xx. Who (Women, men) use river water most? xxi. What purposes? xxii. Family member's responsible to manage water for household use xxii. How much time does it usually take to go to the source, use water, get water, and come back? xxiv. Time of the day to do these tasks xxv. Do you face any types of challenges while go for collecting water

3.4.2.iv FGD protocol[57]

3.4.2.iv.a Logistics

It is important to inform the participants that they are expected to commit about 1.5–2 hours of their time for the FGD and that they would not receive any monetary compensation for their participation (Appendix A4). However, locally appropriate refreshments (e.g., water, tea, and biscuits) should be provided as a token of appreciation. Participants should be given detailed information about the purpose of the FGD and the ethical norms of this research, either verbally or in writing (refer to Appendix A2). Participants have the right to refuse or drop out from the FGD at any time and do not need to give any explanation for their decisions. Any suitable place can be selected as the venue for the FGD; however, care must be taken not to attract the attention of passers-by. Uninvited spectators may cause interference, digression from the topic of discussion, and difficulty in managing the group. The following materials and equipment will be required for conducting the FGDs.

- Notebooks, pens, and clipboards for notetaking
- Audio recorder and spare batteries (if needed)
- Still and video camera (smartphones or tablets can be used)
- Copies of the 'Participant consent form' translated into the local language

[57] Charles, K. 2017. REACH Methods Manual, Dhaka

3.4.2.iv.b Instructions for the note-taker

The entire FGD should be audio recorded; however, the note taker should write down details of the discussions being carried out. It is important to write down the exact words and phrases said by the participants, rather than summarizing the key points of the discussion. There is no need to mention the names of participants, but it might be helpful to distinguish between the responses of one participant from another to account for debates or discrepancies. The purpose of note-taking is to have a backup for the audio recordings, which may be incomprehensible or have technical problems. The notes will also serve as an important source of data for the transcriber. The note taker should preferably have a passive role and not distract the participants, except in cases where clarification is required. Photographs can be taken during the FGD; however, prior permission should be taken from the participants.

3.4.2.iv.c Instructions for transcription and translation

The transcriber should write down details of the entire FGD in a word document, using data from the audio files and written notes. Comments or questions by the Facilitator/Note-taker should be labelled as **I**, while any comments or responses from participants should be labelled with **P** at the left margin. A response or comment from a different participant should be separated by a return and then inserting a new **P**.

Audiotapes should be transcribed verbatim (i.e., recorded word for word, exactly as said), including tone of voice (enthusiastic, angry, pessimistic, joking, etc.), emphasis (italicize specific words), fillers (hmm, umm), and pauses (…), where appropriate. The transcript should not be cleaned up by removing foul language, slang, grammatical errors, or misuse of words or concepts. The transcriber should identify portions of the audiotape that are inaudible or difficult to decipher. If a segment of the tape (a word or short sentence) is partially unintelligible, the transcriber should type the phrase [inaudible segment] in square brackets.

If participants are speaking at the same time (i.e., overlapping speech) and it is not possible to distinguish what each person is saying, the transcriber shall place the phrase [cross talk] in square brackets immediately after the last identifiable speaker's text and pick up with the next audible speaker. If the transcriber is unsure of the accuracy of a statement made by a speaker, this statement should be placed inside parentheses and a question mark is placed in front of the open parenthesis and behind the close parenthesis. e.g.? (The world is opaque)?

Clear reporting of the setting of the FGD is important to enable records to be correctly identified for analysis. Please use the template below for the layout of all files.

Following the transcription process, the transcripts should be translated into English, using the same format. All audio files, transcripts (in both languages), photos of the FGD, and information of the participants (if possible) should be sent to the REACH team at Oxford University.

3.4.2.v Analytical Approach

As mentioned earlier, the study follows both descriptive and arithmetic techniques to analyses the survey data. In the descriptive analysis, the summary of the variables has been described. Data from FGDs, key informant interviews were transcribed, categorized, and discussed under three broad themes of water use, associated risks or challenges, and gender issues. The result was used to support the findings since the mixed method was adopted. Arithmetic statistics including frequencies, percentages, mean±SD were calculated to make meanings to the data collected.

3.4.3 Key Informants Interview

To further validate findings and incorporate local knowledge and experience, key informant interviews were performed[58]. For these purposes, a key informant is defined as anyone who has first-hand knowledge about the community[59]. The key informant survey is a technique of gathering data from people whose professional and/or organizational responsibilities indicate that they are familiar with certain features of the population being researched, as well as potential paths and limitations for community change (Eyler et al., 1999). The respondents for the interview were purposively selected for this activity (Appendix A8a). Twelve KIIs have been conducted in six sites namely Konabari, Kashimpur, Bhakral, Bhadam, Mausaid, Abdullahpur. Each of these sites was selected to cover upper, mid, and downstream sites of the Turag River areas. The stakeholders included assembly members, unit committee members, district health service, and traditional authorities. Interviews as noted by Teye (2012) do not require large sample sizes as emphasis is placed on process and meaning. Each interview has taken 1-1.5 hours to gather detailed information on the given issues (Appendix A8) from the interviewee/respondents. Each group consists of three

[58] Ministry of Health and Family Welfare, Bangladesh, Partnership for Maternal, Newborn & Child Health, WHO, World Bank and Alliance for Health Policy and Systems Research. (2015). Success Factors for Women's and Children's Health: Bangladesh. https://www.who.int/pmnch/knowledge/publications/bangladesh.pdf
[59] UCLA CENTER FOR HEALTH POLICY RESEARCH. https://healthpolicy.ucla.edu/programs/health-data/trainings/Documents/tw_cba23.pdf

members where the interviews were conducted. The interview was taken by one and the other one helped to take notes and the third one was there to give logistic support like taking photos, communicating with others, arranging snacks, etc. Before starting, the facilitator introduced him/herself to the group and clearly outlined the objectives of this research (Appendix Photographs I6, I7, I8 & I9).

3.4.3.i Site selection: 12 KIIs were undertaken in five sites (05) of the study area (Appendix A9):

- Upstream: Kashimpur, Konabari, Bhakral
- Downstream: Abdullahpur, Mausaid

3.4.3.ii Interviewee selection: 12 interviewees' from different study sites were selected based on the following categories (Appendix A8):

- Local Government (01)
- Local leader (01)
- Community or user group (03)
- Community youth leader (01)
- Industrial worker (02)
- Health officials (02)
- NGO worker (02)

3.4.4 Observation for River Use Behaviour

The findings from the literature review informed the structure and content of the third method: a water-use behaviour survey. The study design is based on previous observational studies led by Arturo Villanueva[60] (MSc in WSPM, University of Oxford) originally developed on water-use classification system by White, Bradley & White (1972)[61] and further illustrated by the IIED (2002)[62].

3.4.4.i Survey Design

[63]The principal purpose in designing a water-use behaviour survey was to capture the demographic profiles of the various practices taking place along the Turag as identified in the literature review (i.e., fishing, bathing, swimming, etc.). In other words, this study was

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[60, 63] Arturo Villanueva, 2016. Urban River Use and Risks: A Study of Practice along the Turag River in Dhaka, Bangladesh; Master of Science in Water Science, Policy and Management, University of Oxford

[61] White, G. F., D. J. Bradley, & A. U. White. 1972. Drawers of Water: Domestic water use in East Africa. Chicago: University of Chicago press

[62] https://pubs.iied.org/sites/default/files/pdfs/migrate/9049IIED.pdf?

designed in learning who was interacting with the river, when, how, and for what purpose(s). The challenge was designing a simple yet comprehensive survey through which researchers could rapidly document complex observations of individuals engaging with the river in diverse practices.

At the survey's core was the water-use classification system developed by White, Bradley, & White (1972) and furthered by the IIED (2002, p. 27), which grouped water-use types into four broad categories: Consumption, Hygiene, Amenities, and Productivity[64]. Though the classification system developed by White, Bradley, & White was initially intended for water use in rural East African villages, its structure remains extremely relevant in an urban setting such as Dhaka's. Through various iterations of the survey design, additional questions were added, optimizing the breadth of data gathered per documented observation (such as gender, age, time, etc.). The survey question is illustrated in Table 3.7.

Table 3.7: Final survey questions and multiple-choice answers provided

1.	***Observer ID***	
2.	***Observation code***	
3.	***Date?***	April 26th-May 3rd
4.	***Time?***	7 am - 6 pm
5.	***Site?***	Site #1-Konabari Site #2-Bhakral Site #3-Abdullahpur
6.	***Spot?***	**Site #1-Konabari** spot i. North spot ii. South **Site #2-Bhakral** spot i. North spot ii. South **Site #3-Abdullahpur** spot i. North spot ii. South
7.	***Gender?***	□Male □Female
8.	***Weather condition?*** ***(Take photo)***	Gloomy/ Cloudy/ Rainy/ Sunny
9.	***Condition of River Water*** ***(Take photo)***	Very Bad=1 Bad=2 Moderate=3 Good=4 Very Good=5
10.	***Gender? (Take photo)***	□Male □Female
11.	***Age group? (Take photo)***	□Child □Adult □Elderly
12.	***Gender group? (Take photo)***	□Women □Men □Girls □Boys
13.	***Number?***	[Open field][65]
14.	***Assemblage? (Take photo)***	Group or Individual

[64] https://pubs.iied.org/sites/default/files/pdfs/migrate/9049IIED.pdf?
[65] [Open field] indicates that the surveyor could enter any necessary value or description

15.	***Consumption? (Take photo)***	○ Drinking ○ Cooking ○ Water collection
16.	***Washing? (Take photo)***	○ Vegetable washing ○ Dish washing ○ Cloth washing ○ Property washing
17.	***Hygiene? (Take photo)***	○ Bathing ○ Ablution ○ Personal washing ○ Open defecation
18.	***Amenities? (Take photo)***	○ Boating ○ Angling ○ Swimming/Recreational ○ Other non-essential tasks
19.	***Productivity? (Take Photo)***	○ Navigation/Transport ○ Fishing ○ Commerce ○ Irrigation ○ Watering plants ○ Watering and bathing of Livestock ○ Case (Fish) culture ○ Duck rearing
20.	***Others*** (Anything unusual or seems important or interesting)	Ex. Queue, quarrel, male or female working separately, etc.
21.	Please elaborate on observation(s). Particularly, explain the division of activities if more than one was selected	[Open field]

3.4.4.ii Selection of Survey Platform

Two HUAWEI tablets, model T1.7.0, running on the latest operating system, android version 4.4.2, were selected to conduct the necessary field observations. The next task was finding the appropriate survey application ("app"), which offered:

1. Offline capabilities to conduct surveys in remote areas without relying on access to a 3G/4G/LTE bandwidth.
2. Mobile support, allowing surveys to be carried out on tablets/smartphones;
3. A user-friendly layout when displaying a complex matrix of questions; and
4. A reliable output format (with preference to export CSV files).

After testing several survey platforms, the GIS cloud mobile data application seems most feasible for this observation. The benefits of GIS Cloud included exceptional offline capabilities including "suggested" GIS positioning and the ability to include pictures, videos, and audio notes per observation entry. Therefore, the research has proceeded with the "GIS Cloud" mobile data collection application. Figure 3.1 illustrates a sample observation entry displayed in the final version of the GIS Cloud mobile data collection service.

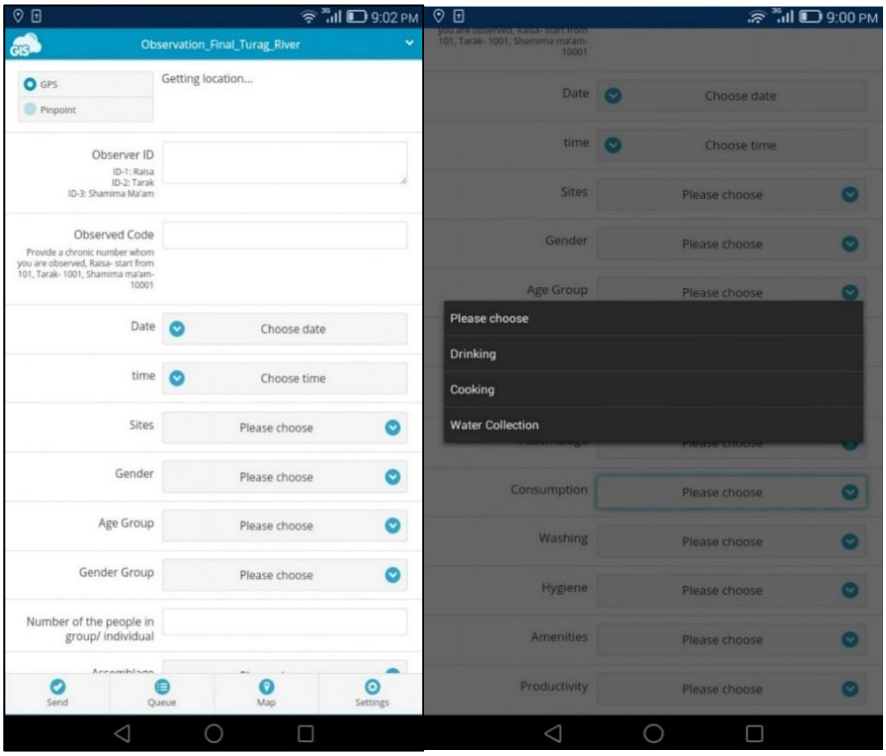


Figure 3.1: Sample entry in GIS cloud mobile data collection app (HUAWEI T1 7.0)

3.4.4.iii Site Selection

The study is mainly based on water use behaviour survey using eight days of observational studies. Once the survey design was completed, three sites in the northern part of the city along the Turag River were selected for the survey. The areas were selected based on the diverse and numerous human activities taking place along the Turag River. The first day of observations served as a “piloting” visit to identify the potential sites within the selected area.

The three sites were:

Site-1: Abdullahpur (10062256.3951, 2740133.6992)

Site-2: Konabari (10055811.7982, 2753729.9356)

Site-3: Bhakral (10056786.3703, 2748317.2386)

Two potential spots (North and South) from each site have been selected to gain maximum interactions and to justify the results obtained from each spot of respective sites. These sites represent Upstream (Konabari), Mid-stream (Bhakral), and Downstream (Abdullahpur) of Turag River, also where possibilities of interaction with the river were highest.

3.4.4.iv Conducting the Survey

Once the sites were identified, an observation schedule was established to determine when observations could be conducted. An eight-day observation schedule was arranged to capture a full week of activities (Table 3.8). Over those eight days, daily visits were made to each of the three sites for the same amount of time (to avoid any bias) starting from 7 am. The observation was carried out in three different time slots in three sites by rotation. Each slot is comprised of three hours of survey which include only observation excluding interviewing. Two groups consisting of two members collect information from two different spots of the same sites at the same time. Anytime an individual or a group of individuals interacted with the Turag River in any capacity, an “observation” was documented using the GIS Cloud mobile data collection app.

Table 3.8: Demonstrates the observation schedule over the 8-day period, which covered morning, afternoon, and early evening time slots

Time of day	Fri day	Satur day	Sun day	Mon day	Tues day	Wednes day	Thurs day	Fri day	Observation hours
7-10 am	S1	S2	S3	S1	S2	S3	S1	S2	24
11-2 pm	S2	S3	S1	S2	S3	S1	S2	S3	24
3-6 pm	S3	S1	S2	S3	S1	S2	S3	S1	24
Hrs/day	09	09	09	09	09	09	09	09	

3.4.4.v Tools of Analysis

Recorded observations were summarized in CSV (Comma Separated Values) files automatically produced by GIS cloud’s platform. These were transferred to and analysed using Microsoft Excel 2016. Data cleaning was also done by using Microsoft Excel 2016. Simple algorithms were applied to tabulate the variables that are discussed in the findings section.

3.4.4.vi Ethical Permission

The observational study along riparian zones and enumerator training to ensure confidentiality for participants who will not be known nor identified with specific consideration for child participants. Provision was made for a duty of care for the enumerators to ensure any potential harm to them (post-electoral tension, political violence) was carefully considered and mitigated[66].

[66] Based on Young Lives’ “Ethics of Research with Children” page 22-24. http://www.younglives.org.uk/sites/www.younglives.org.uk/files/YL-WP53-Morrow-EthicsOfResearchWithChildren.pdf

Chapter 4: Study Area: Turag River and Selected Sites

The Turag River earlier called "Kohor Doriya" or "Kohor" (Wikipedia) is a prominent river in Bangladesh only 7.9 km from Dhaka city (Haque, 2018). The river is of paramount importance for being the main drainage channel of Dhaka city (Salam & Alam, 2014) and having great importance from the economic point of view (Ahmed & Bodrud-Doza, 2013). In navigability categories depending on the least available depth (LAD), the Turag River is recognized as a third-class waterway by the Bangladesh Inland Water Transport Authority (BIWTA, 1989)[67] as the available navigable depths of this river is between 1.50 to 1.8 m (Haque, 2018). The Turag is also home to a substantial amount of human activity ranging from navigation (Rahman et al., 2013), fishing (Baki et al., 2015), agriculture (World Bank, 2007), and in many instances, as a source of water for domestic purposes (Bhuiyan et al., 2011). The Department of the Environment declared the Turag River to be in environmentally critical condition in September 2009, citing significant pollution produced by enterprises along the river.

4.1 Features of Turag River

4.1.1 Origin and Routes/Courses

Running from north to south along the western front of Dhaka, the Turag stems from the Bangshi River (lower) at Kaliakoir *upazila* under the Gazipur district. It gets divided into two parts at the point of Birulia *union* of Savar *upazila* under Dhaka district. One part of the river flows over Kaliakoir, Ashulia, Savar, Mirpur, Keraniganj, and finally falls into the Buriganga River at Hazaribag in Dhaka district (Rahman et al., 2013). Another part falls into the Buriganga River of Kaundia *union* of Savar *upazila* in Dhaka district. Three tributaries Gollar khal, Salda, and Labundha were met at Boalia *union* of Khaliakhar *upazila* under Gazipur district and Mirzapur of Tangail *sadar*. The river has one distributary, Tongi khal which originated from Turag at Burulia *union* of Savar *upazilla* and Dhaka district[68]. Table 4.1 shows the main features of the Turag River.

[67] http://biwta.portal.gov.bd/sites/default/files/files/biwta.portal.gov.bd/page/4e97b481_943e_4ca4_ae8a_a325b0aac1b9/Final%20Report_Main%20Text.pdf

[68] River Master Plan. 2019. Report of the Technical Committee on the prevention of Pollution and Increasing Navigability of Rivers surrounding Dhaka

Table 4.1: Features of the Turag River

i. Source Point/Origin **ii. Location**	Bangshi River, Kaliakoir[a] (a) Upazilla: Kaliakoir[b] (b) Zilla: Gazipur	[a]River Master Plan, 2019 [b]BWDB, 2011
i. Mouth Point/Outfall **ii. Location**	Buriganga River, Mirpur[a] (a) Upazilla: Mohammadpur (DCC)[b] (b) Zilla: Dhaka	[a]River Master Plan, 2019 [b]BWDB, 2011
Flowing Trajectory district	Tangail, Gazipur, and Dhaka	Razzak, 2017 BWDB, 2011
Flowing Trajectory Upazila	Kaliakoir, Joydevpur, Mirzapur, Gazipur, Savar, Mirpur and Mohammadpur	Razzak, 2017 BWDB, 2011
Transit	Bangshi, Dhaleswari, and Buriganga of the Dhaka city	Ahmed, 2013
Nature of flow	Perennial (Flows/ active throughout the year), although it has only a small flow in the dry season	Razzak, 2017 Ahmed, 2013
No of Cross-sections	13[a] 12[b]	[a]Haque, 2018 [b]Hossain, 2019

Source: Secondary literature

4.1.2 Physical characteristics of Turag River

4.1.2.i Shape**:** The entire regime of the Turag River is almost a spiral (Razzak, 2017).

4.1.2.ii Catchment area**:** Turag River's catchment is formed like a semi-funnel and is located in the center and southern parts of the Madhupur tract. It runs from north to south inside the 999.74 km^2 basin (Uddin, 2005).

4.1.2.iii Encroached area: At the beginning of the urbanization period of Bangladesh (1978), about 29 km^2 of rivers and canals and about 130.17 km^2 of wetlands were found in Dhaka city and its peripheral areas (Chowdhury et al., 2015). In 2009, it reduced to 10.28 km^2 of rivers and canals and 53.6 km^2 of wetland comprising about 21 percent of the Dhaka metropolitan area (Mahmud et al., 2011). The river is narrowing because of encroachment, which began in earnest after the 1980s (BCAS, 2010). For example, the Turag River in Sinnertek of Mirpur (‘Sand trading' 2013) was originally approximately 400 feet broad but has now constricted to barely 80 to 100 feet (Hossain, 2017). Chowdhury et al. (2015) stated in their most recent article that the Turag was formerly an affluent 100-meter-wide river that has now narrowed to 30-40 meters in width in certain areas, with grabbing still going on. The Turag River is narrowing day by day mostly encroached by human settlement and infrastructure, along with vegetation practices such as cropland, trees, vegetable field in some areas. Near the Gabtoli partition of Turag, the vegetation percentage in 2001 was 22.1 percent and now it is increasing and reached 34.8 percent coupled with the decrease of the water body (Chowdhury et al., 2015). From the study of Chowdhury et al. (2015), the estimated encroached area of Turag (Abdullahpur>Gabtoli) is found to be 120.7943 acres/5.7581 miles. The detailed physical characteristics of the Turag River are presented in Table 4.2.

Table 4.2: Physical description of the Turag River

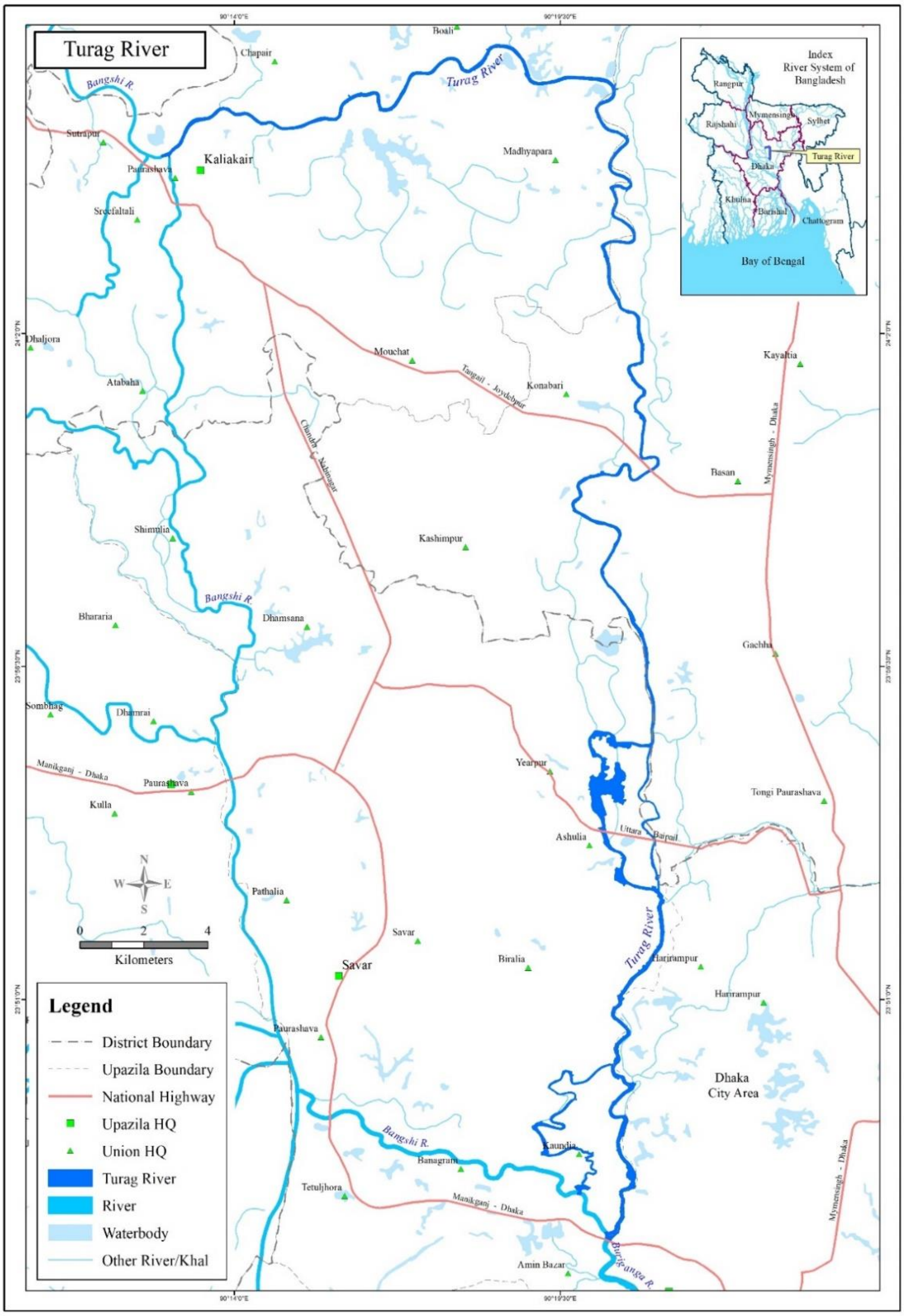
Criteria	Measurements	Sources
Shape	Spiral	Razzak, 2017
Length	75 km[a, b] 71 km[c, d] 62 km[e] 40 miles[f, g, h]	[a]DWASA, 2019; [b]Alam, 2003 [c]River Master Plan, 2019; [d]BWDB, 2011 [e]Razzak, 2017 [f]Roads and Highways Department (RHD), 2020; [g]Rahman et al., 2013; [h]Ahmed et al., 2013
Width	218 m (Mirpur)[a, b] 82 m[c] 15 miles[d, e, f]	[a]River Master Plan, 2019; [b]BWDB, 2011 [c]Razzak, 2017 [d]Roads and Highways Department (RHD), 2020; [e]Rahman et al., 2013; [f]Ahmed et al., 2013
Depth	13.50 m (Mirpur)[a, b, c]	[a]River Master Plan, 2019; [b]BWDB, 2011; [c]Rahman et al., 2013
Total area	386 square miles[a, b, c]	[a]Roads and Highways Department (RHD), 2020; [b]Ahmed et al., 2013; [c]Paul et al., 2013
Catchment area	1021.00 sq km	BWDB, 2011
Least available depth (LAD)	1.50-1.8 m	Haque, 2018

Source: Secondary Sources

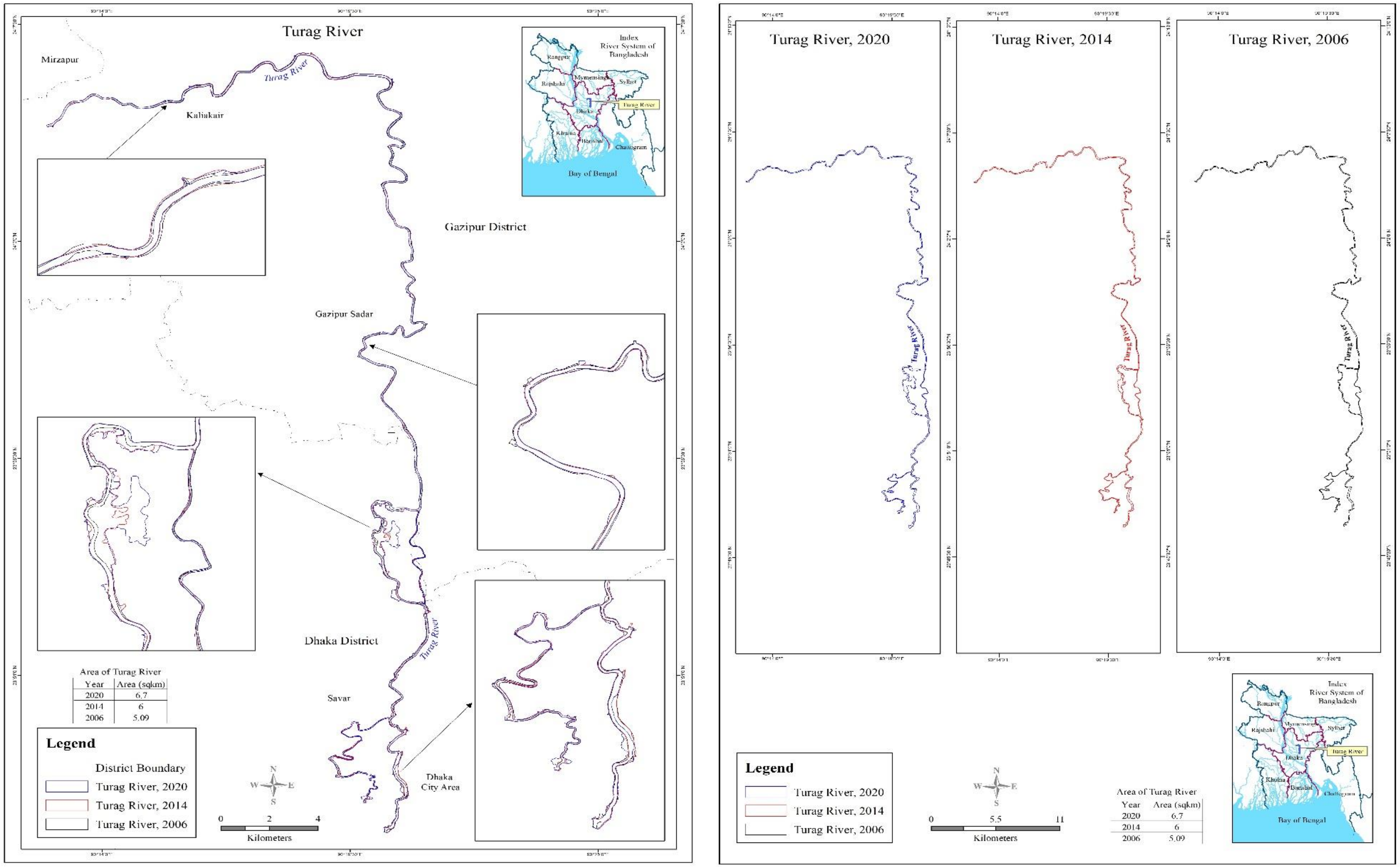
In an attempt to seize the river Turag, a group of sand dealers and land grabbers is defying the High Court ruling and taking advantage of the water body's poor demarcation. The encroachers are stacking sand and raising illegal establishments in the river area. Markets, permanent and makeshift shops, rickshaw garages, restaurants, mosques, and crematorium are being constructed inside the river demarcation pillars while the residents are dumping solid waste, all contributing to the contraction of the water body[69].

[69] River Master Plan. 2019

*Turag River base map (**Map 4**) together with time-series data map provided by CEGIS, 2020 (The Centre for Environmental and Geographic Information Services) shows that area degradation in the Turag River area is very consistent as it increased from only 5.09 sq km in 2006 to 6 sq km in 2014 and 6 sq km in 2014 to 6.7 sq km in 2020. Turag River time-series map has been presented in **Map 5 & 6**.*



Map 4: Turag River base map (CEGIS, 2020)



Map 5 & 6: Represent Turag River time series plot (Source: CEGIS, 2020)

4.1.3 Hydro-Morphology of Turag River

4.1.3.i Hydrology of Turag River

Hydro-morphologically Dhaka city is blessed with four major peripheral rivers namely Buriganga, Turag, Balu, Sitallakhya. Along with the Balu, Buriganga, Dhaleshwari, Shitalakhya, and Tongi rivers, the Turag is an integral part of the city's hydrology (Alam & Khan, 2014).

There are 26 beels on the Turag site, with a total water surface area of roughly 10,000 ha during the full flood and fewer than 700 ha at the end of the dry season. The river Turag runs through the site for around 30 km and there are additional 28 km of khals in the area. Seasonal flow variability in this river is related to the region's climate. The Turag's annual discharge/flow can be broken down into three broad seasons throughout the year, which are generally in line with the region's rainfall period: pre-monsoon (February-June), monsoon (July-October), and post-monsoon (October-January) (Rahman et al., 2013). Data collected by the Bangladesh Water Development Board (BWDB) from 1989-2009 reveals the rivers mean annual flow of 477 cubic meters per second (cms), a maximum annual flow of 737 cms, and a minimum annual flow dipping to 212 cms (Rahman et al., 2013). During the dry season, the river has an average width of 0.12 km, covering around 276 ha of water body, which increases to roughly 500 ha during the flood season (BWDB, 2004).

The tidal effect of the Turag River is dominant in its downstream part. During the monsoon period, water flow increases and inundates the flood plain on both sides of the river. Low flow or dry season flow is particularly important for the Turag River as it becomes polluted from the nearby industries. The water level varies from around 1 m to 2 m from January to April. All the years show a similar pattern and during the dry period tidal flow is dominant (Hossain & Chowdhury, 2019).

4.1.3.ii Morphology of Turag River

Morphologically Turag is an irregular meandering tide-dominated river with a sinuosity ratio is 1.5 (Hossain & Chowdhury, 2019), which indicated the river carries a meandering property rather than straight. Sinuosity is 1.5 or greater of a river refers to the meandering property of the river (Yeasmin & Nazrul, 2011). Also, the Turag River is Thalweg shifting river with its high monsoon period discharge (Hossain & Chowdhury, 2019).

Major Hydro-morphological features of the Turag River were presented in Table 4.3.

Table 4.3 Major Hydro morphological features of Turag River

Features	Nature	Meandering, gradient 2cm/km
Physical description	Bank-level	Left 2.67 m to 5.92 m, right 4.210 to 368 m
	Bed level	-0.748 to -12541 m
	Catchment area	1024 sq km
Discharge/ River Flow	Dry period	124 cusecs, depth 4.5 m
	Monsoon period	1136 cusecs, depth 13.5 m
	Tidal effect	D/S Tidal upstream, non-tidal

Source: BWDB, 2011; Hossain et al., 2019

4.2 Short Description of Selected Study sites along Turag River

As the study focuses on urban water security at the household level so households are the sampling units here. The households in Turag riparian areas constitute the population of the study. The study population, therefore, includes households residing within given areas who are more likely to be exposed to river water and river water-related risks and households living a little bit away from the river and less likely to be exposed to the risks. Such households were treated as the target population. The households living a little bit away from the river and having less chance to be exposed to river water-related risks were treated as the control population. The study population covered the households living near the banks of canals of the Turag River. It has covered the samples from the newly growing industrial zones, the upstream of the Turag River, as well as from the downstream areas. Areas were selected based on the level of water pollution: areas from the upstream, the newly growing industrial cluster, as well as from the downstream.

Considering the sources of drinking water and the proportion of households adjacent to the river, the research team proposed the following twelve areas: ***Konabari, Kashimpur, Ichharkandi, Palasana, Gutia, Gusulia, Bhakral, Bhadam, Rashadia, Kathaldia, Abdullahpur, and Mausaid*** *across Turag River.*

Various features of selected surveyed areas have been presented in **Tables 4.4 and 4.5** and ***Map 7*** shows selected study areas with total population and households.

Table 4.4: Administrative unit of selected Residence Community with Union and Mouza code[70]

Zilla Code	Upazilla Code	Union/Ward Code	Mouza	Administrative Unit Residence Community
33	30	60: Konabari Union	687	Konabari
33	30	47: Kashimpur Union	551	Kashimpur
33	30	31: Gachha Union	488	Ichharkandi
33	30	31: Gachha Union	820	Palasana
33	30	11: Tongi Paurashava	497	Gutia
33	30	11: Tongi Paurashava	471	Gusulia
33	30	11: Tongi Paurashava	183	Bhakral
33	30	11: Tongi Paurashava	157	Bhadam
33	30	12: Tongi Paurashava	654	Kathaldia
26	93	51: Harirampur Union	920	Rashadia
26	38	86: Tegharia Union	004	Abdullahpur
26	96	76: Uttar Khan Union	572	Mausaid

Source: Community Report: Gazipur, Population and Housing Census-2011

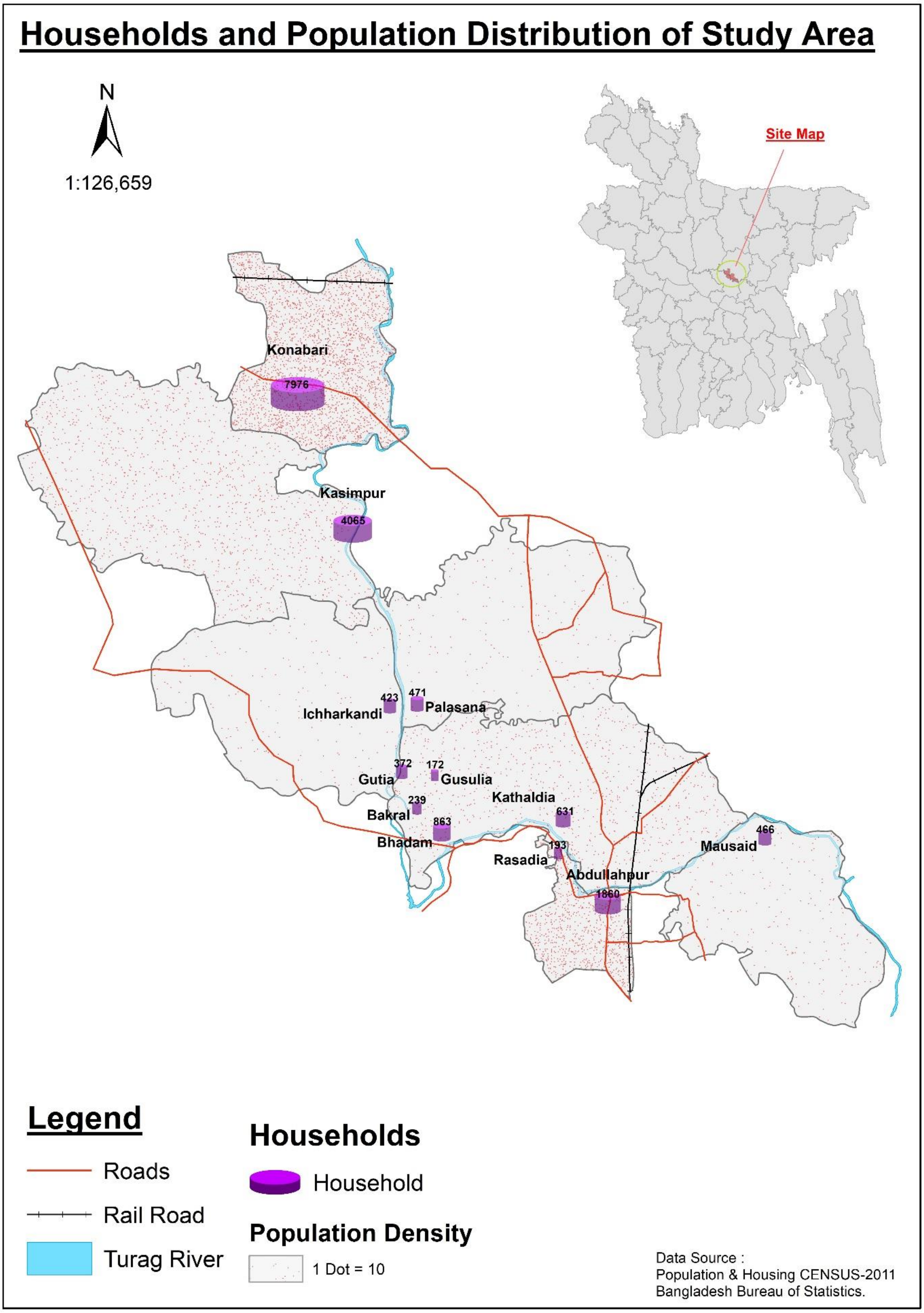
Table 4.5: Characteristics of Survey Areas

Indicators	1. Konabari	2. Kashimpur	3. Ichharkandi	4. Palasana	5. Gutia	6. Gusulia	7. Bhakral	8. Bhadam	9. Kathaldia	10. Rashadia	11. Abdullahpur	12. Mausaid
1. HH	7976	4065	423	471	372	172	239	863	613	193	1860	466
2. Population	30176	13957	1845	2038	1818	789	1068	2850	2640	705	8289	2332
3. Literacy Rate												
3.1 Both	82.7	72.2	63.7	54.8	40.1	67	32.9	69	67.6	34.9	57.6	68.3
3.2 Male	86.6	77.1	70.3	58.7	43.8	73.8	37.3	75.7	71.2	41.1	60.5	72.6
3.3 Female	76.6	66.3	57.2	50.5	36	55.6	28.3	58.1	63.3	28.9	54.6	64.1
4. Housing Structure												
4.1 Pucca	15	7.4	8.3	3.7	9.7	15.1	3.4	2.8	27.3	0.0	29.7	7.7
4.2 Semi Pucca	73.9	79.8	20.8	38.4	28	56.6	45.5	85.2	41.6	16.3	26.8	52.8
4.3 Kutcha	10.7	12.3	62.9	52.8	53	28.3	51.1	12.1	28	75.3	40.6	38.2
4.4 Jhupri	0.4	0.5	8	5.1	9.4	0.0	0.0	0.0	3.1	8.4	2.9	1.3
5. Sanitation												
5.1 With water seal	63.8	84.9	0.2	6.3	14	20.1	47.2	82.4	47.3	0.0	13	42.3
5.2 With no water seal	34.4	11.7	64.5	22.5	36.3	52.2	23	16.8	36	67.9	81.6	46.6
5.3 Non-sanitation	1.8	3.2	24.6	64.6	49.7	24.5	29.8	0.3	16.7	32.1	5.2	10.7
5.4 None	0.0	0.2	10.6	6.7	0.0	3.1	0.0	0.5	0.0	0.0	0.2	0.4

[70] Community Report: Gazipur, Population and Housing Census-2011. Bangladesh Bureau of Statistics. Statistics and Informatics Division, Ministry of Planning. http://203.112.218.65:8008/WebTestApplication/userfiles/Image/PopCen2011/Com_Gazipur.pdf

Indicators	1. Konabari	2. Kashimpur	3. Ichharkandi	4. Palasana	5. Gutia	6. Gusulia	7. Bhakral	8. Bhadam	9. Kathaldia	10. Rashadia	11. Abdullahpur	12. Mausaid
6. Drinking Water												
6.1 Tap	92.9	85.2	0	18.3	12.1	38.4	49.8	97	84.9	39.5	8.8	67
6.2 Tube well	6.9	13.6	85.8	81.7	82.5	45.9	38.7	2.4	0.5	48.4	91.2	28.1
6.3 Others	0.2	1.2	14.2	0	5.4	15.7	11.5	0.6	14.6	12.1	0	4.9
7. Tenancy/ Rented	92.2	81.3	0.9	16.9	11.3	26.4	28.5	89.7	76.4	82.1	21.5	15.5
8. Electricity Connection	99.3	98.8	0	91.4	95.7	92.5	85.5	100	98.4	84.7	94.8	95.9
9. Average Household Size	3.6	3.5	4.4	4.4	4.9	4.3	4.5	3.3	4.1	3.6	4.5	5
10. Employment Rate												
10.1 Both												
10.2 Male	953	676	150	200	274	41	87	133	186	133	756	63
10.3 Female	742	455	29	29	92	8	29	93	131	81	76	8
11. Employment Sector												
11.1 Agriculture												
11.1.1 Male	25	51	86	157	180	18	0	9	9	0	560	39
11.1.2 Female	3	6	5	4	37	1	0	3	4	0	60	0
11.2 Industry												
11.2.1 Male	725	391	11	27	23	5	81	94	106	15	99	11
11.2.2 Female	606	369	22	23	7	3	28	85	101	41	8	5
11.3 Service												
11.3.1 Male	203	234	53	16	71	18	6	30	71	118	97	13
11.3.2 Female	133	80	2	2	48	4	1	5	26	40	8	3

Source: Community Report: Gazipur, Population and Housing Census-2011



Map 7: Household and Population distribution of study areas (Source: Rahman, F., 2020)

Chapter 5: Socio-Demographic Characteristics of Survey Community

Examining the characteristics of the respondents is an important issue to fully understand the background of the respondents and to ensure the authenticity of the sources of data for the study since their compositions and responses would influence the result. When talking about water sources and its associated risks, the characteristics of the respondents (demographic) need to be assessed. In other words, anecdotal evidence proves that one becomes sick based on what one eats, drinks, and the environment that one lives in, which could also be related to age or sex, and lifestyle. According to Murdock & Ellis (1991), demographic data are any data that provide an understanding of population size, distribution, and composition. The current survey was conducted between December 2017 and February 2018 at twelve different sites besides the Turag River area. The methodology of the research is a mixed type. A standard semi-structured questionnaire has been developed as part of the quantitative survey. Whereas qualitative data collection tools as observation, FGD, KII were also applied to understand the problems comprehensively and holistically. The blending of quantitative and qualitative methods enables the researcher to expand the scope of the study as well as augment the validity of findings (Bryman, 2001). This study aims to examine relationships among river water sources, usages pattern, gendered role, and risk related to health. Hence the demographic data of this study having specific application to water source, gendered role, and associated health risks and are presented as follows:

5.1 Characteristics of Surveyed Households and Respondents

According to BBS data 2011, the total HH and population of twelve surveyed areas like Konabari, Kashimpur, Ichharkandi, Palasana, Gutia, Gusulia, Bhakral, Bhadam, Kathaldia, Rashadia, Abdullahpur, and Mausaid are 17713 and 68507 respectively of which 10.3 percent of the households had been selected and surveyed for the present study (Table 5.1). The total population of the sampled 1826 HHs stands at 7134. The average household size among the sampled households is 4.0 which is slightly smaller than the national average urban HH size of 4.4 (BBS, 2011). The estimated HHs size according to Multiple Indicator Cluster Survey (MICS) 2019[71], is 4.3, and according to Bangladesh Demographic and

[71] Progotir Pathey, Bangladesh Multiple Indicator Cluster Survey 2019, Survey Findings Report. 2019. Bangladesh Bureau of Statistics (BBS) and UNICEF Bangladesh. Dhaka, Bangladesh. https://www.unicef.org/bangladesh/media/3281/file/Bangladesh%202019%20MICS%20Report_English.pdf

Health Survey 2017-18 (BDHS), 2020[72] it is 4.3 nationally and 4.2 members in the urban area but study HHs size shows similarity to HIES, 2016[73] where average household size data was reported at 4.1 people nationally and in an urban area it was 3.9. Table 5.1 shows that the HH size of Konabari, Gutia, Gusulia, Bhakral, Kathaldia, Rashadia, and Mausaid range between 4.0 to 4.5 whereas Kasimpur, Ichharkandi, Palasana, Bhadam, Abdullahpur range between 3.0 to 3.9 with the highest HH size in Mausaid (4.5) and lowest in Bhadam (3.0). According to the population census 2001, the average household size was 4.9 but decreased to 4.4 in 2011. The HIES report also reveal the same decreasing pattern. According to HIES 2016, the average size of a household was 5.2; it decreased to 4.8 in 2005 and further decreased to 4.5 in 2010 and 4.1 in 2016; which depicts the decreasing average household size with time. This decreasing trend also supporting our study findings. Table 5.1 presents the detailed distribution and HHs size of the sampled population.

Table 5.1: Household characteristics of the survey area

Survey Area	**Area wise Total**		**Survey HHs and Population**				**HHs Size**	**HHs Surveyed (%)**
	HHs	Population (N)	HHs		Population			
			n	%	n	%		
Konabari	7976	30176	242	13.3	1040	14.6	4.3	3.03
Kashimpur	4065	13957	204	11.2	786	11.0	3.9	5.02
Ichharkandi	423	1845	164	9.0	582	8.2	3.6	38.8
Palasana	471	2038	110	6.0	411	5.8	3.7	23.4
Gutia	372	1818	107	5.9	435	6.1	4.1	28.8
Gusulia	172	789	65	3.6	279	3.9	4.3	37.8
Bhakral	239	1068	85	4.7	362	5.1	4.3	35.6
Bhadam	863	2850	199	10.9	590	8.3	3.0	23.1
Kathaldia	631	2640	222	12.2	914	12.8	4.1	35.2
Rashadia	193	705	68	3.7	270	3.8	4.0	35.2
Abdullahpur	1860	8289	220	12.0	832	11.7	3.8	11.8
Mausaid	466	2332	140	7.7	633	8.9	4.5	30.0
Total	**17731**	**68507**	**1826**	**100**	**7134**	**100**	**4.0**	**10.3**

Source: HH Survey, 2017-18; BBS Report, 2011

72 Bangladesh Demographic and Health Survey 2017-18. 2020. National Institute of Population Research and Training Medical Education and Family Welfare Division Ministry of Health and Family Welfare Dhaka, Bangladesh. https://dhsprogram.com/pubs/pdf/FR344/FR344.pdf

73 Report on the Household Income and Expenditure Survey 2016. 2019. Bangladesh Bureau of Statistics (BBS). https://drive.google.com/file/d/1TmUmC-0M3wC5IN6_tUxZUvTW2rmUxMce/view

5.2 Male Female Ratio

The sex ratio of males to females in a given population is usually expressed as the number of males per 100 females[74]. As in table 5.1, of the total 7134 population in 1826 HHs surveyed, 3573 are male and 3561 are female (Table 5.2). Sex distributions remain the same for both male and female groups with a percentage of 50.1 and 49.9 respectively, surprisingly resembles with the findings of Bangladesh Sample Vital Statistics (SVRS), 2019[75] representing male to female ratio is 50.1:49.9. According to Bangladesh Disaster-related Statistics 2015 (BBS), this ratio is 51.96:48.04, and according to MICS 2019, the ratio is 50.8:49.2. Area-wise sex distribution also represents a similar percentage value (Table 5.2). The average sex ratio for the studied population is 100.4 which is slightly higher than SVRS (2019) survey where the overall national and urban sex ratio is 100.2 while it was 99.6 in urban areas in 2018. According to the BBS report 2011[76], the sex ratio was 100.3 indicating equal numbers of men and women in the country but in the urban area, it was 109[77] which also supports the present findings.

Table 5.2: Population distribution by sex

Area	Male		Female		Total	Sex ratio
	n	%	n	%	N	
Konabari	511	14.3	529	14.9	1040	96.6
Kashimpur	412	11.5	374	10.5	786	110.2
Ichharkandi	282	7.9	300	8.4	582	94.0
Palasana	209	5.8	202	5.7	411	103.5
Gutia	209	5.8	226	6.4	435	92.5
Gusulia	156	4.4	123	3.5	279	126.8
Bhakral	187	5.2	175	4.9	362	106.9
Bhadam	293	8.2	297	8.3	590	98.7
Kathaldia	454	12.7	460	12.9	914	98.7
Rashadia	131	3.7	139	3.9	270	94.2
Abdullahpur	412	11.5	420	11.8	832	98.1
Mausaid	317	8.9	316	8.9	633	100.9
Total	**3573**	**50.1**	**3561**	**49.9**	**7134**	**100.4**

Source: HH Survey, 2017-18

[74] Number of Males per 100 Females in a population, using the following formula: Sex Ratio SR = M x 100 / F. 2011 Population & Housing Census: Preliminary Results, BBS

[75] Bangladesh Sample Vital Statistics 2019. 2019. Bangladesh Bureau of Statistics (BBS). http://www.bbs.gov.bd/site/page/ef4d6756-2685-485a-b707-aa2d96bd4c6c/Vital-Statistics

[76] 2011 Population & Housing Census: Preliminary Results. 2011. Bangladesh Bureau of Statistics (BBS). https://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/7b7b171a_731a_4854_8e0a_f8f7dede4a4a/PHC2011PreliminaryReport.pdf

[77] Population and Housing Census-2011, National Volume-3: Urban Area Report. 2014. Bangladesh Bureau of Statistics (BBS). http://203.112.218.65:8008/WebTestApplication/userfiles/Image/National%20Reports/Population%20%20Housing%20Census%202011.pdf

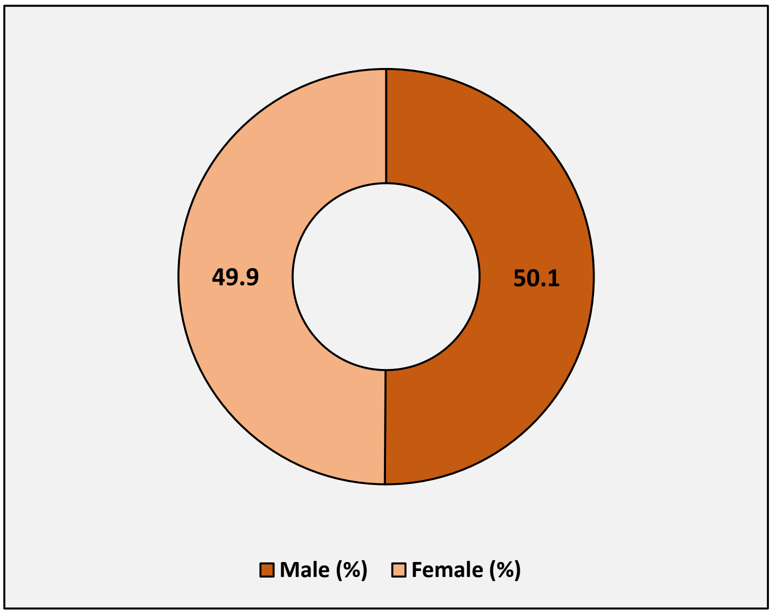


Figure 5.1: Male and Female percentage (%) of the respondents

5.3 Age group of the surveyed population

Figure 5.2 shows that the highest concentration of population exists in 16-25 age groups both in male and female with a percentage of 20.6 and 25.2 respectively with an average percentage of 22.9 (Appendix table B1). Age group ranges from 26-35 and 6-15 securing 2nd and 3rd highest rank (20.1% and 19.4% respectively). The percentage of the population in the lowest age group (0-5) has been found as a percentage of 7.5 with the male percentage of 7.3 and female percentage of 7.7. On the other hand, the percentage of the population in the uppermost age group (66 years and over) is 2.3; the percentage of the male population is 2.2 as against 2.4 for females, indicating more longevity of female as compared to male (Figure 5.2). The findings show that the percentage of the youthful group that ranges in the ages of 16-45 remains highest in the studied communities.

In the case of the child group (0-15 years), working age (16-55 years), and old age groups (56-66 years and over) the proportion are 26.74, 66.84, and 6.39 percent, respectively. According to SVRS report 2018, nearly two-thirds (66.2 percent) of the urban population are reported to be in the working-age group (15-64 years), which has significantly supported our study findings (Appendix table B1). The age distribution of SVRS for 2019 shows that 28.5 percent of the population is under 15 years of age which was 28.8 percent in 2018 in the same background and is nearly equal to the present study (26.9%). People aged between 15-64 years is 66.2 percent in 2019 according to SVRS, which was the same as it was in 2018; as per MICS report 2019 it is 74.5 percent but in the present study, it is 71 percent (Appendix table B1). People aged 65 years and over it in the SVRS survey is 5.3 percent of the total population as against 5.0 percent in the 2018 survey which is far over the present study (2.3%). The conforming proportions are 33.4 percent and 6.4 percent in the 2020 BDHS and 35.5 percent and 5.1 percent in the 2011 census.

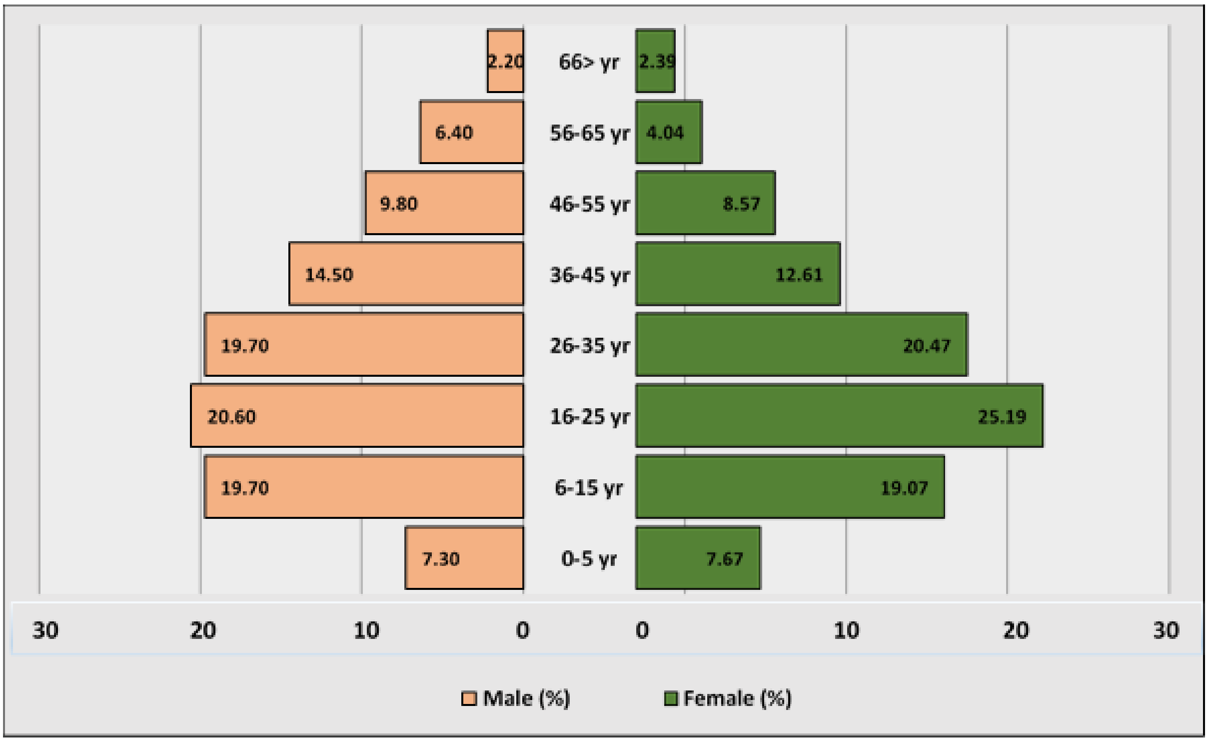


Figure 5.2: Age-Sex pyramid of survey population

5.4 Duration of residency

The study also gathered information on the length of staying of the respondents in the study area and shows that most of the people are living in their respective areas for more than ten years (64.2%) and around 13 percent of them are the residence of these community for about five to ten years and about 8 percent are living in these areas for less than one year. Again, 7.2 percent of respondents are living in their respective areas for between two to five years and 7.4 percent in between one to two years (Figure 5.3). Though some of the respondent households were staying there for less than one year (8.2%) but most of the respondent households were found to stay long in these communities constituting above 64 percent, this indicates the knowledge and familiarity with the surrounding environment and therefore under pine the authenticity of the data collected.

Table 5.3 reveals the specific time length of respondents' staying in each community. The highest percentage (92.7%) of respondents were recorded to live in Ichharkandi for more than ten years while the lowest percentage (20.1%) has been recorded in the Bhadam community. For the same community, the highest 25.5 percent of respondents found to live there for less than one year followed by Kathaldia (17.1), Bhakral (14.1%), Abdullahpur (9.5%), and so on (Table 5.3). The population of Bhadam and Kathaldia shows heterogeneous distribution than the other ten communities where population distribution is more homogenous.

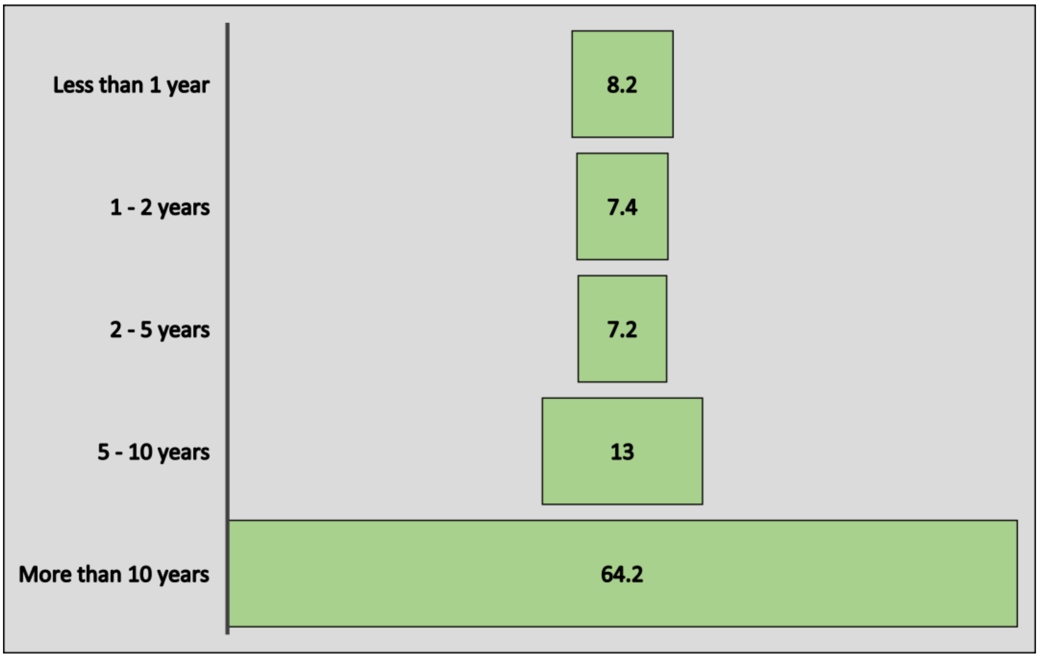


Figure 5.3: Years (%) of residence of the surveyed communities

Table 5.3: Length of staying in the areas by the respondent's community

Area	Residence time										Total (N)
	<1 year		1-2 years		2-5 years		5-10 years		>10 years		
	n	%	n	%	n	%	n	%	n	%	
Konabari	6	2.5	9	3.7	11	4.5	10	4.1	206	85.1	242
Kashimpur	6	2.9	9	4.4	10	4.9	37	18.1	142	69.6	204
Ichharkandi	1	0.6	0	0.0	3	1.8	8	4.9	152	**92.7**	164
Palasana	1	0.9	4	3.6	3	2.7	17	15.5	85	77.3	110
Gutia	3	2.8	6	5.6	8	7.5	12	11.2	78	72.9	107
Gusulia	3	4.6	4	6.2	4	6.2	1	1.5	53	81.5	65
Bhakral	12	14.1	4	4.7	8	9.4	11	12.9	50	58.8	85
Bhadam	51	25.6	45	22.6	24	12.1	39	19.6	40	**20.1**	199
Kathaldia	38	17.1	15	6.8	27	12.2	43	19.4	99	44.6	222
Rashadia	5	7.4	4	5.9	12	17.6	13	19.1	34	50.0	68
Abdullahpur	21	9.5	26	11.8	15	6.8	38	17.3	120	54.5	220
Mausaid	2	1.4	9	6.4	7	5.0	8	5.7	114	81.4	140
Total	**149**	**8.2**	**135**	**7.4**	**132**	**7.2**	**237**	**13.0**	**1173**	**64.2**	**1826**

Source: HH Survey, 2017-18

5.5 Educational attainment of the surveyed population

The 2014 BDHS[78] defined literacy based on the respondent's ability to read all or part of a sentence. Therefore, respondents' general levels of education were also investigated in this study. The result in Table 5.4 reveals that grade 'no education' is most significant among the respondents with a percentage of 28.5 percent where women illiteracy rate (33.2%) has been recorded higher than the male (27.6%) members in this category. For the pre-schooling/signature grade 2.5 percent of the surveyed population can sign their name without any educational background. PSC and JCS education accounted for 25.8 percent and 15.8 percent of the surveyed population, respectively. Secondary and higher secondary education accounted for 12.3 percent and 5.5 percent, respectively. The accomplishment of higher degree is very insignificant among the surveyed population and represents only 3.3 percent of the total male and female. A very negligible percent (0.3%) of respondents also were not sure about their educational background. According to Bangladesh Disaster-related Statistics, 2015 (BBS), represents No education, Class I to V, Class VI to IX, SSC/HSC equivalent, Graduate and above with a percentage of 33.34, 32.58, 18.56, 9.23, and 1.29 respectively which are slightly higher than the present survey findings. The study shows that percentage of no-education and education only at the primary level is dominating with the highest percentage and only 3.3 percent are completed their higher education like bachelor or diploma.

Table 5.4: Education status of the survey population

Grade	Male		Female		Total (N)	Percentage (%)
	n	%	n	%		
No education	928	27.6	1109	33.2	2037	28.5
Pre-school/Signature only	89	2.6	92	2.75	181	2.5
Class 1-5 (PSC)	923	27.4	909	27.18	1832	25.8
Class 6-8 (JSC)	533	15.8	594	17.76	1127	15.8
Class 9-10 (SSC)	477	14.2	401	11.99	878	12.3
Class 11-12 (HSC)	239	7.1	155	4.64	394	5.5
Bachelors/Diploma or Higher	160	4.7	78	2.33	238	3.3
Do not know	16	0.48	6	0.18	22	0.3
Total	**3365**	**100**	**3344**	**100**	**6709**	**94.0**
Missing system					**425**	**6.0**

Source: HH Survey, 2017-18

[78] Bangladesh Demographic and Health Survey 2014. 2016. Bangladesh Demographic and Health Survey 2014 https://dhsprogram.com/pubs/pdf/FR311/FR311.pdf

Sex-wise education status of the surveyed population shows that (Figure 5.4) male members avail higher education more (4.8%) than female members (2.3%) alternatively no-education is higher among female members (33.2%) than male (27.6%) (Appendix table B2).

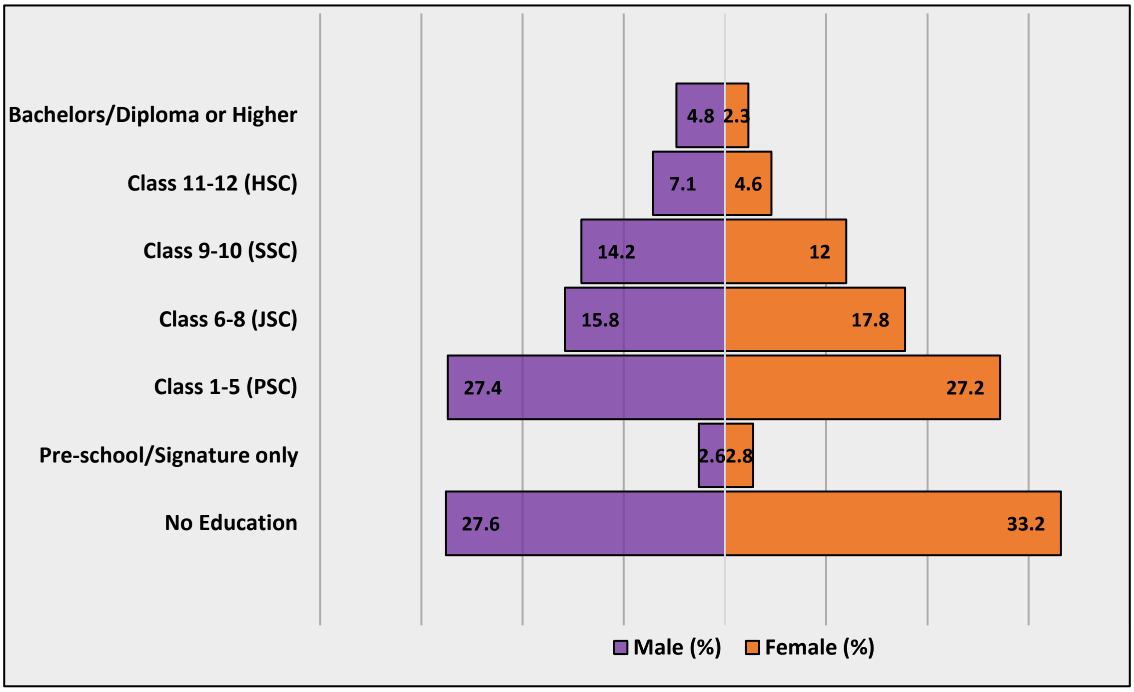


Figure 5.4: Sex wise education level among the respondents

This study also assesses each community's educational level, which led to a crosstab computation (Appendix table B3) conducted with respondents' level of education and their community of residence. Almost all the communities emerged as a community that has no education except that of the Mausaid who has more educated people than the other eleven communities with a percentage of 15.3 in SSC level, 22.8 in HSC level, and 29 in higher education. Konabari is accounted as a community with the highest percentages in the illiterate group comprising 13.9 percent having no education and 22.7 percent with the knowledge of signature only (Appendix table B3).

5.6 Occupation of the respondent HH members

The study also sought to find out the main occupation of the household members in the surveyed area. Diverse occupational groups are found in the study area. Among the sampled HHs more than half (52.8%) of the members are unemployed, housewives, and students. A significant percentage of surveyed HH members are work in garment factory (10.8%) whiles others are engaged in business (7.5%), other factory works (2.8%), skilled labour (2.7%), non-government service (1.5%), farming (2.8%), fishermen (1.2%) and others sharing the rest of the percentages (Appendix table B4). Amongst all, only 0.3 percent of the HH members are found to be employed in government services. The availability of garments and manufacturing industries is the primary cause for the dominance of these factory jobs in cities. The detailed occupational pattern is presented in Figure 5.5.

Apart from listed occupations, four percent of members (283 out of 6708) of the interviewed HHs admitted of not having their occupations in the survey categories (Appendix table B4). There was a wide range of occupations, stated by them and driving was dominant among other types of occupations followed by teaching, begging, cleaning, others day labour, and so on (Appendix table B5).

Sex wise male and female both are equally involved in garments work though males are dominating in most other services as in other factory work (4.1%), non-government services (2.5%), skilled labour (5.1%), business work (14.8%), agriculture works (5.7%) and so on than females (Figure 5.6; Appendix table B4). According to the BBS report 2011, the proportion of households with at least one member employed in the garments sector in Dhaka is 13.0 percent, and women employees in the garment sector represent 11.8 percent resembling with the study findings (Figure 5.6). Female engagement is highest in indoor work as housework (54.4%) and domestic maid (2.1%). A considerable percentage of females (1.2%) are also documented involving business work together with males (14.8%). An interesting matter is that in the studied households the percentage of male (25.7%) and female (24.8%) students is almost the same (Appendix table B4).

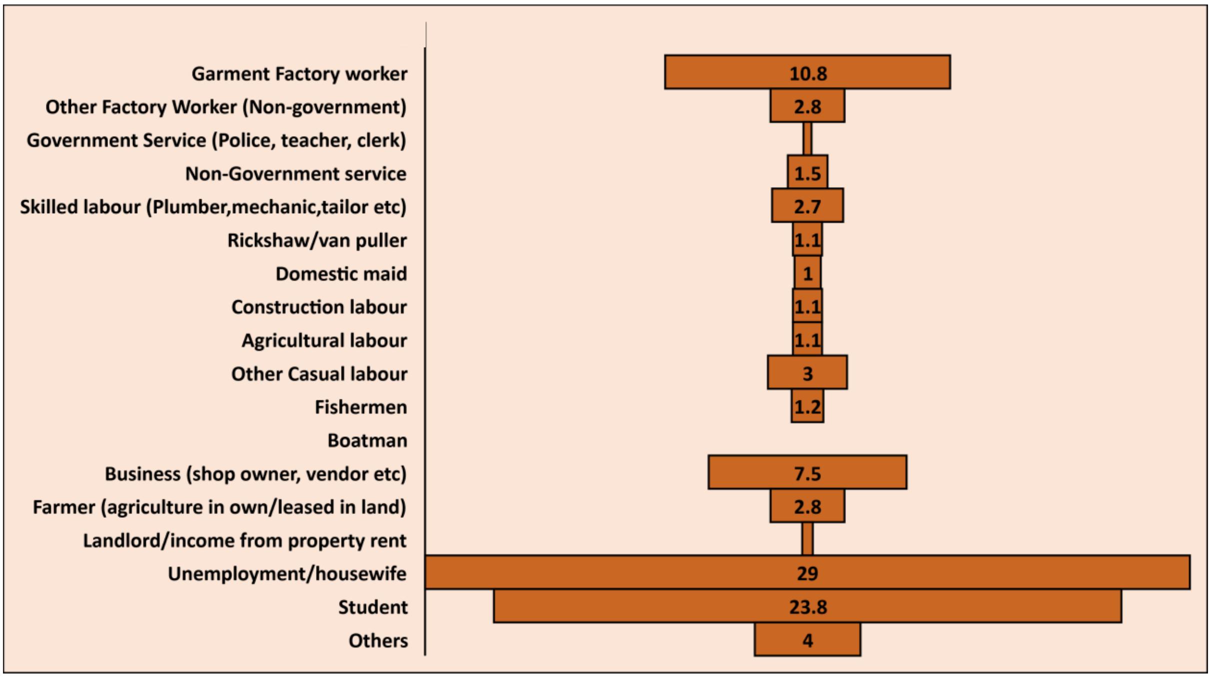


Figure 5.5: Occupation (%) of respondents HH members

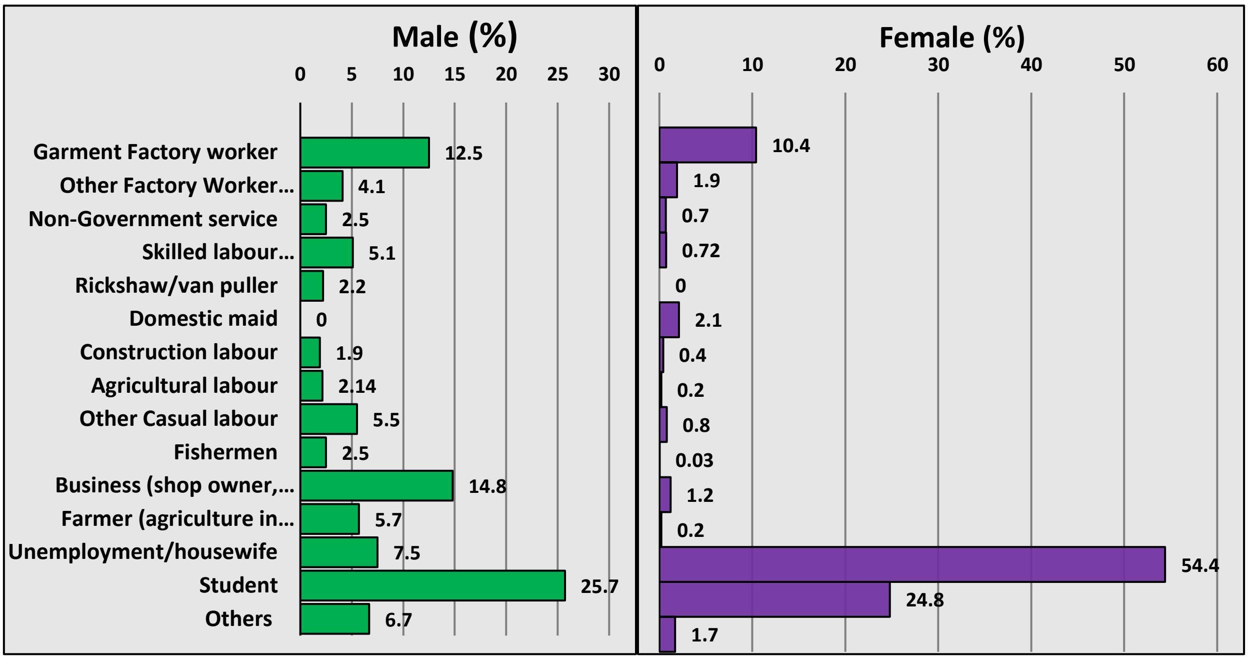


Figure 5.6: Male and female (%) occupation of surveyed household members

5.7 Information related to Household Head

According to the National Association of Home Builders, headship rates are the number of people who are counted as heads of households[79]. The details about household heads of the surveyed areas are discussed hereafter.

5.7.i Sex distribution of household head

Table 5.5 presents the sex-wise distribution of household heads of survey areas. It is observed from the table that among 1826 household surveyed, 91.4 percent (n=1669) HH is headed by male and 8.6 percent (n=157) is female-headed (Figure 5.7; Appendix table B6) while nationally (Bangladesh Population and Demographic Indicator, 2018) there are 86 percent male-headed and 14 percent female-headed households but according to MICS, 2019 it is 87.3 percent (male-headed) and 12.7 percent (female-headed). According to SVRS (Bangladesh Sample Vital Statistics) report (2019), male and female-headed households represent 85.4 and 14.6 percent, respectively. Likewise, all the households in the surveyed areas are dominated by male members than females (Table 5.5).

[79] https://realtytimes.com/headlines/item/7211-20070406_headshiprates

Table 5.5: Percent (%) distribution of household headship by sex and area

Area	HH Head			
	Male		Female	
	n	%	n	%
Konabari	230	12.6	12	0.7
Kashimpur	196	10.7	8	0.4
Ichharkandi	151	8.3	13	0.7
Palasana	95	5.2	15	0.8
Gutia	91	5.0	16	0.9
Gusulia	58	3.2	7	0.4
Bhakral	82	4.5	3	0.2
Bhadam	184	10.1	15	0.8
Kathaldia	203	11.1	19	1.0
Rashadia	62	3.4	6	0.3
Abdullahpur	188	10.3	32	1.8
Mausaid	129	7.1	11	0.6
Total	**1669**	**91.4**	**157**	**8.6**

Source: HH Survey, 2017-18

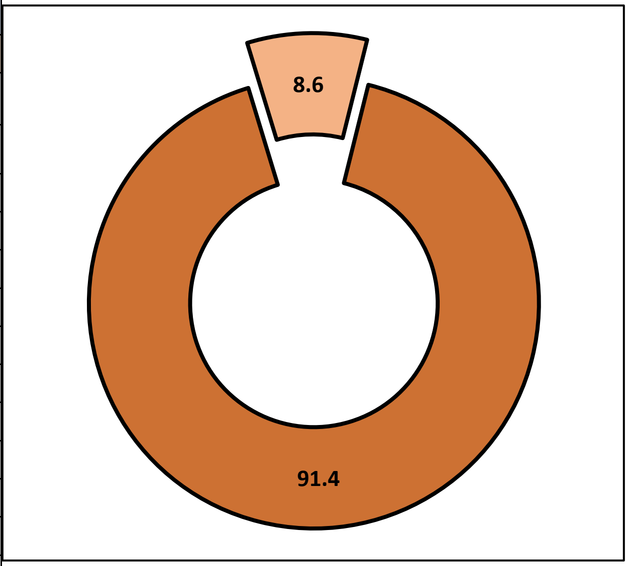


Figure 5.7: Distribution of HH Head (%)

5.7.ii Age distribution of household head

Figure 5.8 shows that the age of most of the household head remains in the range of 26-45 years (56.7%), followed by 46 to 55 years and 56 to 65 years with the percentage of 19.3 and 12.6, respectively. Again, the age group between 16-25 years represents 8.1 percent and the age group above 66 years remains 3.2 percent (Appendix table B7). Study findings also indicate that the household head in the survey area are mostly youth who aged between 26 to 45 years (56.7%). According to the MICS report 2019, the age group between 35-64 years represents 65.7 percent of household heads at the national level which is supported by the present study.

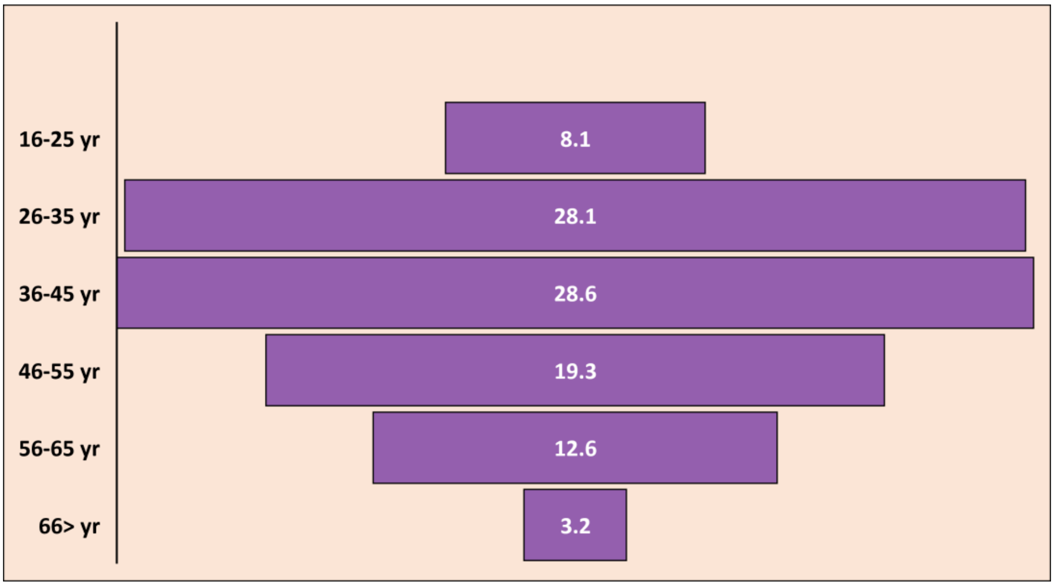


Figure 5.8: Age distribution (%) of HH Head

5.7.iii Age-sex distribution of household head

Household headship in the studied communities starts from 16 years to more than 66 years of age. Age-sex distribution of household heads shows that the age of the household head of the survey area dominates in the ranges from 26 to 65 years in both sexes (Appendix table B7). Females likewise males, age ranges from 36 to 45 years (2.5%) are seen to take up the household responsibilities as head with the round percentage of 29.3 (Figure 5.9; Appendix table B7). According to SVRS report 2019, the age of household head ranging from 15 to 60 for male group represent 86 percent and for the female group, it is 14 percent.

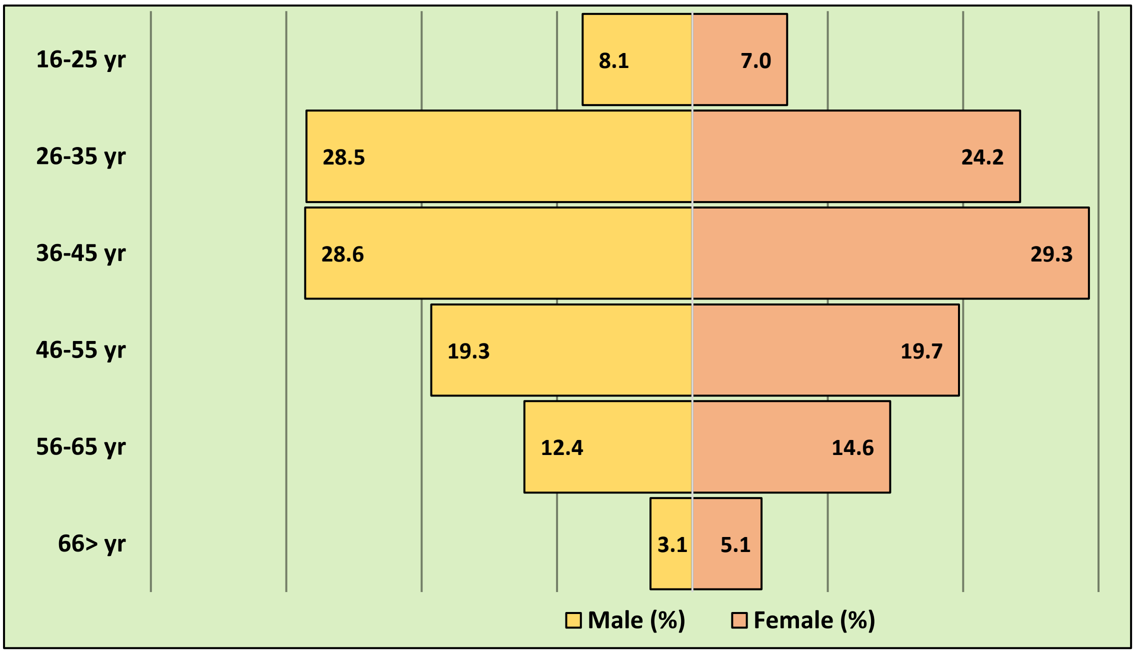


Figure 5.9: Age-sex distribution (%) of HH Head

5.7.iv Education status of the household head

Survey findings revealed that most of the household heads in the studied communities had no education (43.4%) and 0.2 percent could sign only (Appendix table B8). Around 3.5 percent of the surveyed household heads could not cross the bachelor's or higher degree where male represent 3.3 percent and female represent 0.1 percent. Again, 5.1 percent could pass HSC (male 4.9%, female 0.2%), 13 percent could pass SSC (male 12.8%, female 0.2%) and for JSC 12.4 percent (male 12% and female 0.3%) could pass and for PSC 21.9 percent (male 20%, female 1.9%) could pass (Figure 5.10a; Appendix table B8). According to MICS report 2019, weighted percent of education of household head represent no education 35 percent, primary education 27.1 percent, secondary 25.6 percent and higher secondary and more 12.3 percent nationally.

Round percent of sex-wise education distribution of household heads shows that females more uneducated (68.2%) than males (41.1%). Except that of the primary education (PSC) which shows same in both sexes in all levels of education male percentage is higher that of the female household heads (Figure 5.10b; Appendix table B8). According to SVRS report 2019, no education, primary education, and secondary education for male and female-headed household count 80.53:19.47; 86.9:13.1; 90.89:9.11 percent, respectively.

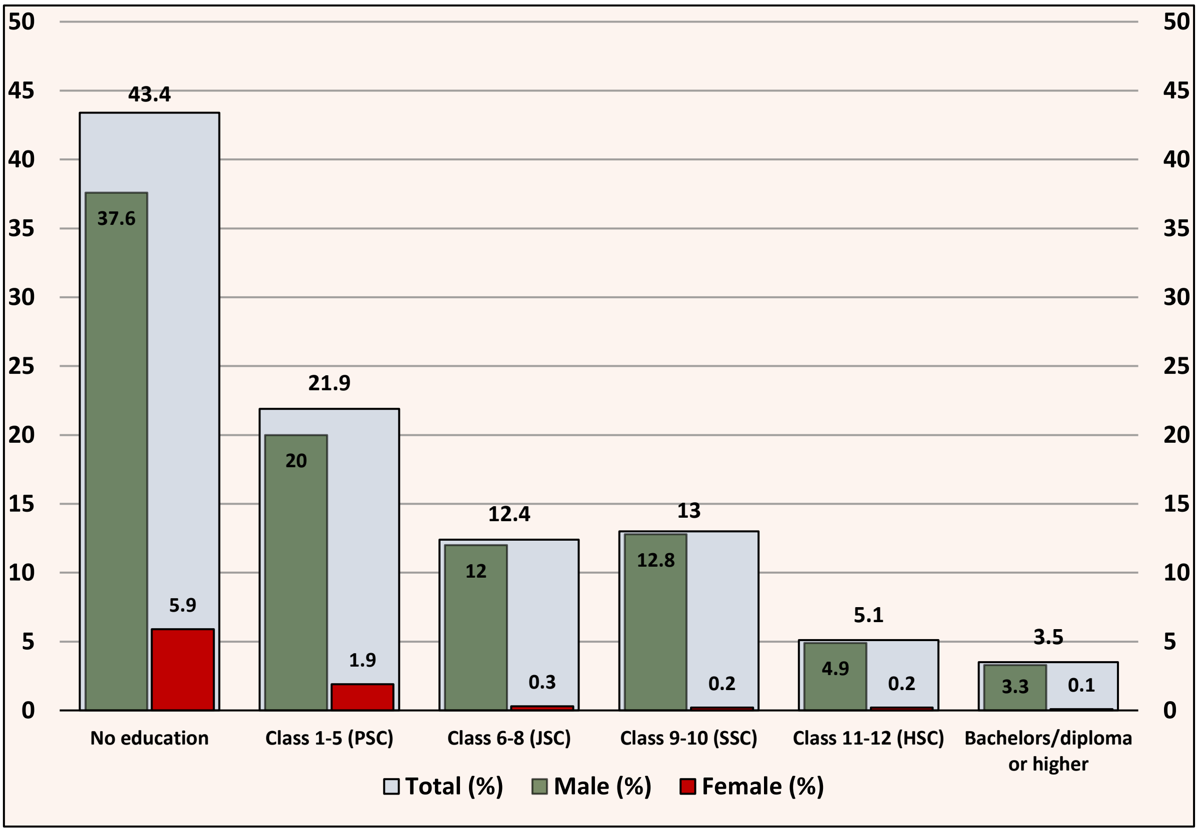


Figure 5.10.a: Sex wise education level of household heads (in breakdown %)

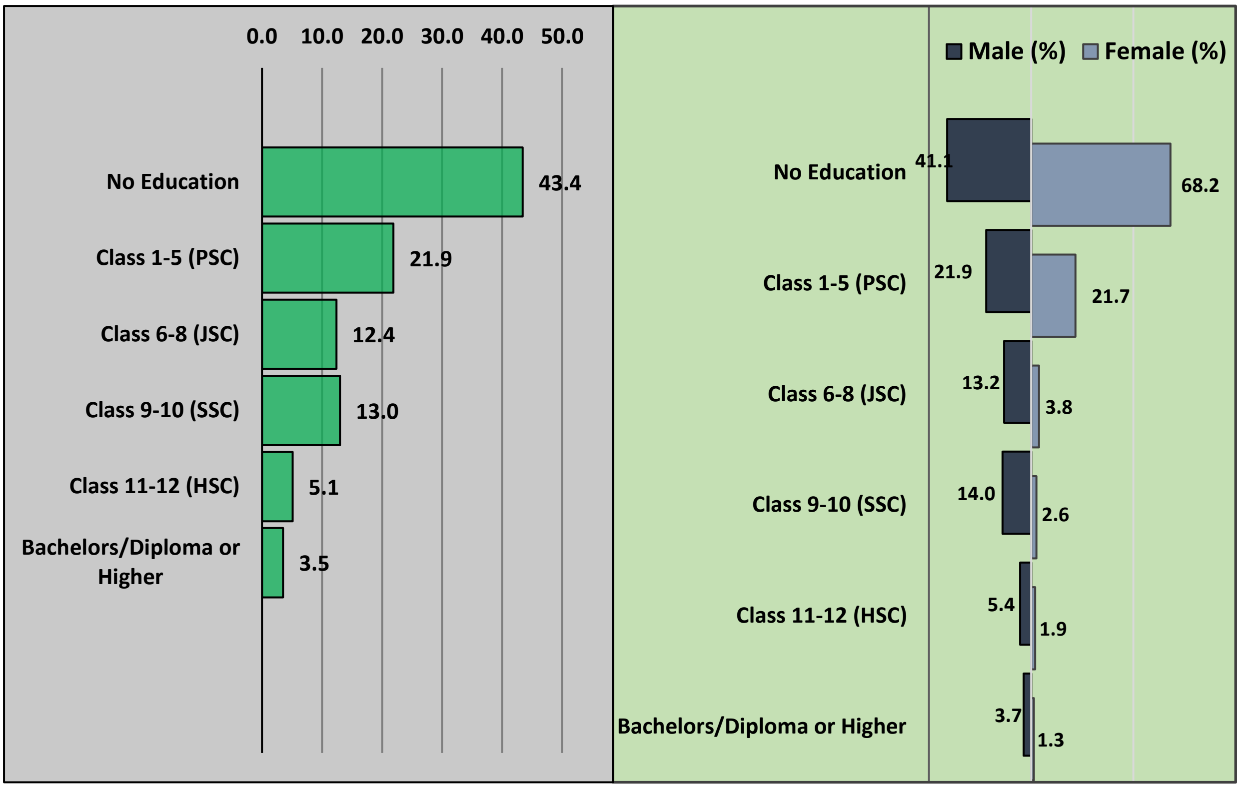


Figure 5.10b: Sex wise education level of household heads (in round %)

5.7.v Occupation of the household head

Occupation wise business (20.4%) and garments factory workers (15.3%) are the topmost prevalent among household heads. Agriculture-related activities like farmers (9.7%) and agriculture labour (3.6%) work are also high among them. Household heads are also found involved in construction (2.9%), skilled (6.4%), and other casual labour (6.9%). Sex-wise, involvement of female household head has been remarked as garments (1.3%) and other factories (0.5%) worker and as domestic maid (0.9%) (Figure 5.11; Appendix table B9).

Cross-tabulation of grade-wise occupation (Appendix table B10) and age-wise occupation (Appendix table B11) of household heads have also been checked to find out the priority of choosing occupation of the studied population. Garment factory worker, businessman, labour work is the highest preference among the non-educated group but remain consistent among primary, secondary, and higher secondary education group. Considering the active age category group, 26-55 years age group are the most active group and works in garment and other factories, labor work, business, etc. Notably, the 46-65 age group is more involved in farming, agriculture, and other labor-related activities than factory and business work (Appendix table B11).

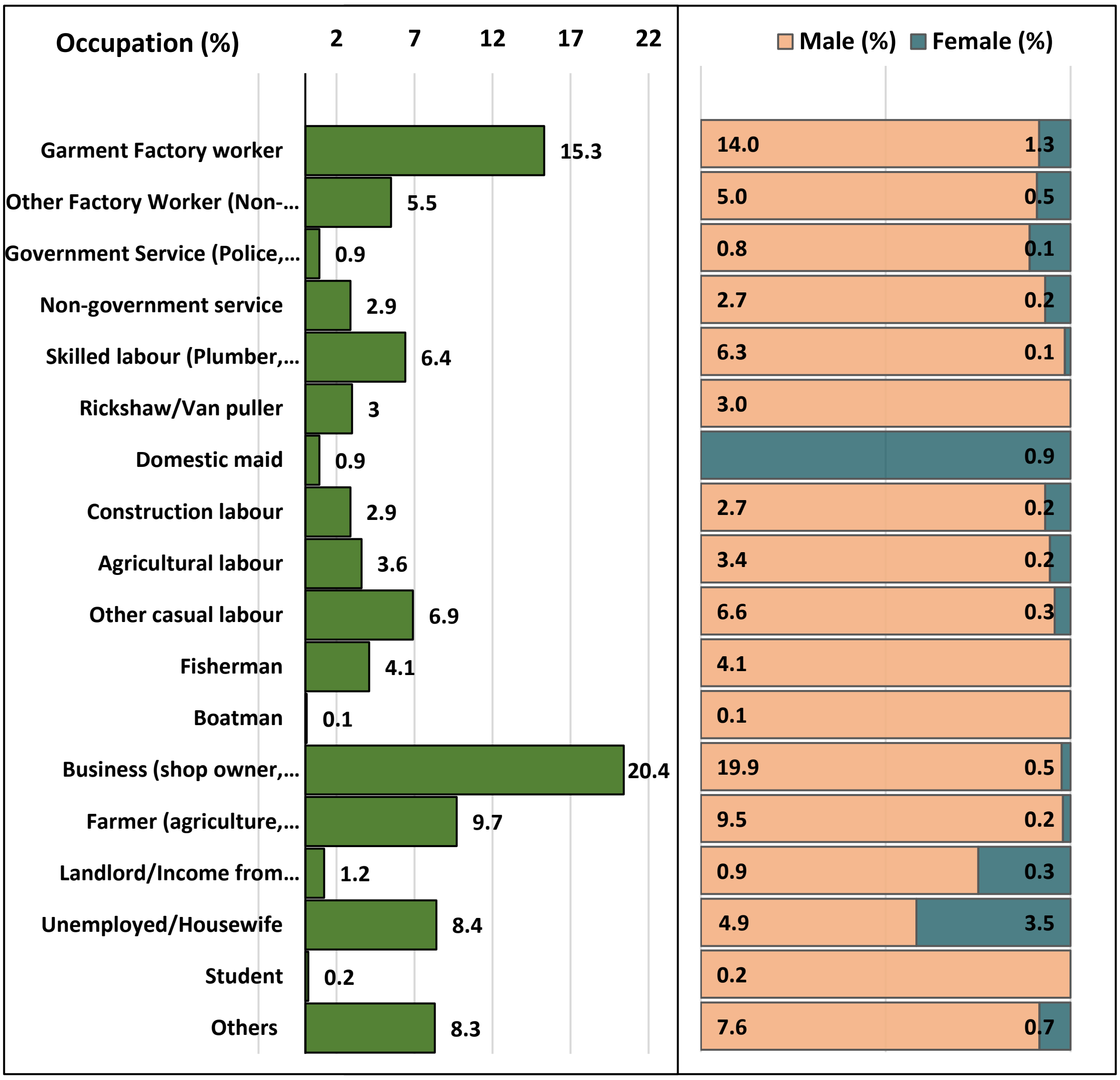


Figure 5.11: Occupation status of household heads (%)

5.8 Households Monthly Expenditure

The study also tried to find out a rough estimate of surveyed households' monthly expenditure under eight main categories as house rent, education, food or cooking, utilities, treatment, clothing and footwear, remittance, and miscellaneous. According to the HIES report 2019, the average monthly income at the current price was estimated at Tk. 15,988 at the national level and in urban areas it was Tk. 22,600 in 2016. According to the same report, corresponding to income, the average monthly expenditure per household at the national level was estimated at Tk. 15,715 and in urban area Tk. 19,697 at the current price in 2016. The present study shows an average monthly expenditure of the studied community as Tk. 23,971 (approximate) (USD=282.94) which depicts a similarity with the HIES report for 2016 in urban area (Appendix table B12). The details of expenditure categories are discussed below-

5.8.1 House rent

The study findings show that among 88.4 percent of households surveyed (n=1612), 37.3 percent had not paid any rent that means they either live in their own house or having free accommodation. A very few of them (3.2%) lived in a rented house spent one thousand takas or less monthly. Most of them spent 1001-2000 taka (10%), 2001-3000 taka (9.6%) and 3001-4000 taka (6.4%) as house rent. On average the respondent's household spent 2710 taka (USD=31.99) per month (Figure 5.12; Appendix table B12).

5.8.2 Education

Households seem to spend more money on education than house rent with a mean value of Tk. 3586 (USD=42.33). Most of the households spent (13.5%) between 3001 to 7000 taka and 10 percent of households spent 501 to 1000 BDT in this concern. Again, according to 24.6 percent of households, there was no cost in receiving education from the institutes (Figure 5.12; Appendix table B12). The expenditure on education per household at the national level is Tk. 900 though in urban areas, it is Tk. 1502 (HIES, 2019).

5.8.3 Food/Cooking

Many of the households (31.7%) spent a maximum of 7001-1000 taka on food whereas 19.8 percent of households spent 10001-15000 taka and 5001-7000 taka by 19.2 percent of households. The lowest 1000 or less taka had been spent monthly by 1.0 percent of households. The average monthly expenditure for food thus stands for Tk. 9143 (USD=107.92) (Figure 5.12; Appendix table B12). In comparison, the HIES report 2019 revealed monthly food expenditure per household was taka 7,354 at the national level and 8,254 takas in urban areas in 2016.

5.8.4 Utilities (Water, Electricity, Gas)

Most of the households (34.8%) spent 751 to 1000 taka per month on the utilities like water, electricity, and gas. Also, 252 to 500 BDT spent by 17.5 percent, 501 to 750 BDT by 10.2 percent, and 1501 to 2000 BDT by 7.3 percent of households. The average monthly expenditure for gas, water, and electricity is Tk. 1141 (USD=13.47) (Figure 5.12; Appendix table B12).

5.8.5 Treatment (Doctors fees, medicines, etc.)

The average monthly treatment cost of the respondent household is recorded as Tk. 1342 (USD=15.84). Maximum households spent 101 to 300 taka (19.8%), 301-500 taka (19.3%), 751 to 1000 taka (15.1%) and 1001 to 2500 taka (14.4%). More than 2500 taka has been spent by 12 percent of households (Figure 5.12; Appendix table B12).

5.8.6 Clothing and footwear

Study findings show that the community spent more money on clothing and footwear rather than treatment purposes with an average expend of Tk. 1456 (USD=17.19). The highest 22.3 percent of household members spent 751 to 1000 taka for clothing and footwear followed by 251 to 500 takas by 21.1 percent, 1001 to 1500 taka by 13.1 percent, 1501 to 2000 taka by 13.7 percent, and 2001 to 5000 takas by 11.7 percent of households. A maximum of more than five thousand takas has been spent by only 1.6 percent of households (Figure 5.12; Appendix table B12).

5.8.7 Remittance (send money back home)

Expenditure on remittance is documented in only 11.6 percent of cases. The highest 1 to 2500 taka is spent by 6.8 percent and 2501 to 7500 takas by 21.1 percent of households (Figure 5.12; Appendix table B12).

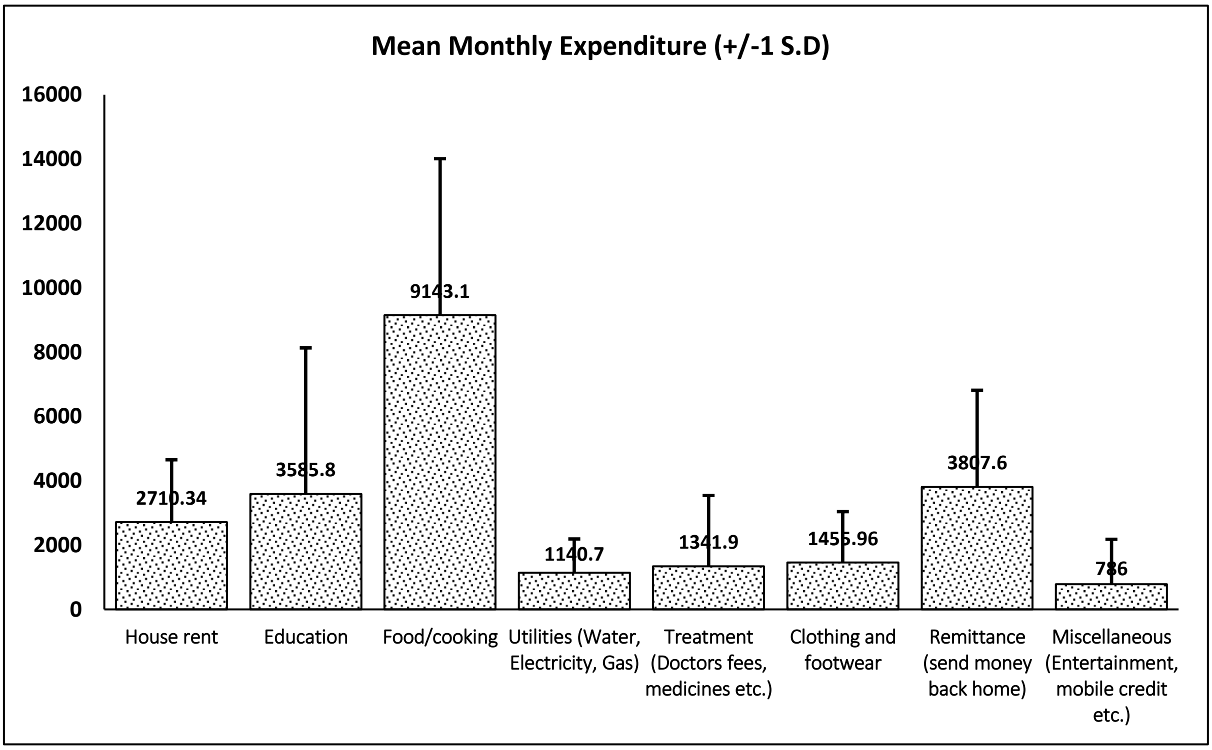


Figure 5.12: Average monthly expenditure of respondent households (Mean±SD)

5.8.8 Miscellaneous (Entertainment, mobile credit, etc.)

Household members of the survey areas had so many other expenditures including entertainment, mobile credit, and other amenities purposes with average spending of 786 takas. The maximum 31.3 percent of households spent 251 to 500 takas followed by 501 to

1000 by 22 percent and 1 to 250 takas by 21.7 percent of households (Figure 5.12; Appendix table B12).

5.9 Proportion of household having at least one member employed in the garment sector

It has been found that among 1826 households surveyed at least 280 households (15.3%) have members that are employed in garments factory (Appendix table B11). Out of a total of 7134 household members, 768 are worked in the garment factory which represents 10.8 percent of the total population with the male to the female percentage of 12.5 and 10.4 (Appendix table B4).

Multiple numbers of job types in garments factories are documented, most of them are involved in sewing, cutting, and packaging related activities (6.5%) with a very noticeable percent (1.6%) involved in dyeing/washing activities (Figure 5.13; Appendix table B13). The survey results also revealed that a very insignificant percentage are engaged in managerial work (0.7%) which may be related to their education and as they do not obtain any higher degree. Except that all, others work (1.9%) includes operators, helper, cooking, quality checking, etc. (Appendix table B14).

Garment's workers in the studied area have long-term involvement in this sector. Most members are working in this factory for 5-10 years (3.8%) and some of them are working for more than 10 years (1.9%). Working in the factory for less than one year is represented by 3.7 percent, 1-2 years by 3.2 percent, and 3-4 years by 2.8 percent of members (Figure 5.13; Appendix table B13).

For working in the garments, they have urged to sign in different payment structure. Most of the workers do not have any job contract (9.7%) while only 4.9 percent do a contract job. Therefore, payment was mainly done on daily basis (11.6%) with a rolling contract where 1.1 percent had permanent, and 0.3 percent had fixed-term contact with the factory authority (Figure 5.13; Appendix table B13).

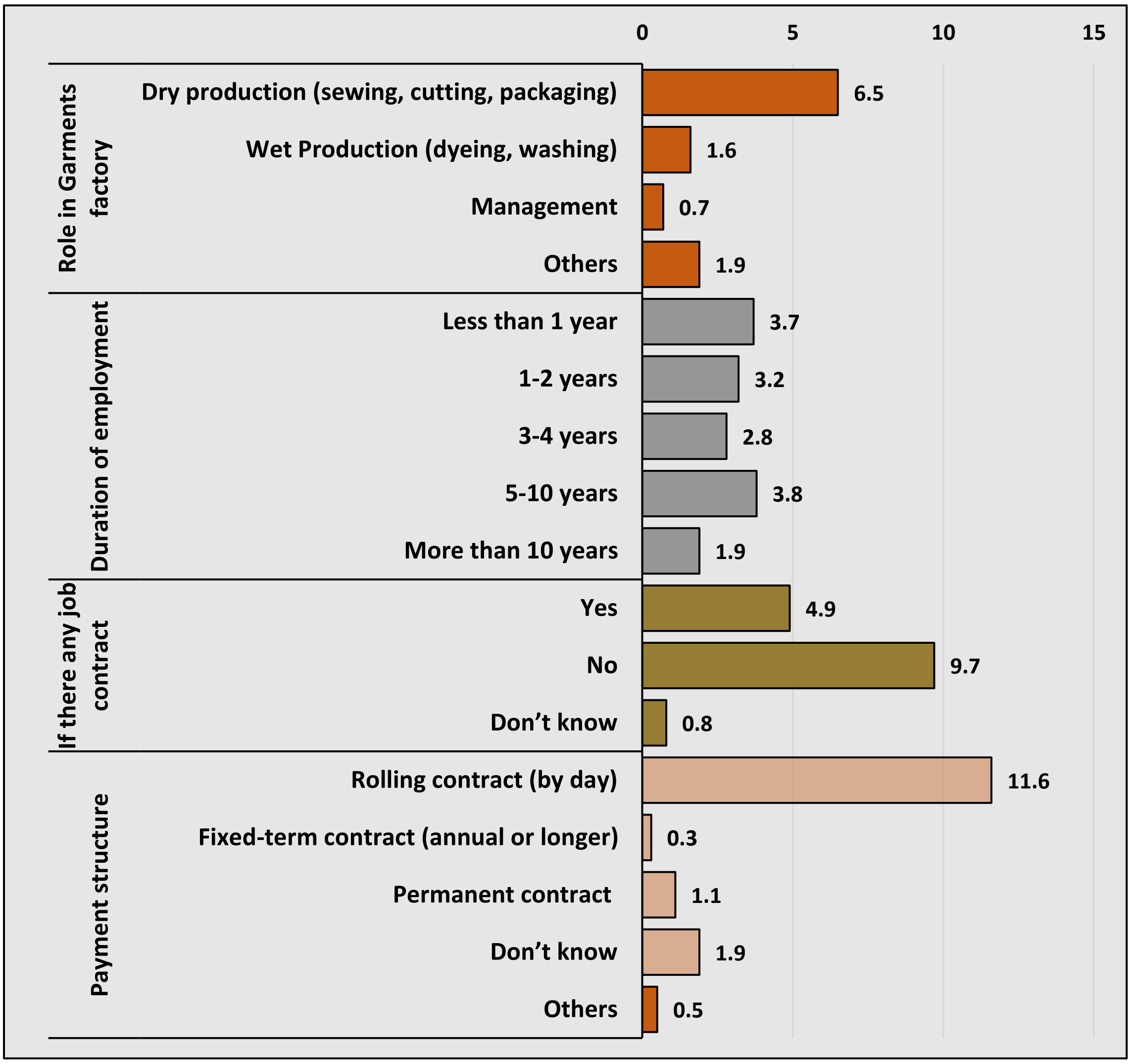


Figure 5.13: Job information of HH members employed in garments factory

5.10 Household Possessions or Assets

Information on the assets owned by the households is typically associated with literacy and education, and health. These durable assets are used to determine the relative wealth quintile of households which are discussed under the following broad categories-

5.10.1 Household occupancy status

Most of the studied households are seen to reside in their own house (51.6%) with very remarkable percentages are tenants (31.7%). Some of them are also seen to live in the government's land or embankment area (15.7) of the river (Figure 5.14; Appendix table B15). A very negligible percentage is (1.1%) living with their relatives or in the land temporarily given by their relatives, local leader, factory they are working, some of them also work as a caretaker in return they got a place to stay (Appendix table B16). According to the MICS report 2019, 54.3 percent of the urban population (nationally 84%) in

Bangladesh has the ownership of a dwelling and 43 percent has resided in a rented dwelling (nationally 13%).

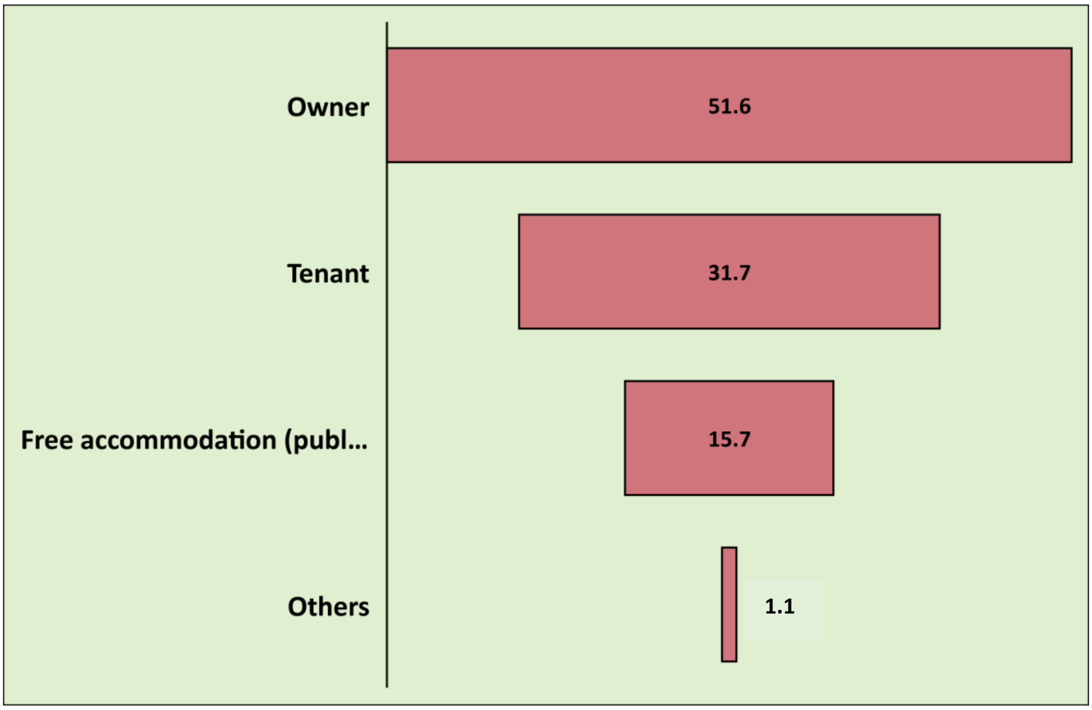


Figure 5.14: Occupancy status of respondent households (%)

5.10.2 Household possessions of electronic appliances, mobile phones, and vehicles

Electric fan (94.3%), almirah/wardrobe/showcase (76%), television (74%), refrigerator (46%), radio/CD/DVD players (6.8%) are topmost household possessions among the studied respondents. Computer/laptop was owned by 5.1 percent whereas IPS/generator by only 1.7 percent of studied households. According to BDHS report 2019[80], ownership of electric appliances (television, refrigerator, electric fan, and water pump) also increased between 2014 and 2017. According to the same report published in 2020[81], electric fans were owned by 80.2 percent, almirah/wardrobe 37.3 percent, televisions by 47.3 percent, refrigerators by 29.1 percent, computer/laptop by 5.7 percent, radio/DVD player by 2.6 percent, and IPS/generator by 2.0 percent of households in Bangladesh.

Mobile phones, the most popular household possession (Table 5.6), are owned by 74.3 percent of households. SVRS report, 2019 shows in Dhaka about 78.2 percent of individuals own mobile phones which is 73.7 percent nationally. Ownership of mobile phones in the

[80] Bangladesh Demographic and Health Survey (BDHS) 2017–18: Key Indicators. 2019. National Institute of Population Research and Training (NIPORT), and ICF. https://dhsprogram.com/pubs/pdf/PR104/PR104.pdf
[81] https://dhsprogram.com/pubs/pdf/FR344/FR344.pdf

urban population is 96.6 and nationally it is 94.4 percent according to the BDHS report 2020.

Regarding possession of means of surveyed communities livelihood apparatus's, a bicycle is owned and documented by the highest percent (8.6%) of households, together with ownership of motorcycle by 3.3 percent, rickshaw/van/animal cart by 3.2 percent, auto-bike/tempo/CNG by 1.1 percent, and car/truck/microbus by 0.8 percent of households (Table 5.6; Figure 5.15). Bicycle is the most owned means of transport in Bangladesh with 27.6 percent of the households owning one, motorcycle owned by 7.6 percent of households, rickshaw/van by 5.7 percent, auto bike/tempo/CNG by 2.0 percent, and car/truck/microbus by 0.8 percent of households in Bangladesh (BDHS, 2020).

Table 5.6: Household possessions (%) of interviewed respondents

Household assets	*Frequency (n)	Percentage (%)
Ownership of electronic appliances		
Mobile phone	1357	74.3
IPS/generator	31	1.7
Computer/laptop	94	5.1
Refrigerator	842	46.1
Radio/CD/DVD player	124	6.8
Television	1352	74.0
Almirah/wardrobe/showcase	1388	76.0
Electric fan	1722	94.3
Ownership of means of transport		
Power tiller/tractor	13	0.7
Car/truck/microbus	14	0.8
Auto-bike/tempo/CNG	20	1.1
Rickshaw/van/animal cart	58	3.2
Motorcycle	60	3.3
Bicycle	157	8.6
Electric/diesel pump	108	5.9

Source: HH Survey, 2017-18; *MR= Multiple Response; N=1826

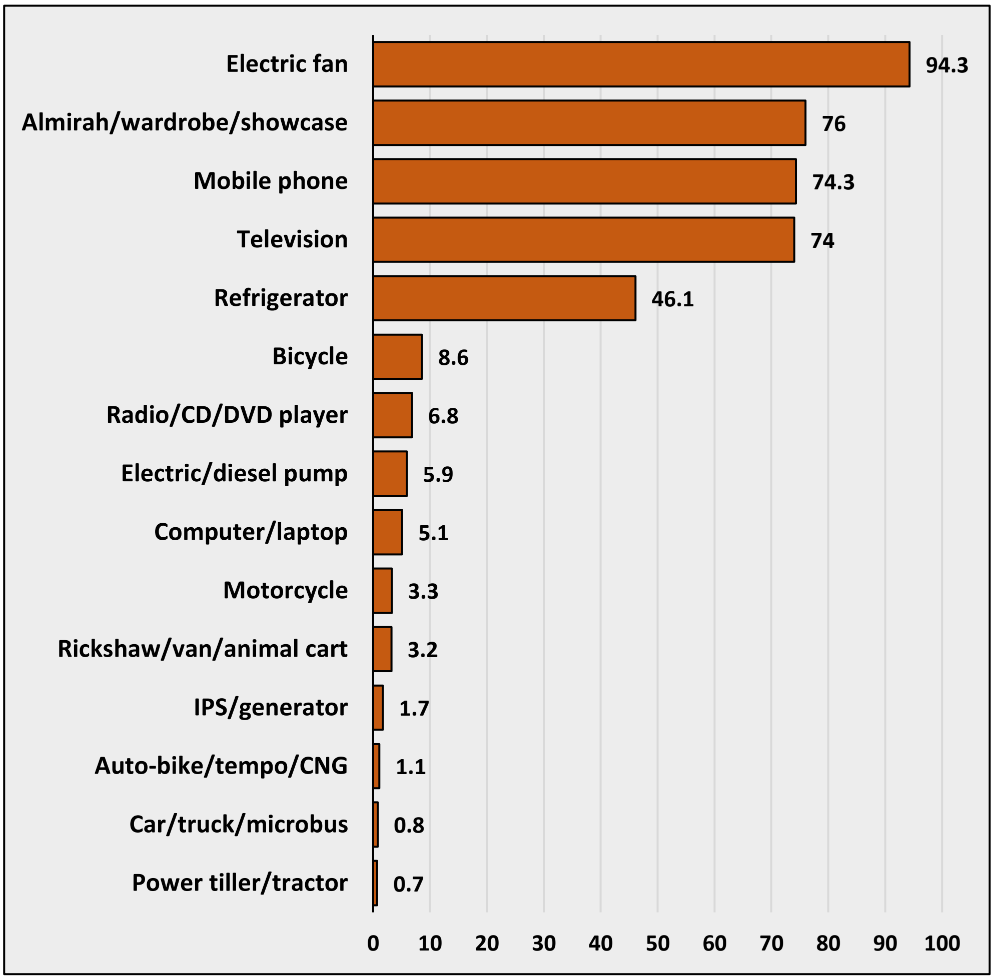


Figure 5.15: Household possessions (%) of surveyed households

5.10.3 Ownership of land

5.10.3.a Agriculture land

Among the 1826 households surveyed only 22.5 percent (n=390) of them have owned agricultural land where 76.9 percent (n=1425) are landless (Table 5.7). According to MICS report 2019, 37.7 percent of households own agricultural land nationally whereas among urban communities it is 26.2 percent which closely pertinent with the present findings, but the result is higher than the present study according to the BDHS report 2020 in case of both nationally (46.7%) and urban areas (38.8%).

Among the studied communities, 11.3 percent own only 1 to 50 decimals of agricultural land with a mean standard deviation of 20.2±14.2 (Table 5.7). Again, 51 to 100 decimals of agricultural land had been owned by 5.8 percent of households and 101-200 decimal by 2.6 percent of households. The highest more than 500 decimals have been owned by only 0.4 percent of households. On average the studied households own 67.9±90.1 decimal agricultural land each (Table 5.7).

Table 5.7: Homestead land owned by the respondent households (%)

Ownership of Land		Frequency n	Percentage %	Mean±SD
Households own agricultural land	*Yes*	390	22.5	------
	No	1425	76.9	
	Don't know	11	0.6	
	Total	**1826**	**100**	
Lot of agricultural land household own (*in decimal*)	1-50	203	11.3	20.2±14.2
	51-100	102	5.8	77.9±17.1
	101-200	42	2.6	147.2±20
	201-300	6	0.5	253.2±29.7
	301-400	7	0.4	345.1±24.3
	500>	4	0.4	636.5±162.1
	999*	26	1.5	------
	Total	**390**	**22.5**	**67.9±90.1**
Households own homestead land	*Yes*	993	54.4	------
	No	822	45.0	
	Don't know	11	0.6	
	Total	**1826**	**100**	
Lot of homestead land household own (*in decimal*)	1-20	855	46.8	6.4±4.3
	21-50	68	3.7	32.1±8
	51-100	21	1.2	74.8±16.9
	101-200	10	0.6	148.2±21.4
	201-500	2	0.1	415±120.2
	999*	37	2.0	------
	Total	**993**	**54.4**	**12.1±27.2**

Source: HH Survey, 2017-18; 999*=don't know

5.10.3.b Homestead land

The survey also had the attempt to record the ownership of homestead land of the studied communities which shows that about 54.4 percent of households (n=993) have their homeland (Table 5.7). The highest 46.8 percent of households have only 1 to 20 decimals of land with a mean standard deviation of 6.4±4.3 (Table 5.7). About 3.7 percent of households have 21 to 50 decimals, 1.2 percent have 51 to 100 decimals of homestead land. A very few (0.7%) have 101 to 500 decimals of homestead land. The studied households have an average of 12.1±27.2 decimals of homestead land.

5.10.4 Ownership of farm animals/livestock

The survey results showed that among 1826 households only 17.3 percent (n=315, multiple responses) own households' livestock (Table 5.8). Nationally it is 55.3 percent, and in urban areas, 22.6 percent of households by MICS report 2019.

Amongst those who owned farm animals' 16.2 percent (n=296) own cow/buffaloes. Highest percentage of households (5.6%) own only one cow or buffaloes whereas three cow or buffaloes were owned by 4.8 percent of households (Table 5.8). On average each studied household-owned more than two with mean±SD of 2.4±1.9. In comparison, cows/buffaloes are owned by 31.6 percent of households at the national level and 10.8 percent in urban settings according to BDHS (2020).

Livestock like goat/sheep in the studied areas are owned by 10.3 percent of households (Table 5.8). Goat/sheep ownership at the national level represents 18.8 percent and 6.7 percent at the urban level (BDHS, 2020). Most of the studied households own only one goat/sheep with a percentage of 7.7. The highest nine goats/sheep are owned by only 0.1 percent where the mean of ownership with standard deviation is 1.6±1.4 (Table 5.8).

Table 5.8: Livestock owned by the respondent households (%)

Ownership of Livestock		**Frequency**	**Percentage**	**Mean±SD**
		n	**%**	
Does the household own any livestock	*Yes*	315*MR	17.3	------
	No	1511	87.2	
Household own Cow/Buffaloes	*Yes*	296	16.2	------
	No	1530	83.8	
Number of Cow/Buffaloes	1	102	5.6	***2.4±1.9***
	2	87	0.1	
	3	51	4.8	
	4	29	0.1	
	5	14	2.8	
	6	7	1.6	
	7	2	0.8	
	8	1	0.4	
	9	1	0.1	
	10	1	0.1	
	22	1	0.1	
Household own Goat/Sheep	*Yes*	188	10.3	------
	No	1638	89.7	
Number of household's own Goat/Sheep	1	141	7.7	***1.6±1.4***
	2	16	0.9	
	3	13	0.7	
	4	8	0.4	
	5	2	0.1	
	6	5	0.3	
	8	2	0.1	
	9	1	0.1	

Source: HH Survey, 2017-18; 999*=don't know; MR=Multiple Response

5.11 Housing Characteristics

Various housing characteristics of respondent households has been discussed under the following headlines -

5.11.1.a Floor material of the house

Most of the floor materials of respondent's households are made of brick or cement (60.2%) and mud (35.5%). Wood or bamboo made, and tiles or mosaic made floor were also documented belonging to 3.6 and 0.5 percent households respectively (Figure 5.16; Appendix table B17). Other materials (0.3%) like tin, jute, plastic was also used for constructing the floor. According to BDHS report 2020, cement is the most used flooring material in urban households is 63 percent which is recorded 33.5 percent at the national level. Wood or bamboo made flooring is recorded as 0.7 percent nationally and 0.3 percent in the urban area, ceramic tiles as flooring has been recorded as 3.1 percent and 9.1 percent nationally and in urban settings in 2017-18 by the same report (BDHS, 2020).

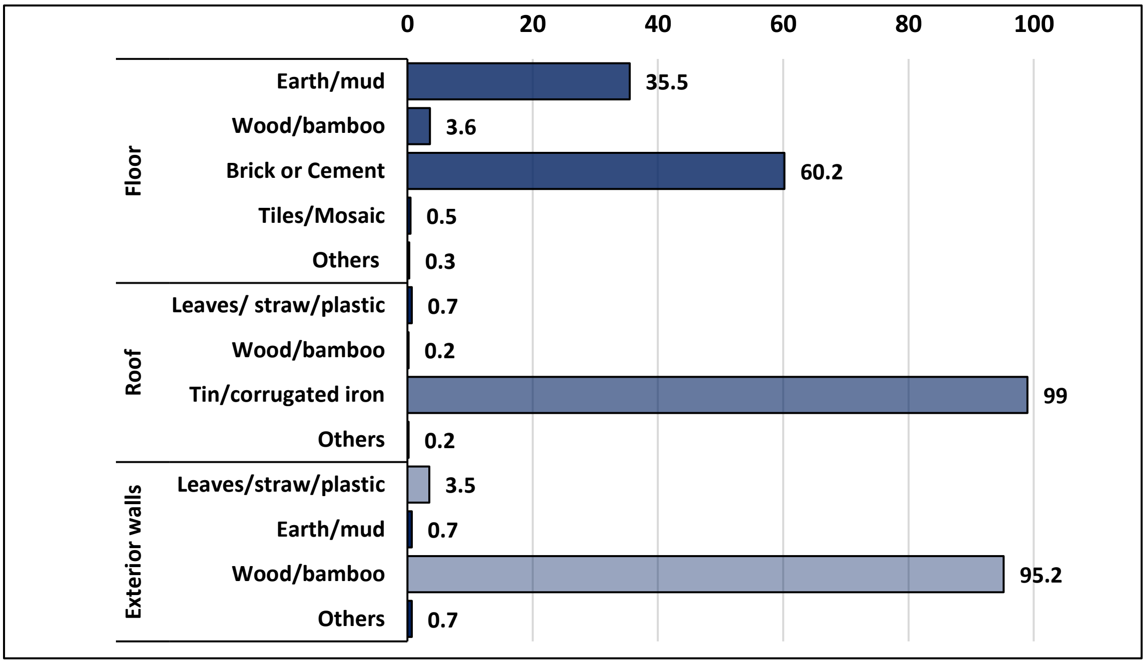


Figure 5.16: Housing materials of the studied households (%)

5.11.1.b Roof material of the house

In ninety-nine percent (99%, n=1807) cases the roof of respondent's households was made of tin or corrugated iron (Figure 5.16; Appendix table B17). The floor consists of leaves, plastic, bamboo, and other materials were also documented. In country-wide comparison, it is shown that 84.3 percent of Bangladeshi households use tin as roofing materials, while 68.7 percent of urban households have been documented to use the same materials (BDHS, 2020).

5.11.1.c Materials of the exterior walls

The main materials of the exterior wall of the respondent households were made of wood or bamboo in 95.2 percent cases (Figure 5.16; Appendix table B17). Leaves/straw/plastic is also used by 3.5 percent of households with various other materials (1.4%). HIES report 2019 indicates that wall materials in the urban area consist of wood by 32.9 percent of households (nationally 49%) and with leaves/cement by 5.6 percent of households (nationally 8.8%).

5.11.2 Rooms shared for sleeping

For various reasons, household members share rooms for sleeping. This household survey analysis shows that members of the households usually use a minimum of one room and a maximum of nine rooms for sleeping. People living and sleeping in one room is documented in the highest percentage of households (44.8%). Two rooms and three rooms were used for sleeping by 38.7 and 11.8 percent of household members, respectively. The highest six to nine rooms have been used for sleeping by only 0.6 percent (n=10) of household members. From the survey, one to two rooms are mainly used by the surveyed households for sleeping with the mean standard deviation of 2±0.9. The present findings of the mean number of persons per room used for sleeping (2±0.9) are supported by the findings of the MICS report 2019, which shows that the mean number of persons per room used for sleeping at the national level is 2.34 person which is 2.38 person in the urban area (Table 5.9).

Table 5.9: Room's members of the households use for sleeping

<table>
<tr><th rowspan="2">Rooms used for sleeping</th><th colspan="2">Surveyed Households</th><th colspan="2">MICS, 2019</th></tr>
<tr><th>Frequency (n)</th><th>Percent (%)</th><th>National (%)</th><th>Urban (%)</th></tr>
<tr><td>1 (One)</td><td>818</td><td>44.8</td><td>3.21</td><td>35.0</td></tr>
<tr><td>2 (Two)</td><td>706</td><td>38.7</td><td>40.0</td><td>38.5</td></tr>
<tr><td>3 (Three)</td><td>216</td><td>11.8</td><td rowspan="7">27.9</td><td rowspan="7">26.5</td></tr>
<tr><td>4 (Four)</td><td>54</td><td>3.0</td></tr>
<tr><td>5 (Five)</td><td>22</td><td>1.2</td></tr>
<tr><td>6 (Six)</td><td>6</td><td>0.3</td></tr>
<tr><td>7 (Seven)</td><td>2</td><td>0.1</td></tr>
<tr><td>8 (Eight)</td><td>1</td><td>0.1</td></tr>
<tr><td>9 (Nine)</td><td>1</td><td>0.1</td></tr>
<tr><td>Total</td><td>1826</td><td>100</td><td>-----</td><td>-----</td></tr>
<tr><td>Mean number of persons per room used for sleeping</td><td colspan="2">2±0.9</td><td>2.34</td><td>2.38</td></tr>
</table>

Source: HH Survey, 2017-18; MICS Report, 2019

5.11.3 Kitchen shared for cooking

Most of the studied households had separate rooms that have been used as a kitchen (83.2%, n=1519) whereas 16.8 percent had no such room for being used as the kitchen (Table 5.10). Among the households who had their separate space for the kitchen, around 50.2 percent of them do not share it with other households. Findings also show that 24.3 percent of respondent households had shared the kitchen with more than two households and 8.8 percent shared it one to two other households (Table 5.10).

Table 5.10: Kitchen shared with other households

Room for kitchen		Frequency	Percentage
		n	%
Separate room used as a kitchen	*Yes*	1519	83.2
	No	307	16.8
	Total	**1826**	**100**
Number of households with shared kitchen	*Not shared with any other household*	916	50.2
	Shared with 1-2 other households	160	8.8
	Shared with more than 2 households	443	24.3
	Total	**1519**	**83.2**

Source: HH Survey, 2017-18

5.12 Household Facilities

5.12.1 Power sources for lighting and electronics

Most of the surveyed households had their power sources for lighting and electronics from grid supply electricity (93.6%). A similar result has also been documented by the report of SVRS 2019, that overall electricity is used by 93.5 percent of households nationally which is 96.3 percent in Dhaka in 2019. Except that other power sources of studied households includes candle (4.3%), kerosene/kupi/harican lamp (3.7%), side-line connection from another family (3.5%), charge light (2.9%), solar panel (0.8%), and various other sources (0.3%). 0.6 percent of households are documented who do not have any power supply in their houses (Figure 5.17; Appendix table B18). Where the SVRS report shows that the use of solar panels is 3.3 percent and kerosene is 2.9 as the source of lighting in Bangladesh.

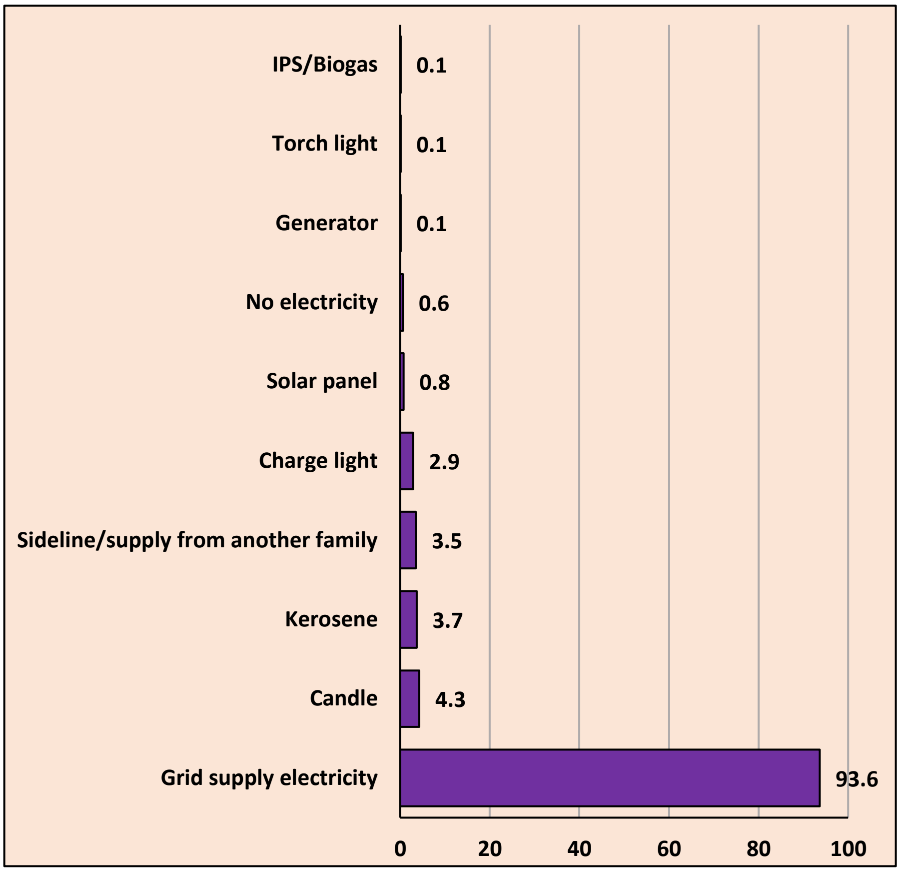


Figure 5.17: Power sources for lighting and electronics among studied households (%)

5.12.2 Sources of fuel

Sources of fuel at studied households includes wood or fuel sticks (75.6%), supply or cylinder gas (44.4%), straw/shrubs/grass (34.8%), animal dung (5.5%), kerosene (0.7%), electricity (0.3%) etc. (Figure 5.18; Appendix table B19). Survey results show that community people mainly depend on natural sources as fuel material than natural gas. According to SVRS report 2019, straw, leaf, husk, wood, or charcoal all together used by 69 percent nationally and 46.4 percent of the residents of the urban area in 2019. The overall use of supply gas is only 15.6 percent at the national level and 30 percent in urban areas. Supply gas, biogas, and LPG altogether constitute 26.8 percent of the total fuel use (SVRS, 2019).

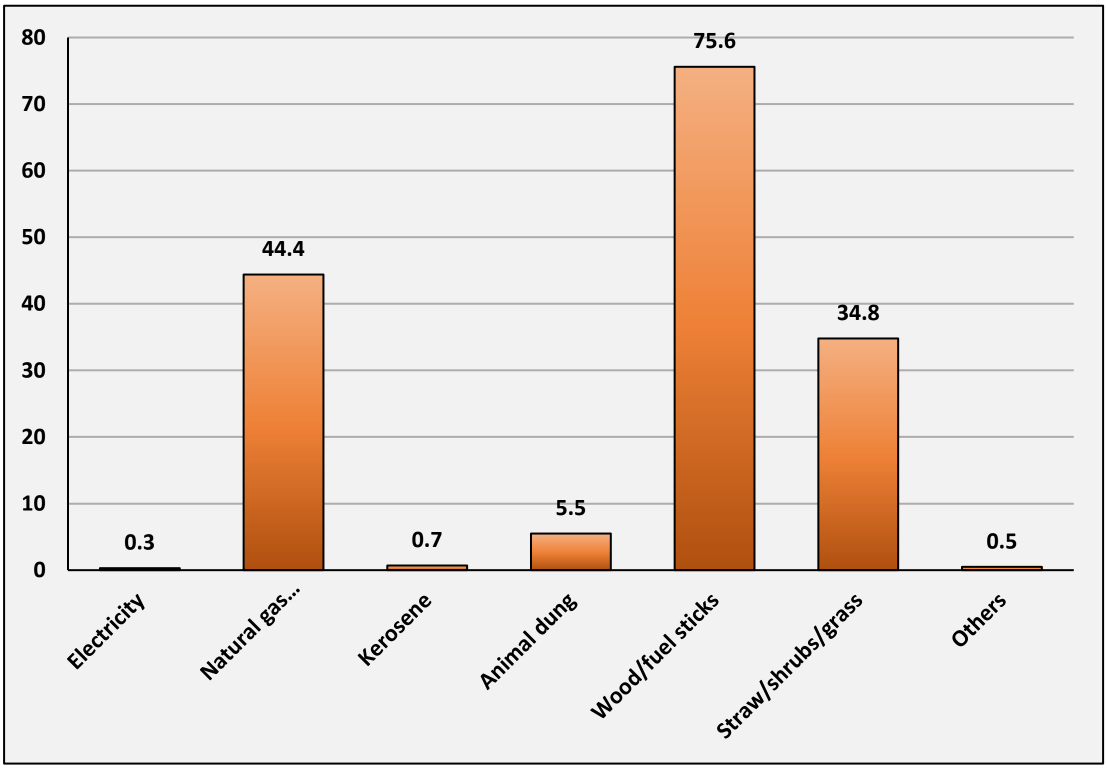


Figure 5.18: Power sources for lighting and electronics among studied households (%)

5.12.3 Household Toilet facilities

Toilet facility is different for the different age group (adult and child) in Bangladesh. Therefore, the results have been discussed under the following headlines below-

5.12.3.a Toilet facility for adult

Flush or pour-flush to piped sewer systems, septic tanks, or pit latrines, ventilated improved pit latrines, pit latrines with slabs, and composting toilets are examples of enhanced sanitation facilities. Therefore, the survey results show that the practice of improved sanitation by the adults of the studied household documented as flush to the septic tank (34.1%), pit latrine with slab (26.6%), flush to pit latrine (14.7%), and ventilated improved pit latrine (6.8%). Unimproved sanitation facilities such as open pit (3.1%), hanging toilet (13.9%), and open defecation (0.8%) were also reported in very considerable frequency among the surveyed household (Figure 5.19; Appendix table B20). According to MICS report 2019, use of improved sanitation by the households at the national level and in Dhaka were documented as- septic tank 22.8 and 18.3 percent; pit latrine with slab 36.4 and 25.3 percent; flash to pit latrine 17.1 and 15.3 percent; ventilated improved pit latrine 1.0 percent and 1.1 percent. Similarly, unimproved sanitation is recorded as 8.3 nationally and 6.4 percent in Dhaka; hanging toilet 2.5 percent nationally and 1.4 percent in Dhaka; the practice of open defecation 1.5 percent and 0.2 percent in Dhaka.

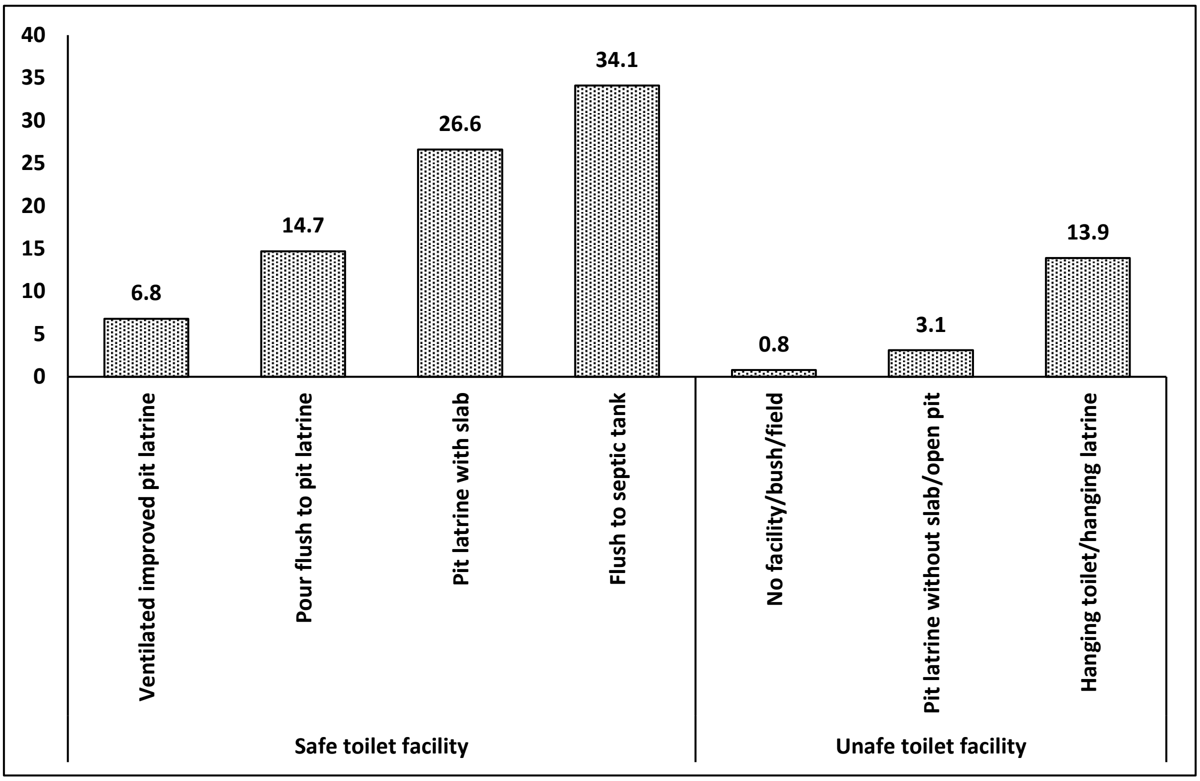


Figure 5.19: Toilet facilities for adult in the studied households (%)

5.12.3.b Disposal of child's faecal wastes

Appropriate methods for disposing of the stool include the child is using a toilet or latrine and putting or rinsing the stool into a toilet or latrine (MICS, 2019). Whiles in 18 percent cases child's wastes were recoded to dispose of in the toilet, which is quite safe, but 4.4 percent dispose of it to open ground/bush, 4 percent dispose in pond/river and rest 0.3 percent dispose of it to drain, dustbin, under the mud, etc. places. Such disposal practices especially in an urban area not only pollute the environment but also increase the risk of disease occurrence (Figure 5.20; Appendix table B21). Whereas at the national level disposal of child's faeces is documented as, 23.8 percent households put/rinsed into toilet or latrine, 12 percent left in the open space, and 35.9 percent put/rinsed into drain or ditch (MICS, 2019).

Even though just 3.9 percent of the population practices open defecation nationally (and only 1.4 percent in urban areas), more than half of the population uses better sanitation facilities that are not shared. Only a little more than a third of the population (38.7% nationally, 60.2 percent in urban areas) disposes of kid faeces properly, and only approximately two out of every five households do so, despite the consequences of sickness and mortality among children (UNICEF, 2020).

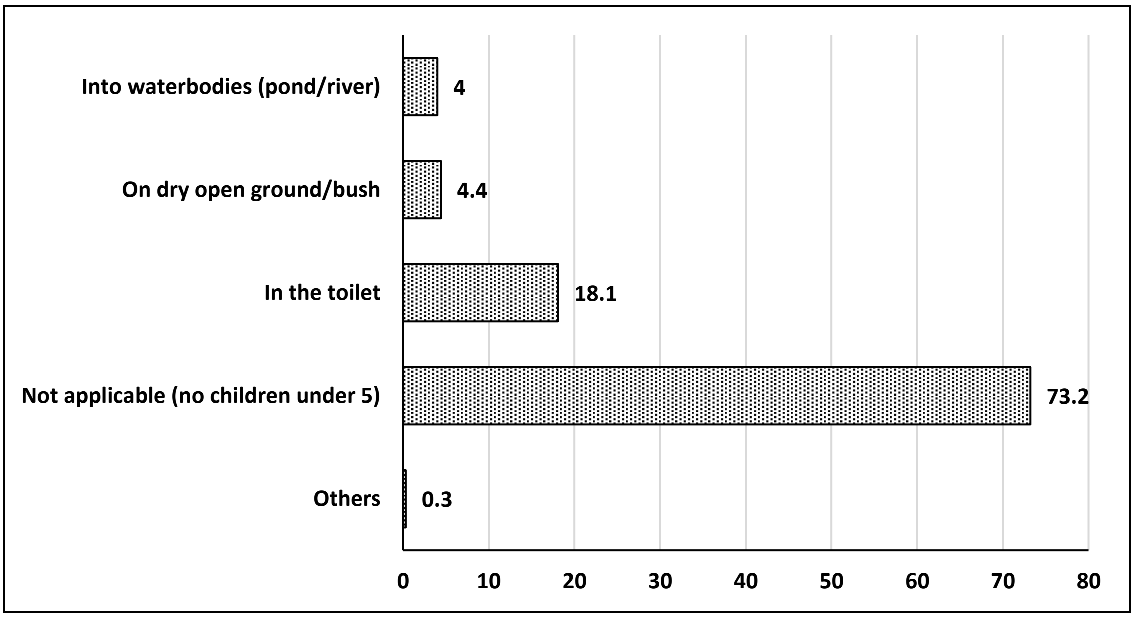


Figure 5.20: Place of disposal of child's faeces (%) by the respondent households

5.12.4.c Mean number of persons per toilet used

It has been revealed that 45.7 percent of households have their separate toilet whereas 54.3 percent of them use shared toilet facility (Figure 5.21; Appendix table B22). In 26.6 percent of cases the same toilet is used by one to four households, in 12.9 percent of cases toilet is shared by five to ten households and the percent of the shared toilet using by more than ten households is 14.8 (Figure 5.22; Appendix table B22).

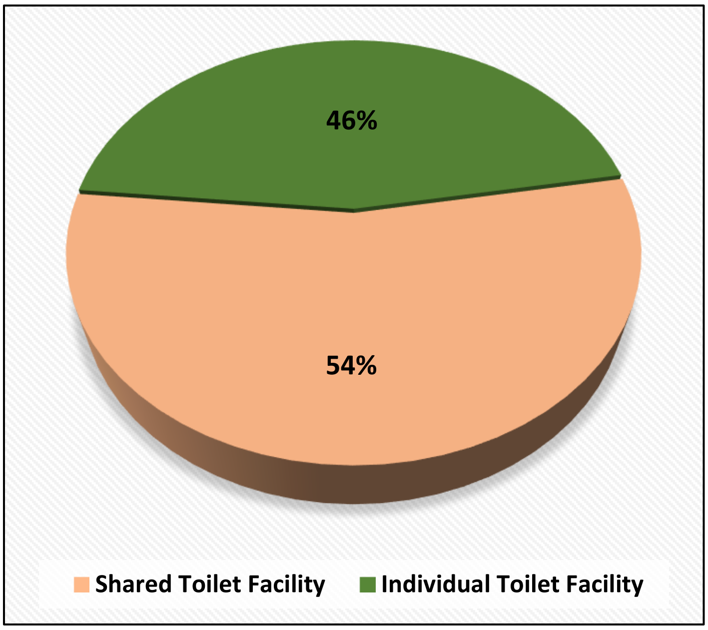


Figure 5.21: Households with and without shared toilet facility

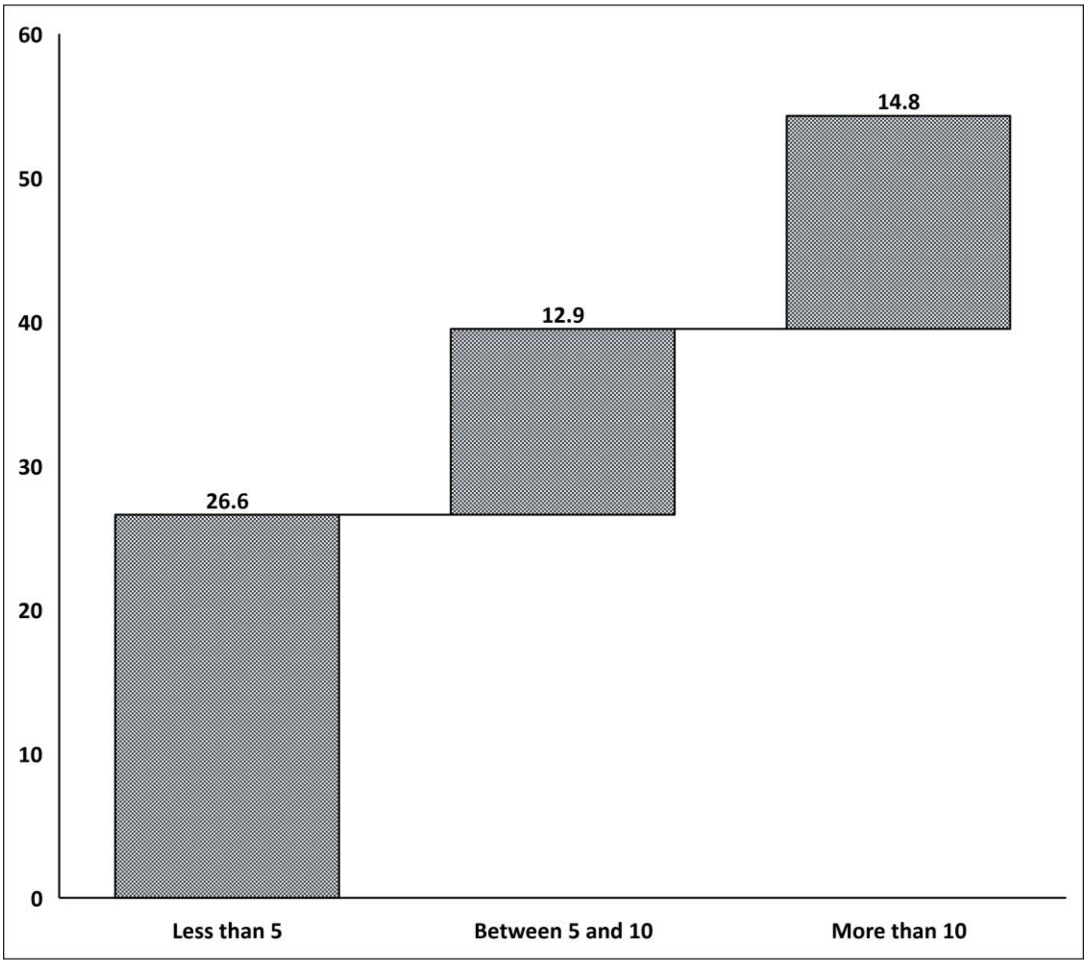


Figure 5.22: Share toilet facility of responded households (%)

Chapter 6: Urban Water: Available Sources, Usage's Pattern and Related Issues

More than 15 million people live in Dhaka city, with 35 percent of them living in slums/squatter settlements, equating to nearly a billion people in poor nations who do not have access to clean and sustainable water (Hunter et al., 2010). The average user to water-point ratio in Dhaka's slums is 1000:1. (ADB, 2016). For its growing population, the Dhaka WASA is struggling a lot to support this huge population to supply safe water. Nevertheless, government initiatives to support urban water-poor are noticeable which includes establishing water standpoint where local people can collect water twice a day, water supply to a certain point with people of water need by tanker truck, etc.

This chapter mainly highlighted available sources of water community use for drinking and other domestic purposes usage pattern and other related issues under the following headings-

6.1 Objectives

The main objectives are listed as-

i. To find out available drinking and domestic water sources in the survey areas;
ii. To find out seasonal variation of water usages;
iii. To find out the reasons for shifting from primary to secondary sources of water;
iv. To explore the challenges faced by the people of switching from primary to secondary sources of water;
v. To find out the ownership of water resources;
vi. To reveal the payment means or tariff system of water sources;
vii. To know about community concerns regarding water sources and other related issues.

6.2 Methodology

This study includes both quantitative and qualitative sources of data. The quantitative data collection includes a semi-structured questionnaire survey across twelve sites along the Turag River area. Qualitative data collection includes six FGDs and twelve KIIs in selected sites of the Turag River area (***more details are discussed in Chapter three of Methodology***).

6.3 Findings

The study findings revealed various primary and secondary sources of water for drinking and domestic purposes at the community level with other related issues which has been presented and discussed under the following headings-

6.3.1 Sources of drinking water

The study findings show that most of the surveyed households (97%) are depended on only one water sources, where 2.5 percent of households collected water from two different water sources, 0.3 percent collected water from three different sources and only 0.1 percent collected water from four different sources (Appendix table C1). Details of different sources of water are discussed below-

6.3.1.i Available and main sources of drinking water

Thirteen available sources of drinking water had been identified during the survey. Electric (motorized) tube well locally called submersible tube well are used by a maximum of 73.8 percent of respondents (Figure 6.1; Photograph 2a & 2b). Two other major sources of water among the surveyed communities are pipe connection into the yard (16.7%) and dwelling (4.5%) (Photograph 2c). Other available sources of drinking water include deep and shallow tube well (2.6%) and public tap water (2.1%) (Photograph 2d). On the contrary, study findings also revealed that a notable percentage (2.8%) of the survey population also depended on open sources (Photograph 2e) of water (rainwater, river, lake, pond, etc.) for drinking purposes. Other water sources (0.7%) include another household's water sources, compressor pumps, madrasas submersible, brickfield, etc. (Figure 6.1; Appendix table C2).

Therefore, the study findings indicate that personal, community-level, or cluster installed electric tube well (locally called submersible pump) remain the main source of water for the studied community (Figure 6.1). As total coverage has yet not been achieved in the studied areas, only 23.3 percent of responding households have access to WASA supplied water in the form of tap water into the yard or dwellings and a standpipe in the public arrangement (Figure 6.1).

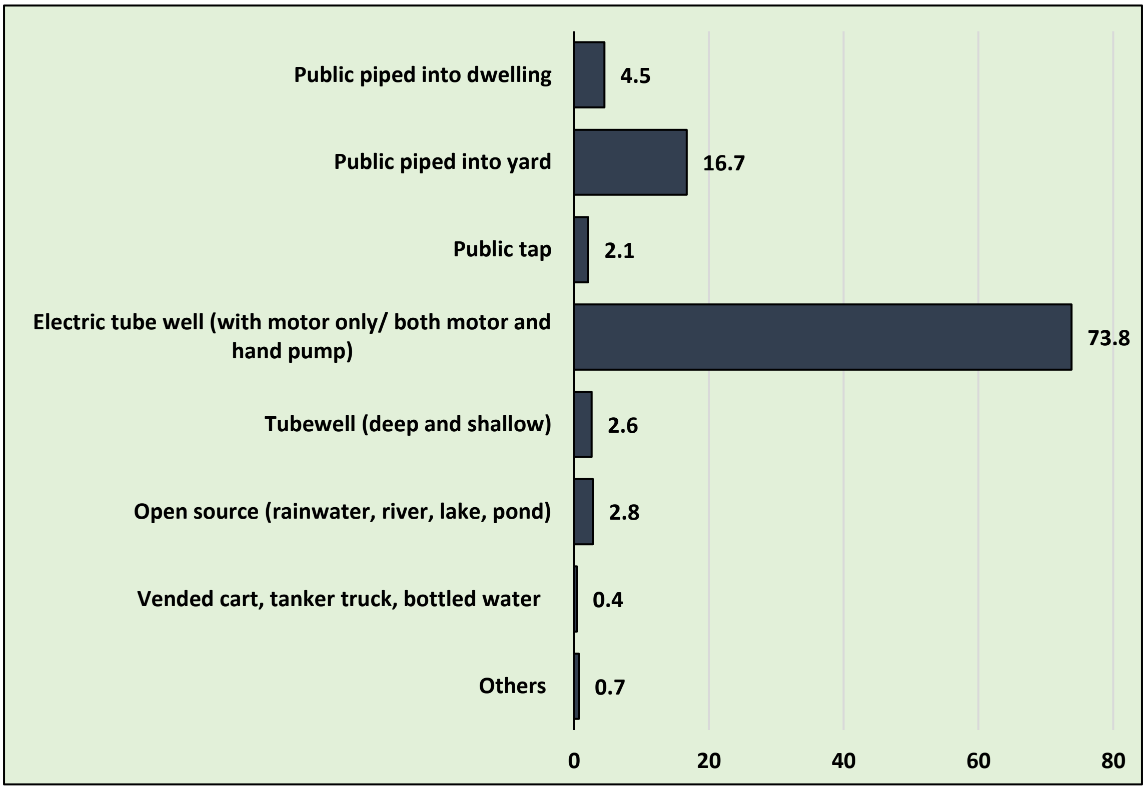


Figure 6.1: Available drinking water sources (%) of the studied communities

Data on same available sources of drinking water according to MICS report 2019 represent public piped into dwelling 5.4 percent nationally and 21.4 percent in the urban area; public piped into yard 4.7 percent nationally and 12.2 percent in urban areas; public tap/standpipe 1.2 percent nationally and 3.9 percent in urban areas; electric tube well/borehole 85.6 nationally and 92.6 in the urban area; the percentage of uses rainwater 0.4 percent in the national wise and 0.2 percent in the urban area; cart with small tank 0.1 percent nationally and 0.2 percent in urban; bottled water 0.3 and 1.3 where the use of surface water 0.9 and 0.3 percent nationally and in the urban area. Therefore, the percentage of using improved sources of drinking water in Bangladesh is 98.5.

While 97 percent (n=1772) of survey households have their fixed main sources of water, 3.0 percent (n=54) do not have any fixed water sources rather depends on two or more water sources that seem more accessible to them (Appendix table C1). Table 6.1 shows that those who did not have their fixed sources mainly collect water for drinking from electric/motor tube well owned by other households (2.2%), deep and shallow tube well (0.3%), public standpoint (0.1%), pond (0.1%) and others (Appendix table C4).

Table 6.1: Households having non-fixed main drinking water sources (%)

Main sources of water	Frequency	Percent
	n	%
Fixed sources		
Sub-total	***1772***	***97.0***
Non-fixed sources		
Piped into yard	3	0.2
Pond	2	0.1
Public tap	1	0.1
Deep tube well	4	0.2
Motor tube well	40	2.2
Shallow tube well	2	0.1
Vended truck	2	0.1
Subtotal	***54***	***3.0***
Total	**1826**	**100.0**

Source: HH Survey, 2017-18

Findings from FGD's and KII's (Appendix table D1) has identified the followings available water sources from where the surveyed communities collect water for their daily needs-

- Submersible pump with 5000-liter tank installed by NGO i.e., CARE Bangladesh, VERC, C & A Foundation, etc.
- Submersible pump with 1000-liter tank provided by Government through Gazipur City Corporation
- Brickfield (owned by Brickfield owners)
- Submersible/Motor pump provided by Gazipur City Corporation
- Submersible/Motor pump: Personal/Individual
- Deep tube wells: Self/Landlord
- Nearby mosque, office
- Turag River

6.3.1.ii Site-wise distribution of available sources of water

Motorized tube well remains the main sources of water in Konabari (11.6%), Bhadam (10.7%), Ichharkandi (8.65%), Mausaid (7.4%), Abdullahpur (6.7%), Kashimpur (6.3%), Palasana (6.0%), and Gutia (5.5%). However, despite being motorized tube well the key source of drinking water for most of the communities, piped water into the yard was documented as the main sources of drinking water in Kathaldia, Rashadia, and Gusulia with a percentage of 5.3, 3.5, and 1.9 respectively (Appendix table C3). Open sources of water as a river, pond, lake, and rainwater as drinking water sources remain prominent in Ichharkandi and Palasana

(Appendix table C3). A very notable finding is that in its worst they even collect (2.8%) open sources (rainwater, river, lake, pond, etc.) of water for drinking purposes (Appendix table C3).

6.3.1.iii Secondary or alternative sources of drinking water

As the community mainly dependent on primary sources of water but due to reasons like easier access (2.1%), while infrastructure is not working (0.1%), during the time of new infrastructure installation (0.1%), unreliable supply (0.3%), not getting enough water (0.1%) with alternative sources having a better quality of water (0.1%) and comparatively better taste/smell/colour (0.1%) and cheap tariff (0.1%) influence them to shift from main to alternative sources (Appendix table C5). An interesting finding is community usage of river/canal (0.9%), lake (0.1%), and pond (1.2%) water is highest as the alternative source despite having unavailability of main sources of water (Figure 6.2; Appendix table C4). The survey also revealed that the majority of the households (2.2%) had been using this secondary sources for more than two months (Appendix table C6).

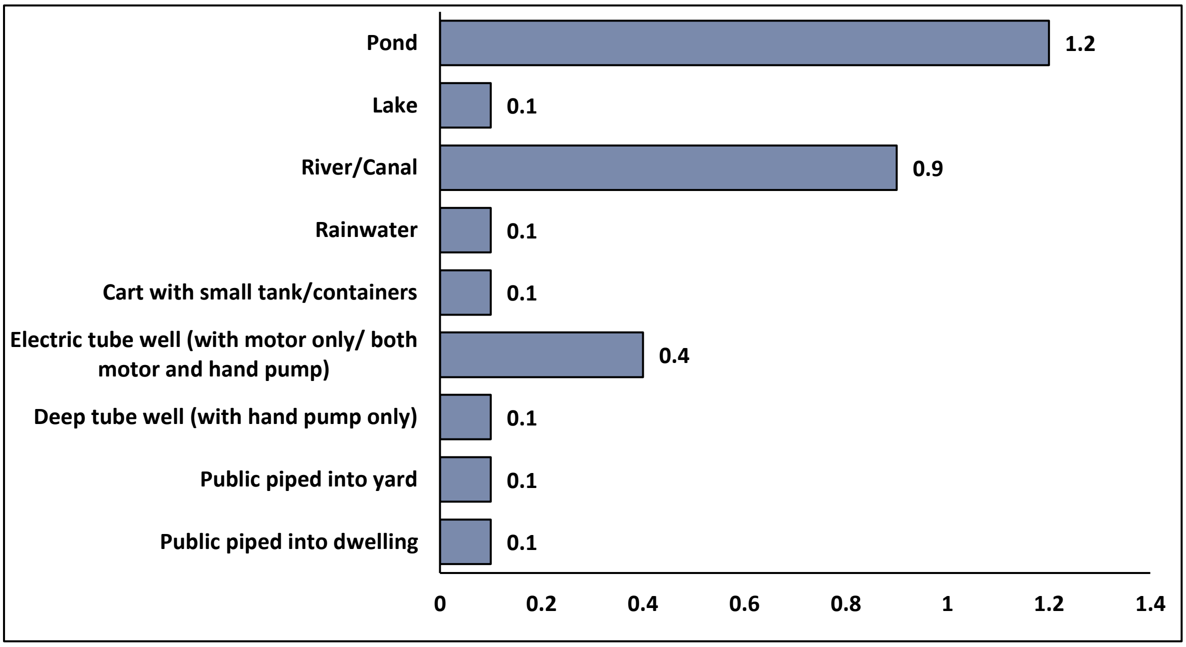


Figure 6.2: Secondary sources (%) of drinking water

6.3.1.iv Challenges faced due to switching from main sources to secondary sources

Among 3.0 percent (n=54) of respondent households using secondary sources of water (Appendix table C4), most of the respondents (1.6%) stated that they did not face any challenges while collecting water from secondary sources. Yet, there are some challenges they faced as more effort and time spent by women in collecting water (0.5%), poor water quality (0.3%), high costs (0.2%), felt uncomfortable in using someone else's source (0.2%), etc. (Appendix table C7).

6.3.1.v Ownership of water sources

Among 1826 households surveyed, most do not have their water sources (58.9%) and only 41.1 percent own deep, shallow, and electric tube wells (Table 6.2). Data on ownership of water resources has shown that 29.8 percent household has their electric tube well, 1.1 percent have their deep tube well facilities and 0.5 percent have shallow tube well of their own (Table 6.2). On the other hand, a total of 38.1 percent households has completely dependent on another unrelated family as a neighbour, landlord for their drinking water source. Tube wells of their other extended family also remains a key source (11.8%) of drinking water (Table 6.2). Collective (2.4%) and public (4.4%) water points are other sources of drinking water for the studied communities.

Table 6.2: Ownership of deep, shallow, and motorized water supplies

Ownership of water source	**Deep tube well**		**Shallow tube well**		**Electric tube well**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Own immediate family	20	1.1	9	0.5	545	29.8	574	41.1
Extended family (cousin, brother, etc.)	2	0.1	1	0.1	162	8.9	165	11.8
Another unrelated family (neighbour, landlord)	12	0.7	1	0.1	519	28.4	532	38.1
Group of families (collective)	2	0.1			32	1.8	34	2.4
Community/government (public)					62	3.4	62	4.4
Others	1	0.1			28	1.5	29	2.1
Total	**37**	**2.0**	**11**	**0.6**	**1348**	**73.8**	**1396**	**100**

Source: HH Survey, 2017-18

6.3.1.vi Sharing of water sources with other households

The study also showed that 70 percent of households (n=1279) have collected their water from shared sources whereas 30 percent (n=547) of households (Figure 6.3; Appendix table C8) have their water supplies and do not share by any other. 28.8 percent (n=526) of the households share water source with one to four families, 17.3 percent of households (n=315) share it with five to ten families and 24 percent (n=438) are with more than ten families (Figure 6.4; Appendix table C8).

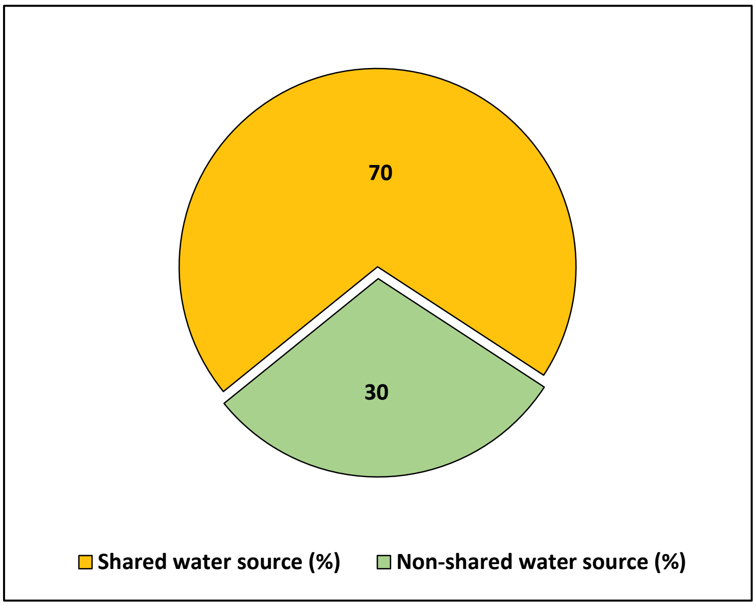


Figure 6.3: Households (%) with shared water source

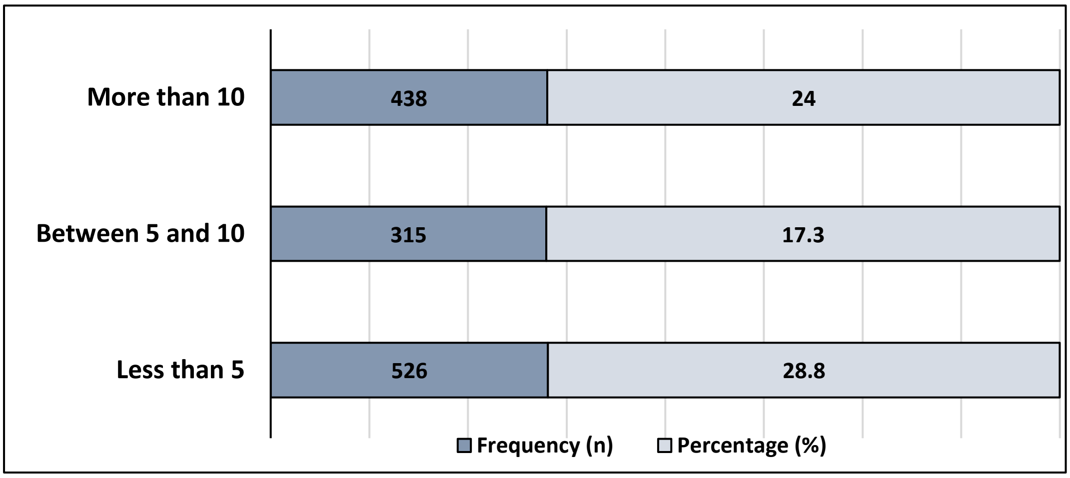


Figure 6.4: Water sources sharing with other households (%)

6.3.2 Sources of water for domestic uses and seasonal variation

6.3.2.i Sources of water for cooking or food preparation, washing clothes or dishes, and bathing

Personal, community-level, or cluster installed electric tube well (locally called submersible pumps) are found to be the main sources of water for the use of domestic purposes in the studied communities (Appendix table C9). Likewise drinking water sources public piped into the dwellings and yard and public tap water remains highest for use in cooking, washing, and bathing. Study findings also revealed that a large percentage of people depend on river/canal, lake, pond, and pond water for various washing purposes and bathing and sometimes for cooking (Appendix table C9).

6.3.2.ii Seasonal variation of water use by sources

Changes of water sources with the season for other domestic uses (cooking, dish and cloth washing, and bathing) were also identified and presented in Table 6.3. Also, variation was not observed in water use during the wet and dry seasons except that the dependency on the river, canal, pond, and rainwater for various domestic purposes remain higher during dry periods than in the wet season (Appendix table C9). Reasons behind such type of variation can be identified as during the dry season groundwater level become lower and thereby, intensify the scarcity of safe water; therefore, need more power supply to draw it out but due to interrupted electricity supply its hampered water production and costs of groundwater extraction are estimated to rise more than proportionally as groundwater continues to deplete (Shamsudduha et al., 2019). All these causes do not fulfil community water demand and thereby forcing a certain group to meet their water need from open sources.

Table 6.3: Variation or changes (%) of domestic water use with seasons

	Cooking		**% Changes**	**Washing Clothes and Dishes**		**% Changes**	**Bathing**		**% Changes**
	Wet	**Dry**		**Wet**	**Dry**		**Wet**	**Dry**	
	n	**n**		**n**	**n**		**n**	**n**	
Public piped into dwelling	68	68	0.0	67	64	4.5	68	64	5.9
Public piped into yard	316	312	1.3	303	297	2.0	299	292	2.3
Public tap	40	40	0.0	35	37	-5.7	38	37	2.6
Deep tube well	32	32	0.0	32	32	0.0	30	29	3.3
Shallow tube well	14	10	28.6	11	10	9.1	11	13	-18.2
Electric tube well	1348	1343	0.4	1291	1265	2.0	1275	1247	2.2
Rainwater	2	**15**	-650.0	5	**32**	-540.0	1	**25**	-2400.0
Tanker truck	3	3	0.0	3	3	0.0	3	3	0.0
Cart with small tank/containers	1	1	0.0	1	1	0.0	1	2	-100.0
Bottled water	1	0	100.0	1	1	0.0	0	1	0.0
River/Canal	**8**	**27**	-237.5	**113**	**342**	-202.7	**134**	**400**	-198.5
Lake	2	2	0.0	10	11	-10.0	8	10	-25.0
Pond	4	5	-25.0	**98**	**100**	-2.0	**108**	**110**	-1.9
Others	4	5	-25.0	6	6	0.0	6	6	0.0

Source: HH Survey, 2017-18

Photograph 2a: Electric tube well/borehole with tap (Private installation)

Photograph 2b: Electric tube well/borehole with tap (Group or community installation)

Photograph 2c: Pipe connection with multiple points for community uses

Photograph 2d: Standpoint for community uses

Photograph 2e: River water for use of various domestic purposes

6.3.3 Payment structure of water sources

6.3.3.i Mode of payment

It has been revealed that only 37.8 percent of households (n=690) among 1826 surveyed made payment for their main water sources (Appendix table C10). Only 9.6 percent of payments are made directly into the utility office or to the tariff collector (Appendix table C10). A large percent (15.2%) of them have paid it to the place where water is fetched from or delivered to. In 12.2 percent of cases, water cost is included with their house rent. Some others (0.8%) paid it to the political leader, relative or neighbour, mosque committee, commissioner, tube well owner, etc. (Appendix table C11).

Regarding secondary sources of water users with a percentage of only 3, there is usually no payment system (2.7%) though a very minor percentage (0.3%) were encountered who paid from where water is fetched (Appendix table C10).

Except for the above payment's methods findings of FGDs and KIIs (Appendix table D1) on payment methods of some communities have been listed as follows-

- NGO (Care Bangladesh, VERC, C & A Foundation) = 50 taka monthly
- Government (Gazipur City Corporation) = 30 taka monthly
- To set submersible: one lac taka

- Monthly cost included with electricity
- Included in house rent
- 3800 taka/month
- Monthly = 500 takas for submersible pump water (including electricity bill)
- Amount paid (per household) = 100 takas per month to the landlord

6.3.3.ii Frequency of payments and amounts paid for water

Mostly the payment is made monthly (37.4%) but in some instances, payments have to be made per container (0.4%) of water (Appendix table C10). The minimum 50 or less taka for water has been spent by 2.8 percent of households with the mean±SD of 41.8±9.4 (Figure 6.5; Appendix table C12). The highest percentage of respondent's households (12.2%) spent 51 to 100 takas (mean±SD=86.1±13.1) monthly was the lowest percentage of households (0.7%) spent 1100 to 1700 takas (mean±SD=1381.8±204) monthly as water tariff (Figure 6.5). On average the respondent households had to pay 296±530.7 taka per month as water cost.

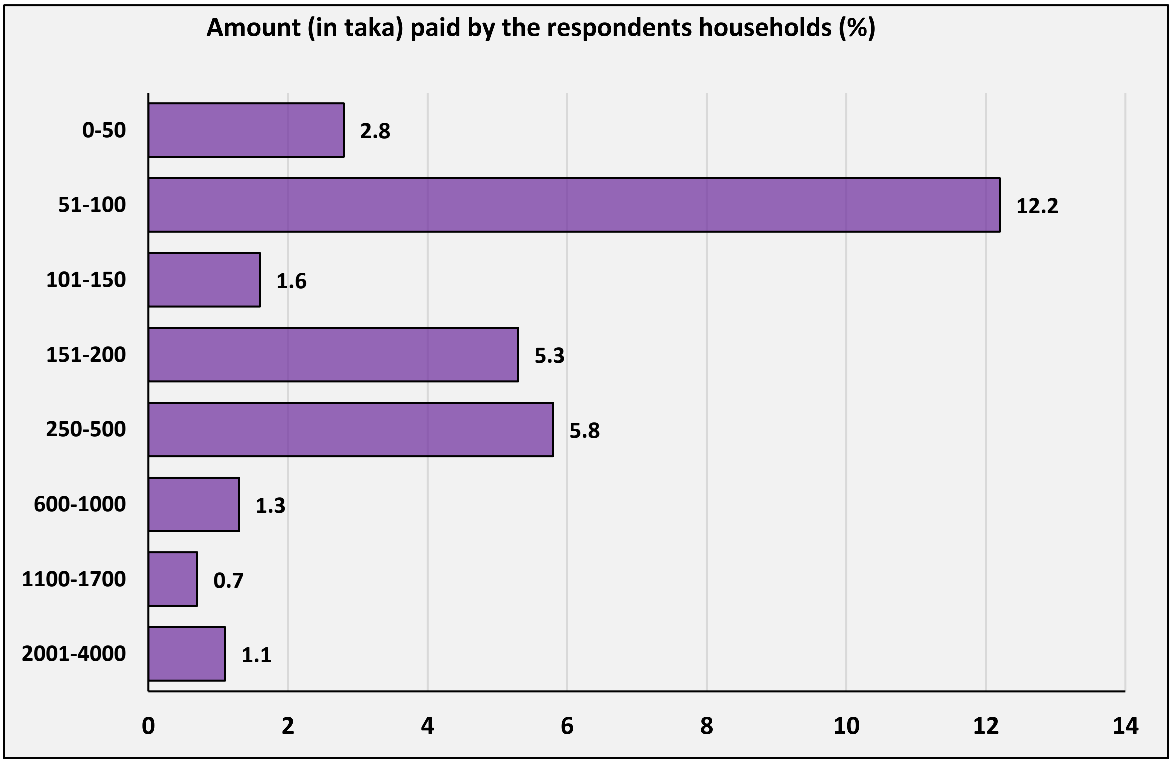


Figure 6.5: Amounts paid for the main sources by the households (%)

Regarding the cost of secondary sources of water users usually had to pay 50-170 taka but in its extreme, they might have to pay up to a maximum of Tk. 700 (Appendix table C12) on monthly basis (Appendix table C10). These secondary sources of water sometimes cost high with low water quality added by the respondents.

6.3.4 Drinking water Interventions, Installations, and Maintenance

As in Bangladesh a developing country, unfortunately, many water supply interventions do not last (Schouten et al., 2003). This section is about any development interventions that have undertaken by the government, private sector, institutions, or CBO's or by the households those have improved drinking water source in the past five years at the communities studied under the following headings-

6.3.4.i Development intervention by the Government, Private sector, Institutions, or CBO's

Households (10.7%) had positive statements regarding government, private sector, institutions, or CBO's interventions to improve the drinking water in the past five years in the areas studied. Their mentioned or agreed interventions to improve their water services are the installation of the piped water system (9.2%), installation of hand pump (0.8%), expansion of vending water service (0.3%), and various other interventions either by the Govt. or by the private sector or by different institutions, or CBO's (Figure 6.6; Appendix table C13).

6.3.4.ii Installation of water infrastructure by the households for private use

In the last five years, only 22 percent of respondent households install new water-related infrastructure for their private use (Appendix table C13) where 13.7 percent of households installed new deep tube well, 5.2 percent new shallow tube well, 1.9 percent add storage tank to existing tube well, and 1.2 percent installed electric/diesel motor to existing tube well (Figure 6.6; Appendix table C13).

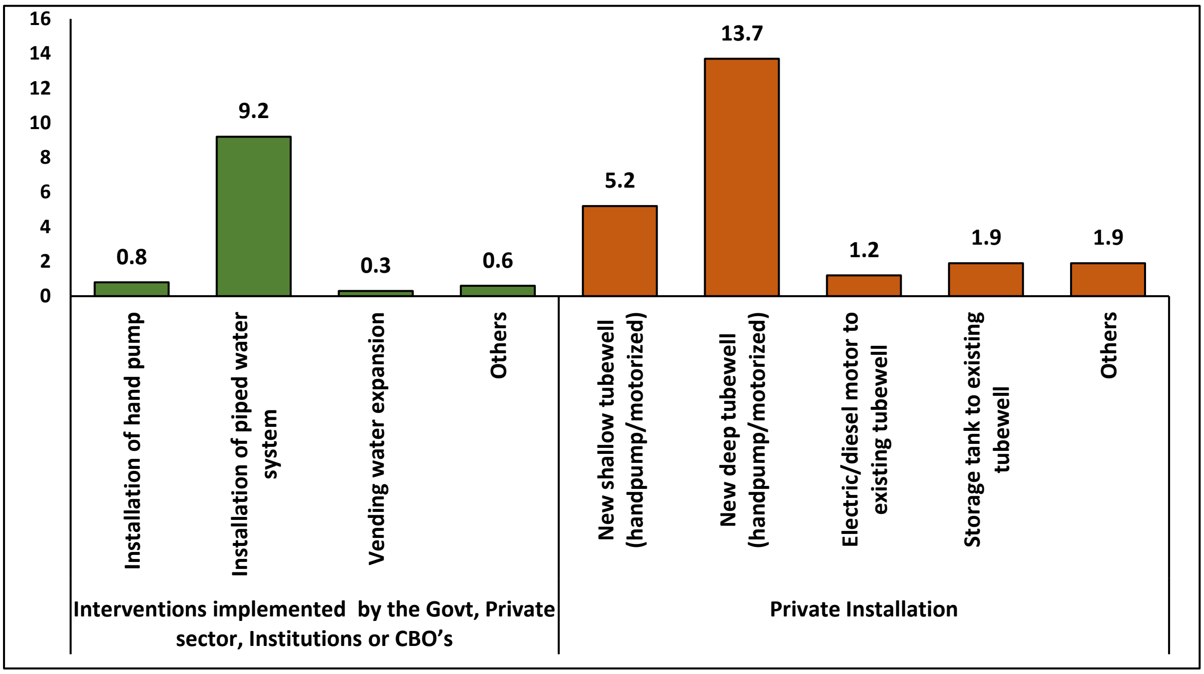


Figure 6.6: Drinking water interventions and installations (%)

6.3.4.iii Installation costs of water infrastructure by the households

In Table 6.2, among the households documented it is seen that only 41.1 percent had their own water resources. While inquiring about the cost of installation of private infrastructure only 19.9 percent had responded of which 2.1 percent had no idea about the costing of new infrastructure installation (Table 6.4). From the survey, it has been found that the households spent 300 takas to more than 150000 takas for installing new water infrastructure. The highest 4.4 percent had been recorded to spent 100001-150000 takas (mean±SD=135133.3±13387.5) and 30001-40000 taka (mean±SD=36756.8±2722.4) by 2.1 percent of respondent households. The lowest 300-5000 taka had been documented to spend by 1.9 percent of households with the mean±SD value of 3171.9±1805.4 (Table 6.4). On average the respondent households (19.9%) were seen to spent 66081±85905.7 (mean±SD) takas to install water infrastructure. Policies aimed at improving infrastructure are required to enhance not just access to water, but also safe and reliable access to water, or risk losing the health benefits of having a local water supply (Caldwell et al., 2003).

Table 6.4: Installation cost of water-related infrastructure

Installation costing of water infrastructure	Range in taka	Frequency n	Percentage %	Mean±SD
Main Water Sources	300-5000	32	1.9	3171.9±1805.4
	5001-10000	26	1.5	7769.2±1674.7
	10001-15000	16	0.9	13093.8±1551.5
	15001-20000	20	1.2	18925±1471.4
	20001-25000	24	1.4	24041.7±1545.8
	25001-30000	29	1.7	29413.8±1350.1
	30001-40000	37	2.1	36756.8±2722.4
	40001-50000	21	1.1	49047.6±2011.9
	50001-60000	14	0.9	58928.6±2730.6
	60001-70000	23	1.4	68130.4±2473.6
	70001-80000	9	**0.5**	78888.9±2204.8
	80001-100000	29	1.6	96379.3±5327.9
	100001-150000	75	**4.4**	135133.3±13387.5
	150001>	9	0.6	367777.8±359575.4
	Subtotal	**364**	**19.9**	**66081±85905.7**
	Do not know (999)	38	2.1	----
	Missing system	1424	78.0	----
	Total	1826	100.0	----

Source: HH Survey, 2017-18

6.3.4.iv Maintenance or repair of the water sources

Survey communities were also asked if they or anyone else did any maintenance or repairs to the water source which could involve replacing screws, rods, washers, buckets, pipes, handles, base platform, or electric parts of the pump motor in the past twelve months. In response, only 14.3 percent (n=261) did some repairs or maintenance work of their water infrastructure in the last twelve months (Appendix table C14). Among the respondents (n=261), only 10.5 percent (n=191) were aware or informed about the repairing cost while 3.8 percent (n=70) had no idea about it (Appendix table C14).

Regarding maintenance or repair costs, households had to spend the lowest 20 takas to the highest 50000 takas (Figure 6.7; Appendix table C14) with average spending of 6709.5±8801.4 (Appendix table C14). 1001 to 2000 takas (mean±SD=1733.3±304.4) by the maximum number of (1.7%) households followed by 2001 to 3000 takas (mean±SD=2817.9±258.3) by 1.6 percent, 5001 to 10000 takas (mean±SD=8267.9±1658.2) by 1.5 percent and 20 to 500 takas (mean±SD=297.1±168.1) by 1.5 percent of households (Figure 6.7; Appendix table C14).

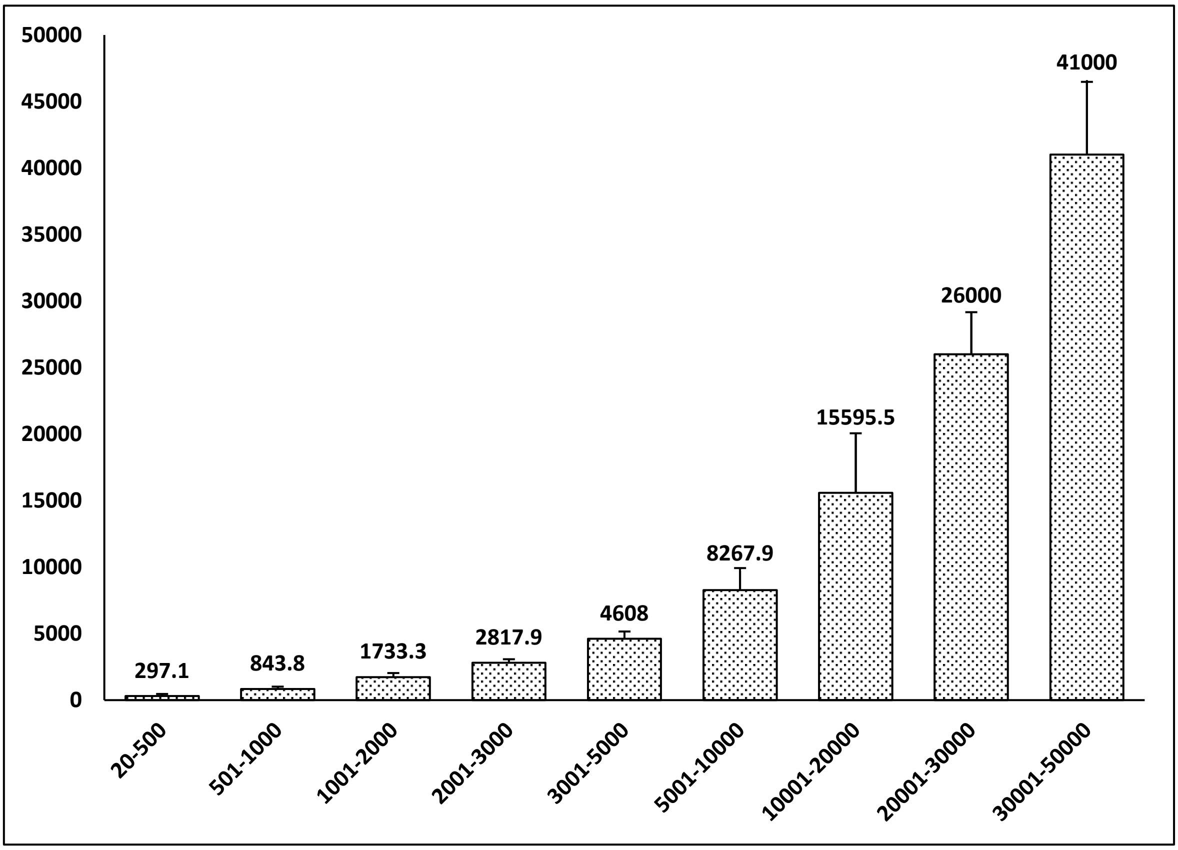


Figure 6.7: Maintenance or repair cost of water sources (mean±SD)

6.3.5 Concerns regarding the water community drink and use for domestic purposes

Communities' concerns regarding the water they drink and use for domestic purposes were also asked (Appendix table C15 & C16), majority 18.4 percent (n=336) people stated negatively of having any concerns regarding the water. The main concerns regarding water of the communities include- unpredictable water supply (13.5%), not enough water (8.4%), the distance of water sources (7.9%), dirty water (6.9%), costs of water (6.5%), unsafe drinking water (6.4%), etc. (Figure 6.8). Except that of the above-mentioned concerns, there are some other concerns (5.8%) as the water source is not enough, supply not reliable, high maintenance cost, depends on others water sources as they do not have their own or unable to install own tube well and so on (Appendix table C16).

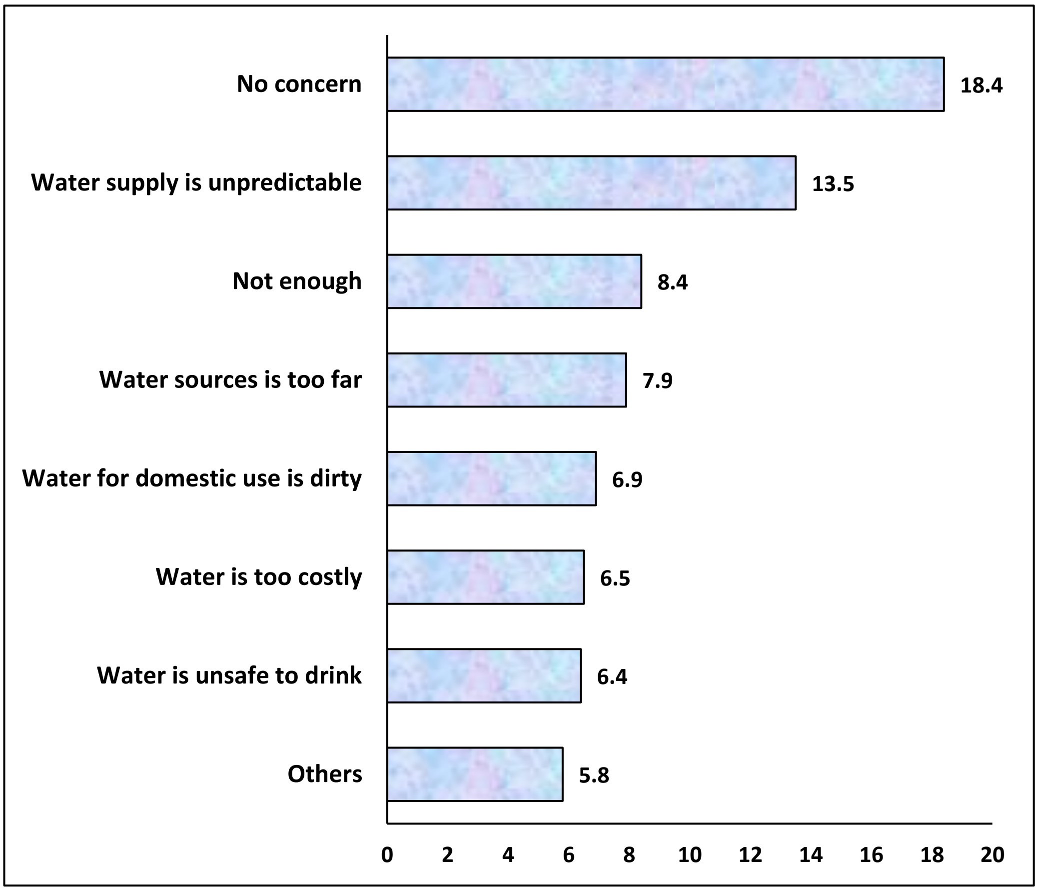


Figure 6.8: Community concerns (%) regarding water they drink and use for domestic purposes

Chapter 7: The Turag River: Uses, Water Quality and Welfare Change Over Time

This portion is completely devoted to the purposes of the Turag River's water usage by the dependent population, as well as gender dominance in the Turag River's interaction. It also discusses how changing water quality in the Turag River affects community welfare over time. Data from two selected sites in the Turag catchment area was collected using the water use behaviour survey. The current study focuses on the use, exposure, risks, and vulnerabilities of different urban vulnerable communities in their interactions with the river Turag's surrounding water.

7.1 Introduction

River is one of the important sources of water (Islam et al., 2015), and recognized civilization grows in the vicinity of the river (Balasankar & Nagarajan, 2000; Ahmed et al., 2016). Cities may be traced back to Mesopotamia, Egypt, the Indus Valley, and China's river valley civilizations. Originally, these communities relied heavily on agriculture, but as the population grew, the city's size grew, and economic activity shifted to commerce (Ramachandra et al., 2014). River basins are typically densely populated places due to advantageous living circumstances such as the availability of arable lands, water for irrigation, industrial, and drinking uses, and efficient transportation (Vega et al., 1998). However, according to recent research, 41 percent of the world's population lives in river basins that are water stressed (Mallick, 2012).

In the 1970s with the birth of independent Bangladesh, its population only consisted of less than 25 percent (Jack, 2006) even, so it is projected to be 44.3 percent by 2030 (United Nations, 2002) due to a huge number of populations moving to rapidly increased urbanized cities and areas. Dhaka is the largest city and the financial, cultural, and business center of the country (Ahmed et al., 2007). With a combined size of roughly 10600 square kilometers, urban centers account for about 7 percent of Bangladesh's total land area (Wikipedia, 2021). The development of export-oriented manufacturing activities has created considerable demand for low and medium-skilled labor, especially for women, and resulting in an increasing number of urban populations. Most of the garment workers cannot afford good quality housing and have to live in unhealthy slum environments (Nakagami et al., 2014). They face challenges in accessing water and often do not have facilities of piped or tube well water like others thereby exposes to unsafe river water which can result in a wide range of challenges from skin diseases to an array of social problems (Nasreen, 2002).

At the beginning of the urbanization period of Bangladesh (1978), about 29 km^2 of rivers and canals and about 130.17 km^2 of wetlands were found in Dhaka city and its peripheral areas (Mahmud et al., 2011) though, by the end of 2009, only 10.28 km^2 of rivers and canals and 53.6 km^2 of wetland were found to exists which is about 21 percent of Dhaka metropolitan area (Mahmud et al., 2011). Dhaka is primarily surrounded by three rivers, Buriganga on the southwest, the Turag on the northwest, and the Balu on the north-east. These rivers providing water supply for domestic, industrial, and irrigation uses; also provide convenient means for navigation, transportation, and communication for the people (Tingsanchali, 2012) serving the reason to rise the industrial sector at its peak. As a result, all the rivers receive a huge amount of untreated industrial effluents and municipal waste through the three major canal systems and thus resulting in water quality parameters such as Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and pH to exceed the permissible limits of daily use. Moreover, the excess concentration of heavy metals including Al, Cd, Cr, Pb, and Hg confirm high chemical contamination of river water (IEE, 2014). However, despite the growing toxicity, the Turag remains central to many of the Bangladeshi citizens who frequently interact with the river for their livelihoods (Paul et al., 2013) and other domestic uses. In recent years, this interaction pattern has changed, unlike the previous period.

Therefore, the research aims to triangulate the inter-linkage of the environment (Turag River), pollution, and population welfare and to understand why members of the local community continue interacting with the river as perceived throughout the observations. This research will provide foundations for future study to find out welfare change as pollution continues to increase and will contribute to developing the theory of river use behavior in challenging urban contexts. This Risk-based research will be directed to support improved policy and practice on how urban river water security risks can be addressed at scale for the benefit of the poor.

7.2 Conceptual Framework of the Study

The present study tries to focus on the interaction of water users (people in different categories) with river water; how the nature of contact with river water having positive or negative impacts on people and ultimately the relationships with reduction or increase of vulnerabilities and poverty. The conceptual framework of the study is given below:

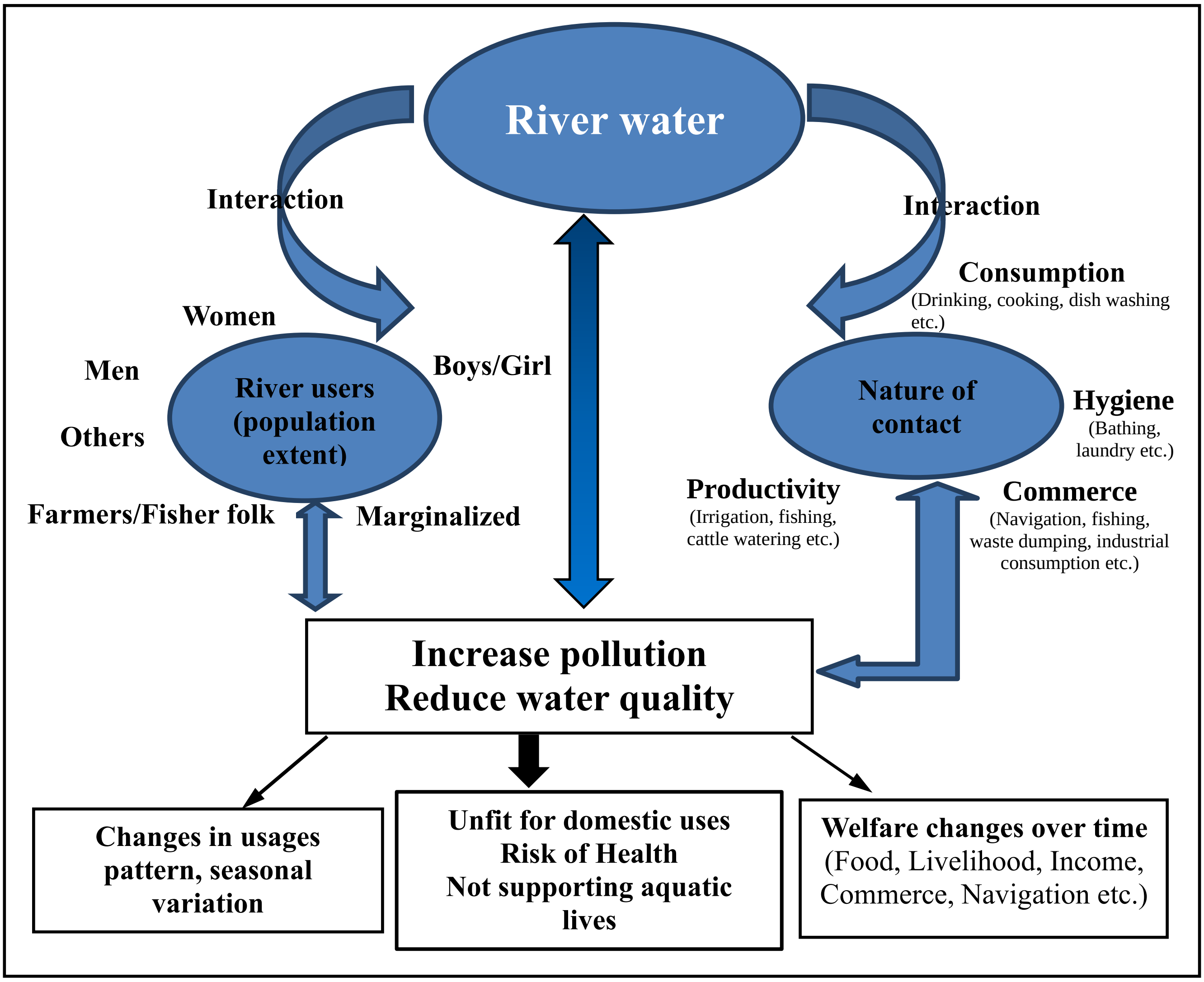


Figure 7.1: Showing the Conceptual Framework of the Study

7.3 Objectives of the Study

The study will mainly focus on the understanding risk of interacting river water. Therefore, the present section aims-

i. to understand how members of the local community interact with river water along with its variation in different sites at times;
ii. to find out gender-disaggregated interactions with Turag River; and
iii. to explain how changes in river water quality influence water use practices along with the Turag River system over time.

7.4 Methodology

This section of the study is completely based on a ***water use behaviour survey*** **(observation)** to find out the nature of interactions with the Turag River by the dependent community, therefore, it aims at capturing different water-uses (practices) along the Turag. Findings of ***FGDs and KIIs*** also give an important insight into the study. Moreover, ***HH survey*** data give information regarding demographic data, the percentage of people using the Turag River, their economic status, etc. Besides these river observational studies, research activities in the Dhaka observatory also include ***water quality*** research led by Prof. Abed Hossain (BUET) and Prof. Paul Whitehead (University of Oxford) to justify the statement that there are variations of interactions with Turag River water quality when it gets degraded. Again, ***reviewing relevant works of literature*** has also given more compact information and the authenticity of the study findings.

7.4.1 Research design

A water-use behavior survey or observations is the main technique of data collection in this study. Therefore, data collected through other methods are also applied to validate the findings of observations.

7.4.1.1 Water-use behavior observations

7.4.1.1.a Survey design

The research methodology employed in this study was primarily developed as a (i) proof-of-concept for larger-scale water use behavior studies and (ii) exploration of the daily interaction of nearby settlers with the Turag River. The findings from the literature review framed the structure and content of the second method: a water-use behavior survey. The study design is based on previous observation studies by Arturo Villanueva (MSc in WSPM, University of Oxford). Arturo’s study was conducted at four selected sites of Turag River namely- Dhour, Dighor, Taltola, and Kamarpara for 7 days in July 2016 whereas the present study involved an 8-day study in April 2018 at three sites along Turag River. This observation studies involved recording the gender and age disaggregated interactions with the river for 9-12 hours a day. Interactions were defined as consumption (drinking, cooking, water collection, and dish/food washing), hygiene (bathing, washing, laundry, and open defecation), amenities (property washing, and swimming/recreational activities), and productivity (navigation, fishing, livestock, irrigation, etc.). River users were categorized as children, adults, and elderly, as male and female, and as groups and individuals.

7.4.1.1.b Site selection

Once the survey design was completed, I began identifying potential sites where observations could take place along the Turag River. The areas were selected based on the diversity and number of human activities taking place along the river. The next step was selecting the specific sites from where observations would be documented. The criteria applied were aimed to ensure

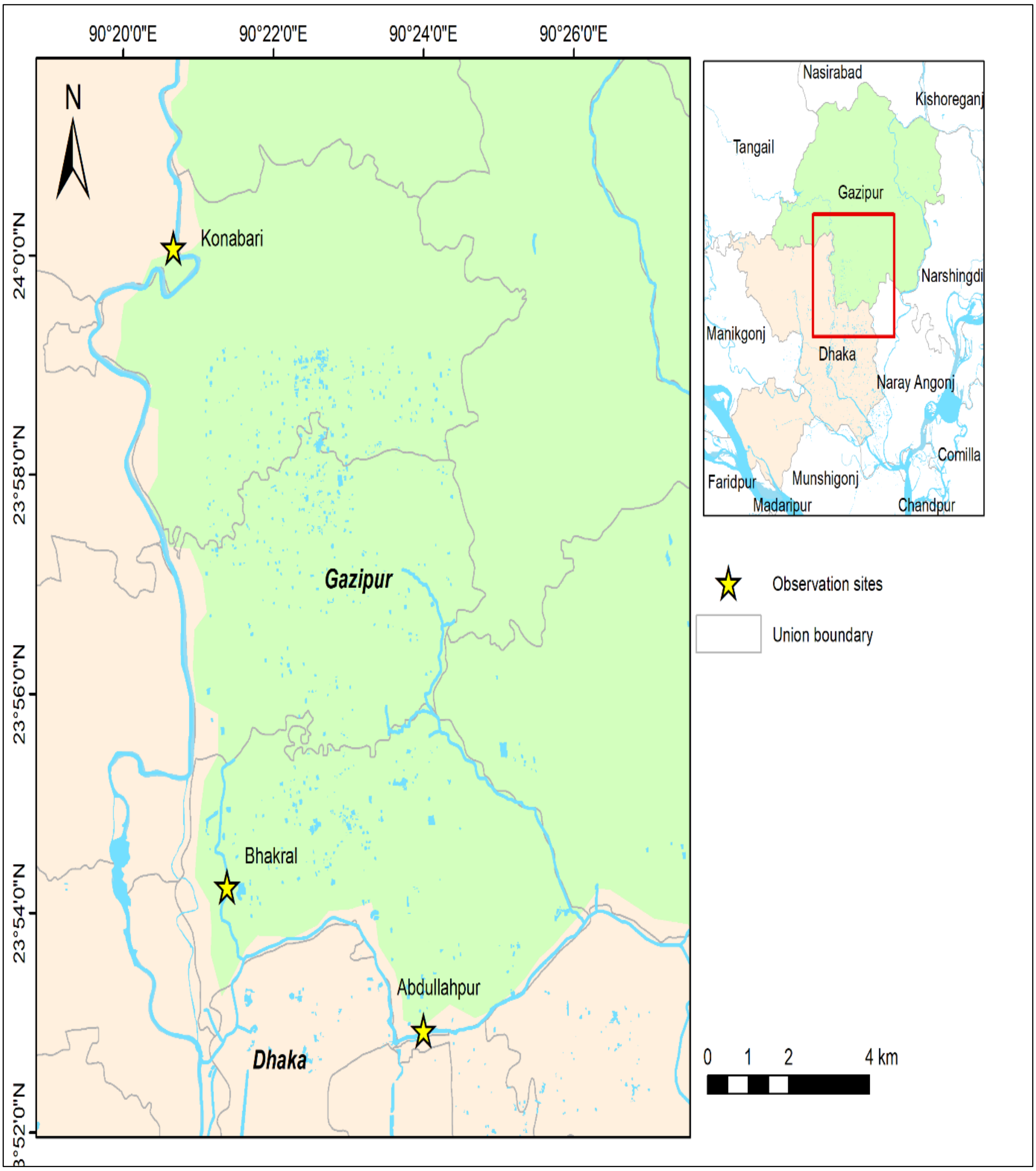
∞ Coverage of up, middle, and downstream area of Turag River.
∞ Maximum and comprehensive interactions with waterbody by the inhabitants.
∞ The safe working environment for the enumerators.

The first day of observations, therefore, served as a "scoping" visit to identify potential sites within the selected area where two spots from each of the three sites had been selected (***Map 8***). The selected three sites (Figure 7.2a) were:

Site 1: Konabari (Spot 1 & 2) (10055811.7982, 2753729.9356) (Fig. 7.2b)
Site 2: Bhakral (Spot 1 & 2) (10056786.3703, 2748317.2386) (Fig. 7.2c)
Site 3: Abdullahpur (Spot 1 & 2) (10062256.3951, 2740133.6992) (Fig. 7.2d)

Two potential spots from each site have been selected to count maximum interactions and to justify the results gain from each spot of the respective sites. These sites represent Upstream (Baimail Nadir Par, Konabari), Midstream (Bhakral), and Downstream (Machimpur, Abdullahpur) of Turag River, also where possibilities of interaction with the river are highest.

Details of water use behavior survey tools are discussed in ***Chapter Three of Methodology.***



Map 8: Showing three observation sites of Turag River area (Source: Hoque S., 2018)

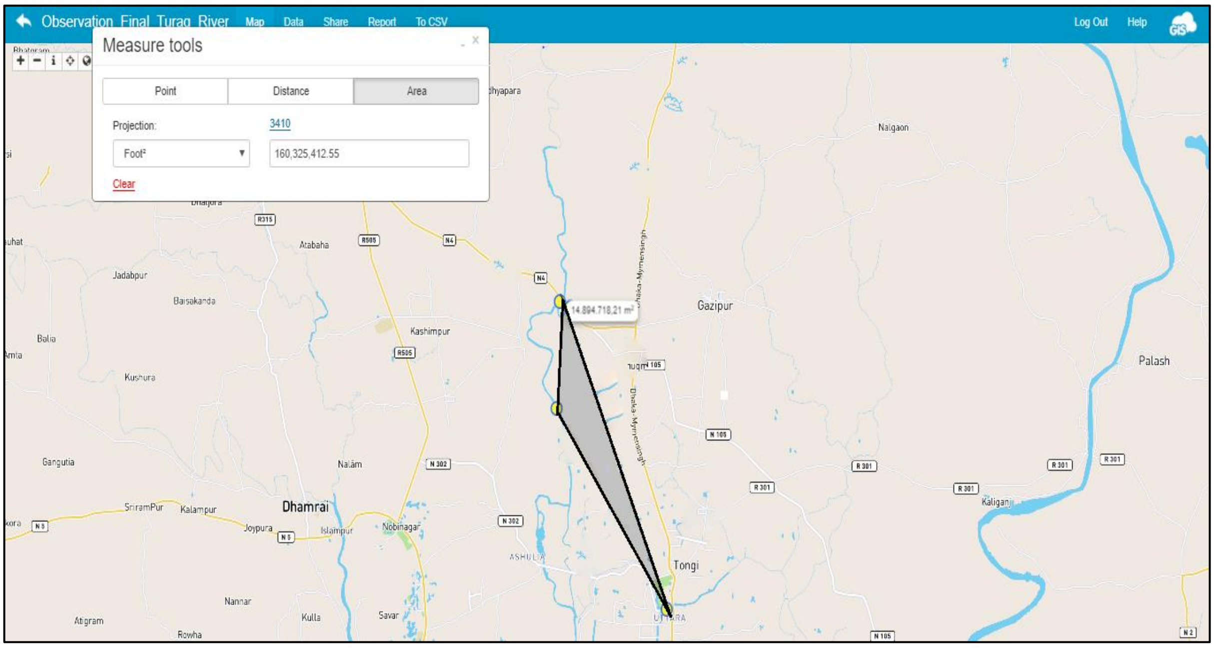


Figure 7.2a: Area triangle (160, 325, 412.55 square feet) of the observation sites

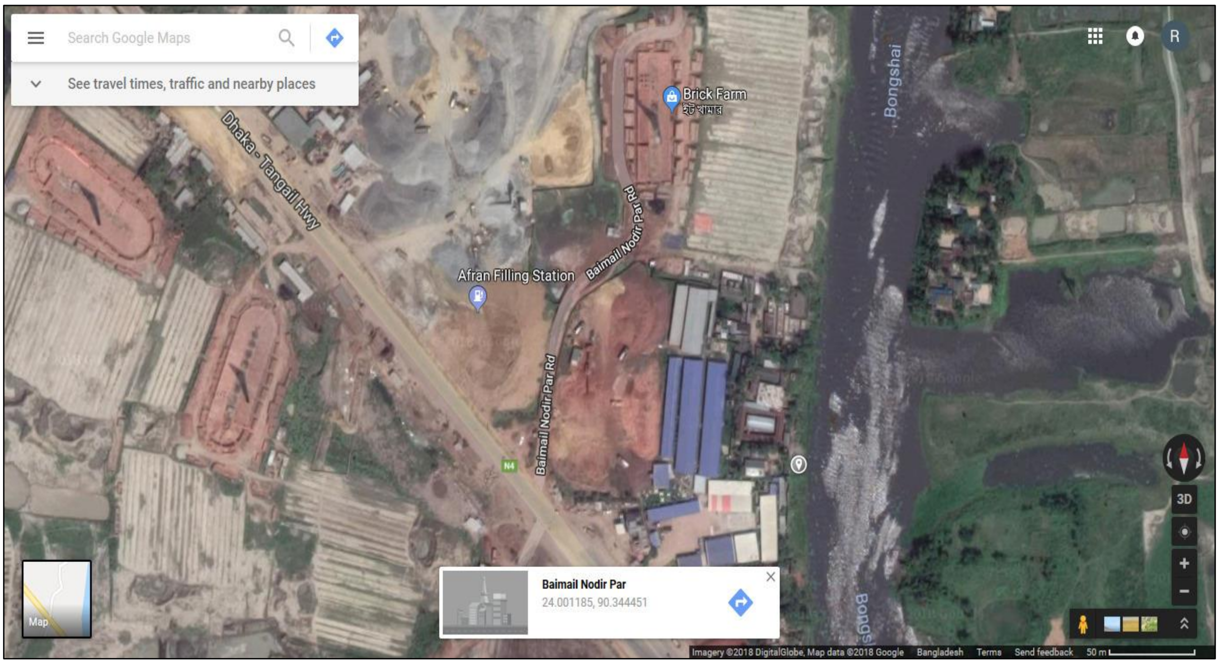


Figure 7.2b: Screenshot showing Konabari (Baimail Nadir Par) observation site (Source: Google Map, 2019)

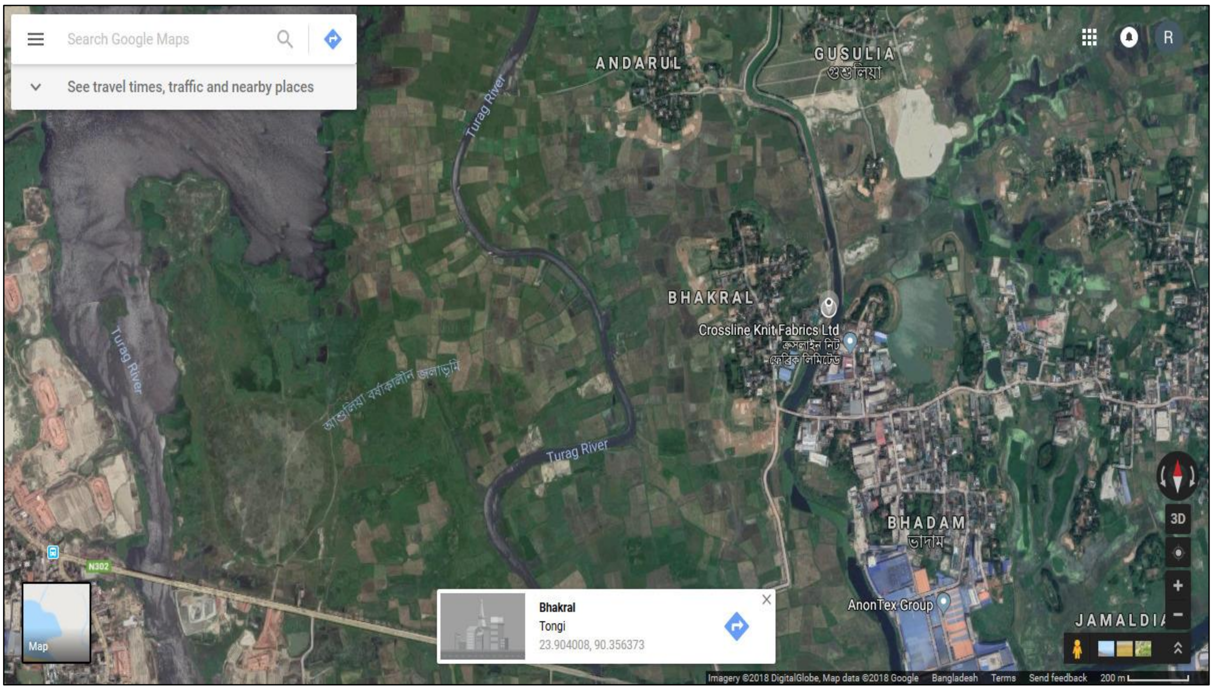


Figure 7.2c: Screenshot showing Bhakral observation site (Source: Google Map, 2019)

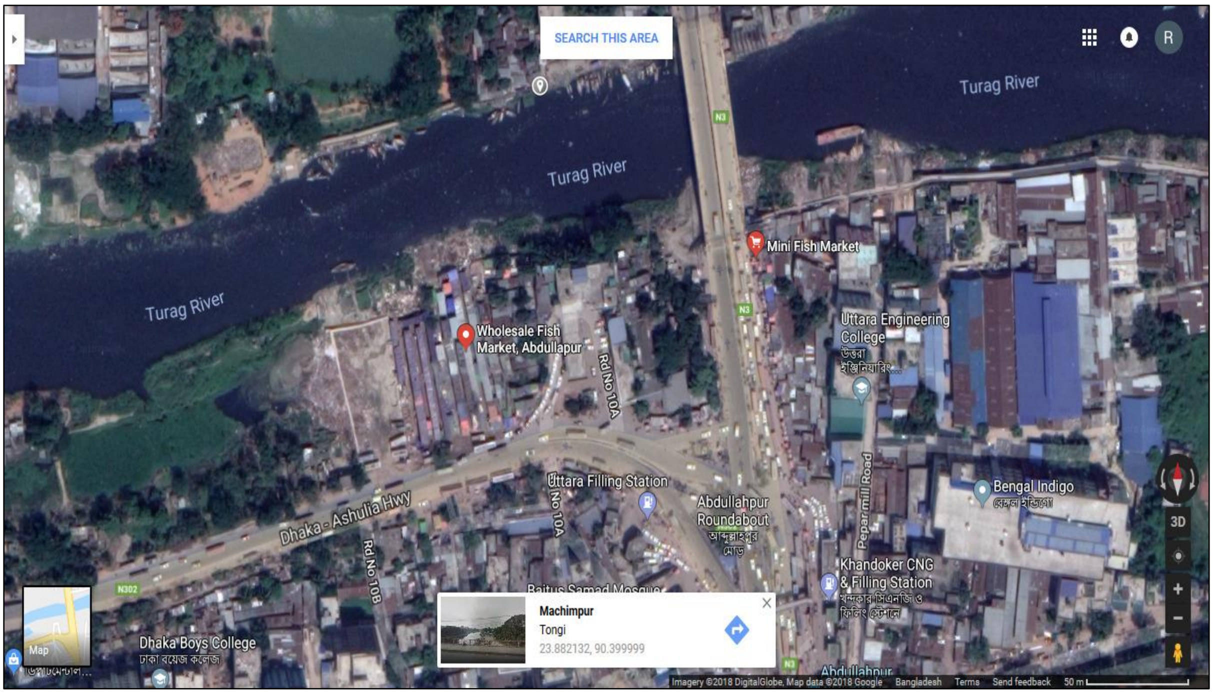


Figure 7.2d: Screenshot showing Abdullahpur observation site (Source: Google Map, 2019)

7.4.1.2 Household Surveys

During Dec-17 and Jan-18, REACH conducted a household survey involving 1800+ households across 12 settlements namely: Konabari, Kashimpur, Ichharkandi, Palasana, Gutia, Gusulia, Bhakral, Bhadam, Rashadia, Kathaldia, Abdullahpur, and Mausaid along the Turag River. According to the findings of the data collection of 1826 households studied, 0.4 percent of adult males, 2.1 percent adult females, 0.3 percent male children, and 0.4 percent female children are documented to interact with the river on a regular basis for various domestic purposes (Appendix table E2).

7.4.1.3 FGDs and KIIs

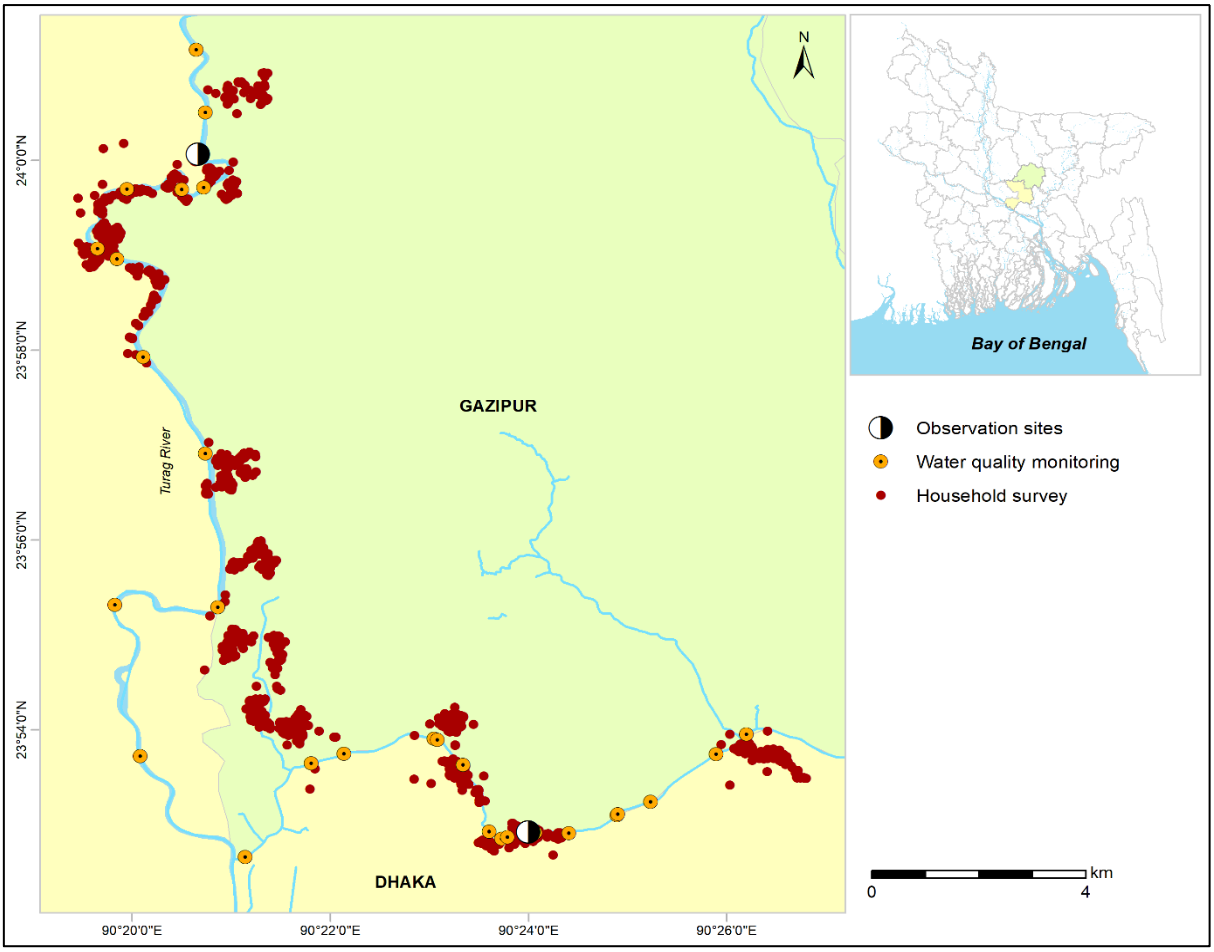
Six (6) FGDs and twelve (12) KIIs have been undertaken to six sites along the Turag River area namely Kashimpur Konabari, Bhadam Bhakral, Abdullahpur, and Mausaid. Reasons for selecting these tools are to gather more selective information on purposes of Turag River uses, user's category, seasonal variation of water use, motivations of interacting with river water or not, community perceptions on river water pollution (***more details in Chapter Three of Methodology***).

7.4.2 Data Cleaning and Final Site Selection

The obtained dataset from the CSV file is then transformed into Excel 2016. Data cleaning is therefore undertaken to find out if there are any irrelevant, incomplete, unclear, incomplete data. The data set shows no or satisfactory interaction with River water in the midstream Bhakral part by the community. As our study aims to explore the interaction of community to Turag River and as selected Bhakral present no satisfactory interaction the final analysis is done based on the interaction of two sites- **Abdullahpur (**Machimpur) **and Konabari (**Baimail Nadir Par). ***Map 9*** shows the area covered and data collection tools applied in this study.

7.4.3 Analytical Approach and Data Presentation

The analysis is completely based on the description. The data obtained from the CSV file has been analysed by frequency and percentage and presented in the table. Photographs have also been used to justify the explanations. These tabulations are explored in the findings section.



Map 9: Observation sites with other data collection tools and sites (Source: Hoque S., 2020)

The results of these three methods were then qualitatively analyzed through the Bourdieuan lens. The following chapter will (i) provide a detailed description of the adopted methods and (ii) describe Bourdieu's social theory of *practice*.

7.4.4 Theoretical Approach

This section is developed based on the theoretical framework of Arturo, 2016[82] presented in his master's dissertation. Accordingly, Bourdieu aims to explain social behaviour in different societal contexts. Habitus, practice, field, and different kinds of capital such as economic, social, and cultural capital are the major theoretical tools Bourdieu employs to investigate his subjects. The formula of his theory is presented as-

Practice = [(Habitus)(Capital) + Field]

[82] Arturo, V. 2016. Urban River use and risk: A study of Practice along the Turag River in Dhaka, Bangladesh. A Master's dissertation submitted to Water Science, Policy and Management (WSPM), University of Oxford

Bourdieu's larger social theory framework, which relies on the following four concepts: agent, field, capital, and habitus. By applying a Bourdieuan lens to an urban community's water-use behaviours along the Turag, the study aims to identify how different individuals (agents) interact with the river, but more importantly, how these individuals fit within their larger community (field) and how their resources (capital) influence their behaviour (habitus) towards the river's waters. Followings are the detailed definition of the components of Bourdieu's theory which are needed to understand the study-

● ***Agent*** – Bourdieu acknowledges the existence of various agents in society, and they can be either individuals or institutions (i.e., organizations). A key characteristic of an agent is its ability to "have [autonomously] acted differently" (Giddens, 1986) in decisions reached and in decisions to be made.

● ***Field*** –Through interactions, agents begin to battle each other for positions within a social field in society (Walther, 2014). Some positions have more power attributed to them, signalling an agent's ability to "transform the rules of the game" (Hage, 2009) or structures of the field, while other positions are less endowed with power and thus, are normally less desirable within a field. Society is composed of numerous fields interacting with one another (Hage, 2009).

● ***Capital***– During these interactions, agents exercise and accumulate capital in efforts to occupy a more desirable position within that field (Bourdieu, 1986). Capital, according to Bourdieu, can be thought of as a resource and it exists in three primary forms, which can be "converted" from one form to another (Bourdieu, 1986):

○ ***Economic Capital,*** refers to the financial assets an agent possesses such as money, property, land, valuable acquisitions, etc. (Bourdieu, 1986).

○ ***Cultural Capital***, on the other hand, refers to the knowledge, certifications, credentials, and qualifications acquired through education and other "time-intensive labour [s] of inculcation and assimilation" (Walther, 2014). Cultural capital informs an agent's ability to dress, speak, and exercise the appropriate behaviour in their social context (Hage, 2009).

○ ***Social Capital***, lastly, represents the networks an agent has developed and maintained, which grant that agent "access to material and immaterial resources, information, and knowledge" (Walther, 2014).

● ***Habitus*** – These human interactions are influenced, as mentioned earlier, by a larger, more comprehensive structure – extending beyond the economic rationale of homo economics or the societal sensitivities of a homo sociological. Bourdieu calls this structure habitus, and he defines it as a "system of lasting, transposable dispositions which, integrating experience, functions at every moment as a matrix of perceptions, appreciations, and actions and makes possible the achievement of infinitely diversified tasks" (Bourdieu, 1977). That is, throughout life, individuals begin to create and modify a unique habitus by drawing from their personal life experiences, anecdotes (both positive and negative), education, friendships, failures, successes, and surroundings (amongst other factors), creating a "set of deeply internalized schemes through which the world is perceived, understood, appreciated, and evaluated" (Sakdapolrak, 2007).

The combined results from the literature review, water-use survey, and interviews were then qualitatively analysed through Bourdieu's social theory of practice.

7.5 Characteristics of Selected Observed Sites

Abdullahpur (Machimpur, Mouza 004, Ward no. 57) is located at 23°88'32.94"N and 90°39'24.91"E in the southern part of the City Corporation. Machimpur, Abdullahpur is situated under the Tongi bridge behind the fish market of West Abdullahpur and close to the Bishwa Ijtema grounds along the Tongi Khal. Because it gets significant pollution loading from the Tongi industrial sector, the river water near the Tongi bridge area is pitch black with the foulest odor and can scarcely be utilized for anything. This industrial region has around 29 heavy industries (Banu et al., 2013), and the capital city's cluster of industries produces 7,159 kg of effluents daily (IWM, 2008)[83]. Across Tongi ward, there are 19 slums or settlements with a combined population of over 651,222 people in 61,000 households[84]. It has also been found that Abdullahpur is a highly encroached area; 79.441066 acres in the year of 2004-2014 with the length of the study were 2.898093 miles (Chowdhury et al., 2015). At Abdullahpur in the Turag River, the areas are encroached mainly by the barren land (Chowdhury et al., 2015). The pollution level of the Turag River at Tongi Railway Bridge is significantly higher than the Ijtema field and Ashulia (Rahman et al., 2012).

83 https://www.thedailystar.net/news-detail-169135
84 CARE. 2012. Wash Study in Tongi

Konabari (Baimail Nadir Par, Mouza 687, Ward no 12) is located at 24°00'40.63"N and 90°19'18.84"E and situated by the Dhaka-Tangail highway, in the north-west corner of the City Corporation. The Tangail highway, brickfields, a commercial market, an industrial park, garment factories, and a pond surround Konabari, which lies on private land. The unplanned settlement was originally formed in 1947 when a brick road was built. Following the opening of the first cotton mill in 1972, the village continued to grow. A medicine maker, a plastics plant, and brick kilns were among the enterprises that arrived at the region in the early 1980s. Mymensingh, Barisal, Putuakhali, Kapasia, and Kishoreganj were the main sources of migration into the town. Early housing was made of mud, and during the 1988 flood, virtually all of it was destroyed. Floods struck the hamlet again in 1998, destroying most of the newly constructed homes. After the second flood, landlords used tin sheeting and concrete footings to rebuild rentable houses. The clothing business first arrived in 1991, but it was not until 2001 that it began to grow rapidly. Women migrating into the community filled many of the machinist and assistant positions created after 2001[85].

At Konabari, BSCIC area the values of pH, DO, BOD, COD, and TDS ranged from 6.25 to 9.65, 0.55 to 2.98 mg/L, 65-142 mg/L, 192-445 mg/L, and 1155-2085 mg/L respectively (Sayed et al., 2015). There has a higher concentration of Pb and Fe exceeding acceptable limits of domestic water supplies and aquaculture standard of Turag River at Konabari industrial area (Islam et al., 2012). Submersible pumps are used by landlords in Konabari to retrieve groundwater for their tenants. Costs are included in housing rent.

HH survey data analysis shows these areas are occupied mostly by garment workers, casual/skilled laborers, and small businessmen (Appendix table B4). The percentage of illiterate persons or no education is also highest in both Abdullahpur (16.8%) and Konabari (13.9%) (Appendix table B3). Interactions with the river were also high in those selected areas (FGDs & KIIs), with women and children using the polluted river water for washing clothes and dishes, mainly to avoid queuing at the public taps.

The majority of the people surveyed in the water usage behavior survey live in squatter camps and illegal settlements (peri-urban areas). As a result, the City Corporation's essential amenities, including as water, sewage, and power, are not extended to these neighborhoods.

[85] CARE. 2014. Urban Socio-Economic and Vulnerability Study of Gazipur City Corporation (GCC). https://www.careevaluations.org/wp-content/uploads/CARE-Bangladesh-Urban-Socio-Economic-and-Vulnerability-Study-of-Gazipur.pdf

Residents get their water and electricity from commercial providers. Submersible pumps are used by landlords in such areas to draw groundwater for their tenants. These expenses are covered by the rent. The high population density and built-up area are key aspects of the communities. They're also bordered by a dense cluster of industries, factories, warehouses, and trade facilities. The villages are connected to the highways by several roads and streets, however the roads within the settlements are narrow and poorly maintained. Furthermore, the communities are located near industrial sites, garbage dumps, and polluted water sources, as well as low-lying areas prone to flooding and waterlogging (CARE Bangladesh, 2015).

A brief comparison of the two communities under investigation: Tenants have access to gas, water, and electricity provided by their landlords in ***Konabari***, which is privately held property. These charges are usually included in the monthly rent. In contrast, ***Abdullahpur*** is built on government-owned land, and most renters and landlords do not have ownership rights to their property. Electricity, water, and gas are examples of government services that are not usually available. However, because the region has hospitals and schools, it has greater access to healthcare and education.

7.6 The Turag River Water Quality

The rivers, lakes, and other water bodies in the Dhaka watershed experience a seasonal variation of water quality. The water quality deteriorates dramatically during the seven months of the year from November to May. During five months of monsoon, from June to October, the water quality improves due to the availability of large rainfall-runoff and flood spills from Jamuna River (DWASA, 2019). There is a serious problem of water pollution in central Dhaka, that is in Bangladesh's Turag-Tongi-Balu River system, which is one of the most polluted in the world at the moment, with industrial developments and townships adding to pollution loads and having devastating effects on river water quality (Whitehead et al., 2018). A survey conducted in 1999 found that the water of the Buriganga, Turag, Dhaleshwari, Balu, and Narai rivers flowing through greater Dhaka city had been fully contaminated, and that the water posed a serious threat to public life and was unsuitable for human consumption[86]. Turag receives pollutants mostly from Gazipur and Tongi industries. Currently, in some cases, the untreated sewage is directly dumped into it due to the absence

[86]http://biwta.portal.gov.bd/sites/default/files/files/biwta.portal.gov.bd/page/4e97b481_943e_4ca4_ae8a_a325b0aac1b9/Final%20Report_Main%20Text.pdf

of an effective collection system and treatment capacity[87]. They dumped sewage is polluting the river resulting in exceptionally low quality of water and is usually a bad odor in and around. As a result, the aquatic ecology of this river is greatly affected.

Bangladesh's growing urbanization and industrialisation have severe consequences for water quality, since industrial effluents and municipal wastes are discharged straight into rivers without regard for the environment (Kamal et al., 1999; Karn & Harada, 2001; Mobin et al., 2014). In 2009, the Department of Environment designated the Turag River as an environmentally critical area (ECA). The Department of Environment, on the other hand, conducted research on the water quality of the Turag River at different times (Table 7.1). The table shows that the values of different physiochemical parameters of Turag River water are continuously changing at an alarming rate as various industries continuously discharging their effluents and wastewater into the Turag River and causing serious pollution. Table 7.1 shows different physico-chemical properties of Turag River water from 2010 to 2016 where pH lies in the range of 6 to 9 mg/l, Dissolved Oxygen (DO) in the range of 0 to 6 mg/l, Biological Oxygen Demand (BOD) in the range of 6 to 154 mg/l, COD 4 to 475, TDS 53 to 1059 mg/l, Chloride 3 to 141 mg/l, EC 100 to 2240 mg/l, alkalinity 30 to 1159 mg/l. Though the ECR, 1997 standard value for those parameters are in the range of 6.5 to 8.5, 6 or above, 6 or less, 200, 1000, 600, 1200, 150 mg/l respectively. It has been clear that in every case the ranges of these parameters are far above the acceptable standards, therefore, indicating the quality of water is unfit for drinking and domestic uses. Also, the surviving environment for aquatic animals especially for fisheries is affecting acutely. A series of work on Turag water quality (Table 7.2) by Sikder et al., 2012; Banu et al., 2013; Meghla et al., 2013; Mokaddes et al., 2013; Mobin et al., 2014; Islam & Azam, 2015; Rabbi et al., 2016; Sarkar et al., 2016; Saha et al., 2017; Rahman et al., 2017 has shown similar result as that of the DoE.

In Bangladesh, inland fisheries represent one of the most diverse biological resources. This resource is also critical to the livelihood of the poor. The productivity of natural fisheries relies heavily upon large nutrient-rich areas, but the continued presence of huge toxic

[87] Government of the People's Republic of Bangladesh & United Nations Development Programme. 2010. Pollution Abatement Strategies for Rivers and Wetlands in and Around Dhaka City. Parliamentary Standing Committee on Ministry of Environment & Forests. http://ext.bd.undp.org/CCED/bgdp/BGDP%20Materials/Review%20Documents/Pollution%20abatement%20strategies%20for%20river%20and%20wetland.pdf)

materials from industries is therefore crucial in maintaining large inland fish populations. From 2010 to 2016, the pH of Turag River water was within the ECR (6.5-8.5) where DO and BOD content was below the ECR irrespective of seasons (Table 7.1) resulting in degradation of fish habitat quality due to deterioration of water quality. Two parameters: Dissolve Oxygen (DO) and Biological Oxygen Demand (BOD) are important for aquatic lives and there are suitable ranges of these parameters for supporting aquatic lives. Large-scale fish mortality in recent times highlights the level of contamination of water bodies with the onset of summer. Increasing temperatures (34–35°C), enhanced the biological activities (evident from higher ammonia and biochemical oxygen demand) which lowered dissolved oxygen levels leading to fish death due to asphyxiation (Ramachandra et al., 2016).

Table 7.1: Variation of water quality parameters in the Turag River by DoE during 2006-16

Parameters	**Range (mg/l)**						**Standards in mg/l** (EQS, ECR 1997)[g]
	2010[a]	**2012[b]**	**2013[c]**	**2014[d]**	**2015[e]**	**2016[f]**	
pH	7.4-7.6	6.7-8.4	7.1-8.03	7.01-8.4	6.14-8.79	6.68-8.11	6.5 to 8.5
DO	0-5.1	0.6-6.1	0.0-4.6	0.0-4.5	0.0-5.9	0.0-6.1	6 or above
BOD	8-29	5.0-38	0.0-65	2.0-154	1.0-86	1.8-70.3	6 or less
COD	-	9.0-290	4.0-303	5.0-475	17-233	10-258.01	200 (4 mg/l for drinking purpose)
TDS (mg/l)	302-906	60-1020	98.4-1049	76.2-959	52.6-804	56-930	1000
Chloride	09-37	3.5-135	8.0-133.8	3.0-141	7.86-129.7	6.0-119.7	150-600
EC(μmhos /cm)	-	-	206-2240	154.5-2230	100-1682	118-1767	1200
Alkalinity	-	-	65-1150	30-425	42-280	38-450	150

	2011		**2012**		**2013**		**2014**		**2015**		**2016**		EQS for Fisheries
Parameters / Season	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	
pH	7.7	7.5	7.6	7.5	7.5	7.3	7.7	7.4	7.7	6.8	7.2	7.3	6.5-8.5
DO	0.5	3.9	0.7	2.7	0.7	2.9	0.7	2.8	0.1	3.6	0.4	4.5	≥5 mg/l
BOD	22.3	9.1	24.9	12.9	31.9	4.5	35.4	7.2	35.7	7.5	30.5	4.5	≤6 mg/l

Source: [a]DoE, Water Quality Report 2010 (ECCO, 2013); [b] DoE, Water Quality Report 2013 (2014); [c]DoE, Water Quality Report 2013 (2014); [d]DoE, Water Quality Report 2014 (2015); [e]DoE, Water Quality Report 2016 (2017); [f]DoE, Water Quality Report 2016 (2017); [g]DoE, Water Quality Report 2016, 2017, Chloride (WHO Guideline values 250)

Abbreviation: DO- Dissolved Oxygen; BOD-Biochemical Oxygen Demand; COD-Chemical Oxygen Demand; TDS-Total Dissolved Solids; EC-Electrical Conductivity; EQS- Environmental Quality Standard

Table 7.2: Variation of water quality parameters in the Turag River during 2006-16

Parameters	Range of water quality parameters							Standards
	2006 (mg/l)	2010 (mg/l)	2012 (mg/l)	2013 (mg/l)	2015 (mg/l)	2016 (mg/l)	2018 (mg/l)	
pH	7.1	7.5	5.69-6.94	6.18-7.45	5.86-7.28 5.3 - 9.0** 8.85***	6.51-9.31	5.24-7.03	6.5 to 8.5 mg/l (ECR, 1997)
DO	6	0	1.12-5.75	0.6-3.9	3.49-5.2 0.34 -7.39** 0.98***	3.94-5.58	1.27-5.43	6 mg/l or above (ECR, 1997)
BOD	2.8	22	4.38-2.65	0.4-1.9	55.92-42.34 4.8 - 35.7** 157.67***	3.10-1.08		2-6 mg/l (ECR, 1997)
COD	58	102	5–177*	---	106-141* 288.33***	----		4 mg/l (ECR, 1997)
Alkalinity	----	----	---	95.49-417.12	53.03± 82.61**	----		>100 (Rahman, 1992)
Hardness	----	----	----	36.9-217.15	130.67± 81.57**	---		123 ppm (Huq and Alam, 2005)
Lead (Pb)	----	----	----	28.30-36.40	0.080-0.033 0.015***	0.056-0.021		0.05 mg/l (ECR, 1997)
Cadmium (Cd)	----	----	0.11-0.03	0.00-0.80	0.001**	0.0068-0.0033		0.005 mg/l (ECR, 1997)
Copper (Cu)	----	----	0.02-0.24	46.30 - 60.00	1.341-0.143	0.47-0.20		1 mg/l (ECR, 1997)
Iron (Fe)	----	----	0.013-0.380*	0.0048	2.52-2.1	1.04-0.47		0.3 – 1 mg/l (ECR, 1997)
E. coli (cfu/100 mL)					<18000	10000–420000*	30,000–490,000*	
Sources	Banu et al., 2013	Banu et al., 2013	Meghla et al., 2013; *Islam et al., 2015	Mobin et al., 2014	Islam & Azam, 2015; *Sikder et al., 2016; **Rabbi et al., 2016 ***Sarkar et al., 2016	Hafizur et al., 2017; *Rampley et al., 2020	Khan et al., 2020; *Rampley et al., 2020	

Employing new technology based on luminescent molecular biosensors, the water quality of the Turag River has been studied by the REACH research team of BUET (Bangladesh University of Engineering and Technology) between Feb-18 to Jan-19. Results revealed (Table 7.3) high levels of cell toxicity, as well as high concentrations of metals, particularly ammonia, chloride, chromium, iron, carbon, nitrate, sulfated, phosphate etc. Chemical analysis also revealed low dissolved oxygen levels and anoxic conditions in the rivers at certain sites which may lead to many pollution problems such as the release of noxious gases such as hydrogen sulfide, and dissolution of metals from the sediments[88]. The experiment by Whitened et al. (2018) found Turag-Tongi-Bula River System in a poor condition from a pollution perspective with extremely poor water quality with dissolved oxygen (DO) close to zero indicating that river water was no more suitable for any domestic uses.

Table 7.3: Range of Physico-chemical parameters of Turag River (2018-19)

Parameter	Feb-18	Jan-19	Parameter	Feb-18	Jan-19
Depth (m)	1.30 - 5.40	1.70 - 6.70	**Phosphate (mg/l)**	2.2 - 10.8	2.3 - 4.4
Temp (°C)	25.2 - 27.3	20.3 - 21.1	**Suspended solids (mg/l)**	14 - 46	38 - 72
Dissolved oxygen (mg/l)	0.11 - 0.25	0.04 - 0.15	**Sulphate (mg/l)**	38.0 - 66.0	90.0 - 120.0
Electrical conductivity (µS/cm)	775 - 1095	598 - 831	**Sulphate (mg/l)**	5.0 - 19.0	14.0 - 31.0
pH	7.0 - 7.6	6.6 - 7.4	**Total dissolved solids (mg/l)**	370 - 506	280 - 400
Alkalinity (mg/l)	125 - 240	180 - 230	**Total organic carbon (mg/l)**	4.47 - 13.10	0.07 - 0.63
Chloride (mg/l)	33 - 49	92 - 793	**Turbidity (NTU)**	26.7 - 39.4	21.0 - 35.2
Ammonia (mg/l)	2.78 - 5.54	1.30 - 2.50	**Colour (Pt – Co)**	15 - 205	86 - 165
Nitrate (mg/l)	11.0 - 33.5	0.1 - 7.9	**Iron (mg/l)**	0.05 - 0.40	0.04 - 0.12

Source: REACH water quality survey data, 2019

[88] Whitehead et al. 2018. Restoring water quality in the polluted Turag-Tongi-Balu river system, Dhaka: Modelling nutrient and total coliform intervention strategies. *Science of the Total Environment, 631–632*, pp. 223–23. https://generic.wordpress.soton.ac.uk/deccma/wp-content/uploads/sites/181/2017/02/whitehead-Hossain-et-al-Turag-modelling-2018.pdf

7.7 Findings

HH survey results show that around 93 percent of survey respondents drink safe water from tubewell, tap water, piped water etc. The study suggests that while most respondents report drinking safe water, 2.8 percent of households use open sources of water for other purposes (Figure 6.1).

The results will be presented in two sections. The first will address the results of the ***water-use behavior survey*** and the second will address the results of the ***qualitative studies (FGDs & KIIs)***.

7.7.1 Water-use Behavior Survey

The eight days observation carried out in April 2018 aimed to collect data on community interaction with the river across gender along with their purposes. Over the 8-day observation period, a total of 336 observations were documented at all the four spots of two observed sites. Through these 336 observations, 1072 instances of water use activity were documented. It is important to note here that on average, individuals were doing multiple tasks at a time than one simple activity, meaning that there could be more than one type of behaviour documented per person. For example, one woman was bathing and washing clothes at the same time in the same spot.

*As this section is mainly based on community interactions with the Turag River and though no direct interaction of the Turag River has been recorded in **Bhakral** observation sites, the analysis of findings presented here is completely based on interactions obtained from **Abdullahpur** and **Konabari** observation sites.*

The study findings are arranged and presented in subcategories as below-

7.7.1.i Weather condition during the observation

The first two days of the survey were bright sunny (Appendix table E1). The weather seemed normal and convenient for any chores. There was no gloominess during the observation period. On day three, the weather was a bit cloudy in the first half of the day, and later on, it rained till evening. Day four and five went well with no rainfall but the weather was cloudy in the second half of the day. Day six and seven were again normal and sunny. Day Eight was cloudy at its first fortnight and ended up with a daylong raining. Figure 7.3 shows that most of the time the observed areas remain cloudy or rainy (56.3%; Appendix table E1). These weather conditions might affect community interactions with the Turag River. Though rain might have improved the water quality, at the same time it halts the community to interact with river who might reside far away. Sunny weather (50%) mostly prevailed in Abdullahpur but rain (37.5%) encountered mostly in Konabari while conducting the survey (Appendix table E1).

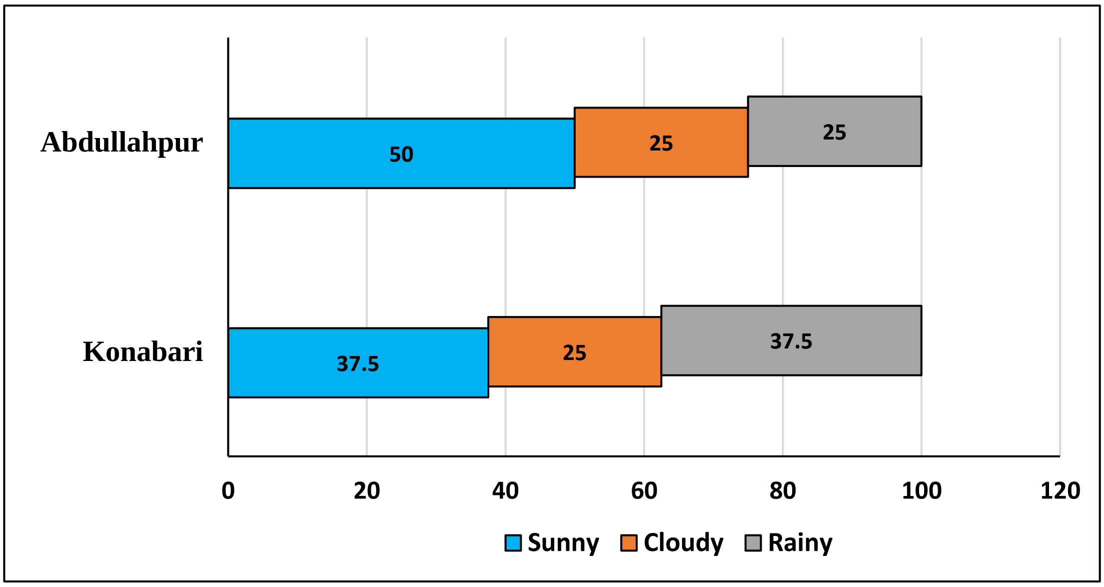


Figure 7.3: Weather condition (%) of observed sites while conducting the survey

7.7.1.ii River condition during the observation

The condition of the river water varied in different sites. A five-point Likert scale as unbelievably bad, bad, moderate, good, very good etc. had been utilized to find out the existing condition of observed river water for each spot of the selected sites (Appendix table E2). In Abdullahpur, the condition of river water was awfully bad throughout the survey period (Figure 7.4). Despite this unfavourable river water condition, various interactions were observed at their highest at both spots of this site. In Konabari, river water was recorded much better than Abdullahpur. Due to heavy rain in the last few alternative days of the survey, the river water condition of reported sites varied variously. For example, moderate to good river water conditions are moved into very well and are recorded at its highest rate. These variations influenced local people to interact differently on this site.

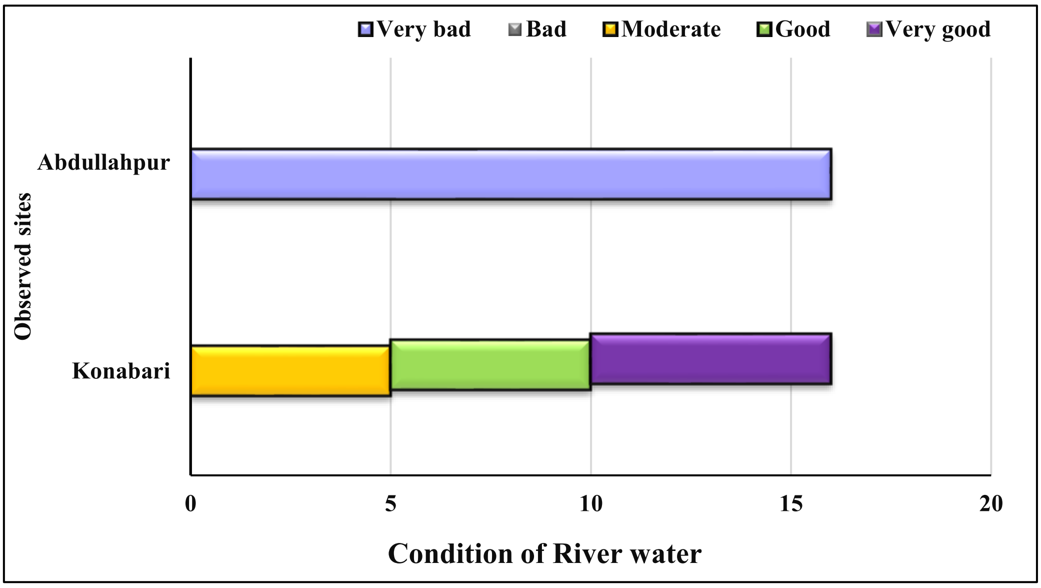


Figure 7.4: River condition observed and ranked using Likert scale by the observers

7.7.1.iii Gender-related information

As per the REACH gender strategy and analysis, the observation was designed using a gender lens along with other indicators. Over the 8-day observation period, women and men represent 56.9 and 43.1 percent respectively (Appendix table E3). Further details have been discussed under the following themes-

7.7.1.iii.a Gender Group

Gender groups had been observed in four major categories: women, men, girls, and boys (Appendix table E4). From these categories' women ranked highest in terms of their interactions with the river (46.6%) followed by men (36.4%), girls (10.3%), and boys (6.7%). Total gender count in Konabari represent 47.4 percent (n=508) and in Abdullahpur it is 52.6 percent (n=564). Gender group breakdown in Konabari embody women 45.3 percent, men 37.6 percent, girl's 11.2 percent, and boy's 5.9 percent. Similarly, in Abdullahpur it embodied 47.9 percent women, 35.3 percent men, 9.4 percent girls, and 7.4 percent boys (Figure 7.5). This high percentage indicates that women are mostly involved and spending more time interacting with the river for various water-related household activities as opposed to men.

7.7.1.iii.b Age Group

Age group-related information had been collected through three main categories namely elderly, adult, and child to find out who is most active in interacting with the river. Observation recorded adult males and females dominating over the river (73%) compared to children (17%) and elderly (10%) group (Figure 7.5). The adult group interaction was found highest in Abdullahpur than in Konabari (Appendix table E4).

7.7.1.iii.c Assemblage

It has been observed that people interact individually (59%) rather than in a group (41%) (Figure 7.5). Group assemblage was mostly noticed during bathing, water collection, cloth, and dishwashing. Sometimes they accidentally met each other on the spot (Appendix table E4).

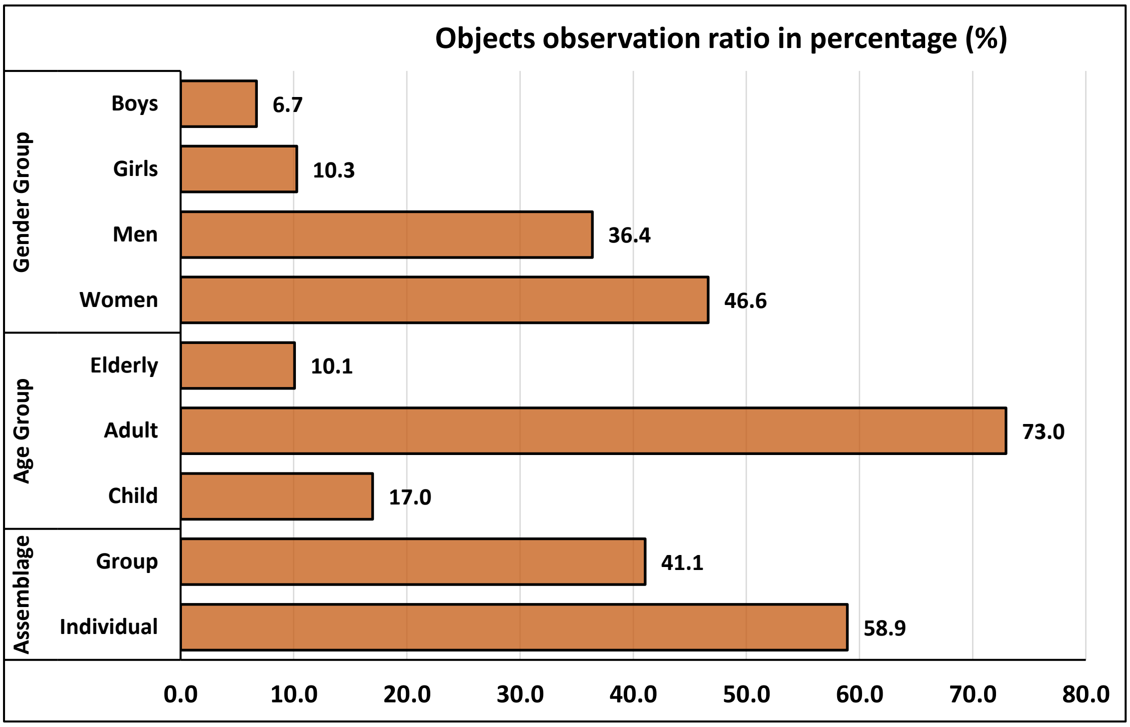


Figure 7.5: Gender wise age group and assemblage while interacting with river

7.7.1.iv Purposes of River use

The distance of the household from the main source of safe water, lack of affordable piped water, and larger household size influenced households to use river water. Data on purposes of water use have been collected in five main categories: consumption, washing, hygiene, amenities, and productivity (Figure 7.6 & 7.7; Appendix table E5). Details of site-wise river interactions have been discussed below-

7.7.1.iv.a Consumption

Data on this category had been collected through three main categories of water use, drinking, cooking, and water collection. No data for drinking purposes was recorded in any observed sites whereas only one interaction was found for cooking (0.5%) in Abdullahpur (Appendix table E5). In this category, water collection is very frequently practiced and got the highest response (99.5%). In Abdullahpur, the rate of water collection is 53.8 percent whereas the highest rate of water collection is reported in Konabari (46.2%) (Figure 7.6 & 7.7; Appendix table E5). Water collection to home is mainly undertaken for property washing, house cleaning, watering of plants, byre (cow shed) cleaning etc. purposes.

7.7.1.iv.b Washing

In this category, cloth washing (40.1%) ranked highest as the most common activity during the observation period and followed by properties washing (29.8%), dish washing (29%), and vegetable washing (1.2%) (Figure 7.6 & 7.7; Appendix table E5; Photograph 3a & 3b). Properties like rickshaw, auto-rickshaw, van, boat, equipment, and other machines are quite common. One of the respondents was also seen washing the carpet with the river water. Site-wise interaction with the river for washing purposes had been recorded in a hierarchy of cloth washing (68.3%), vegetable washing (66.7%), property washing (37.3%), and dish washing (27.4%) in Konabari. Alternatively, Abdullahpur dish washing (72.6%), property washing (62.7%), vegetable washing (33.3%), and cloth washing (31.7%) were documented.

7.7.1.iv.c Hygiene

There were four categories under this interaction. Of the observed subjects, personal washing got the highest response (52%) followed by bathing (34%), open defecation (12.6%), and ablution (1.4%) (Appendix table E5). The bathing practice was more frequent in Konabari (87.7%, Photograph 3c) as the condition of the water was better comparative to Abdullahpur (Figure 7.6 & 7.7; Appendix table E5). Bathing practice in Abdullahpur was recorded as 12.3 percent despite the river condition being heavily polluted. It seems that despite feeling uncomfortable, both men and women were bathing in the river at the same time at the same point though male aggregation is more prominent in the morning time. Women were trying to cover their bodies to keep them not being exposed after bathing until reaching home. But in Abdullahpur, personal washing (washing of external body parts with river water) had been recorded at its highest (53.6%) whereas in Konabari it was 46.4 percent. People also use river water for intimate washing after toileting (Photographs 3d). One of them was also documented as washing her teeth after brushing with this polluted river water. Washing hands with soap in the river water was also quite common. In its worst-case pregnant women were also seen taking bath in this water.

7.7.1.iv.d Amenities

In this category, various non-essential tasks (65.1%) such as gossiping, playing/splashing with water, digging, and carrying mud from one place to another, etc. were observed. Swimming/ recreational activities were recorded as the second highest activity (25.6%) in this category (Appendix table E5). Adult males and children (both girls and boys) were observed swimming in the river. The interaction rate of these purposes increased as the day progressed. Besides these, boating (8.7%) was also noticed at that time which was executed mostly by adult men than other gender groups. Though boating is not common, people were seen to do it for their transportation or as a part of their recreation (Photograph 3e). Angling was also recorded in a very negligible frequency (0.5%).

7.7.1.iv.e Productivity

Navigation or transportation (61.9%; Photograph 3f & 3g) was a very frequent case for river use followed by duck rearing (22.9%, Photograph 3h), commerce (12.9%), and fishing (1.9%) excluding watering plants (0.5%), irrigation (Photograph 3i), watering and bathing of livestock, and case culture. Duck rearing is a quite common income-generating activity and is usually practices when the water level is high and in better condition than average (Appendix table E5).

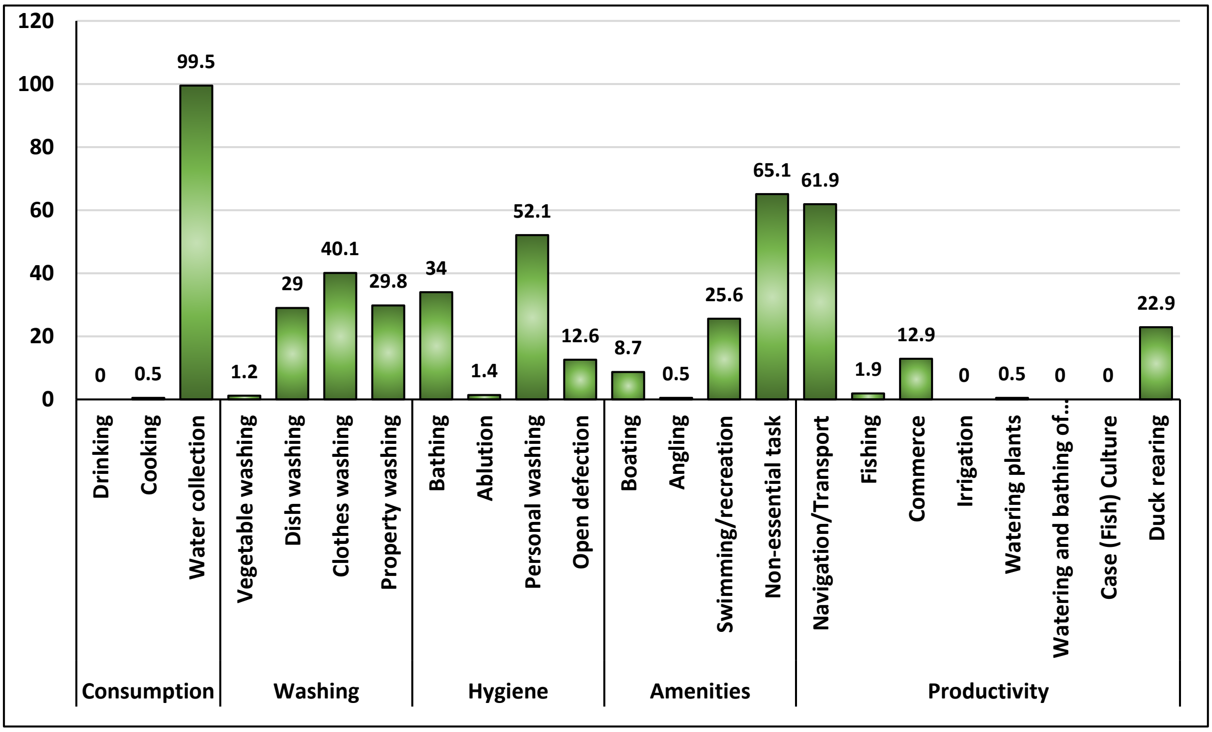


Figure 7.6: Total (%) interactions by purposes

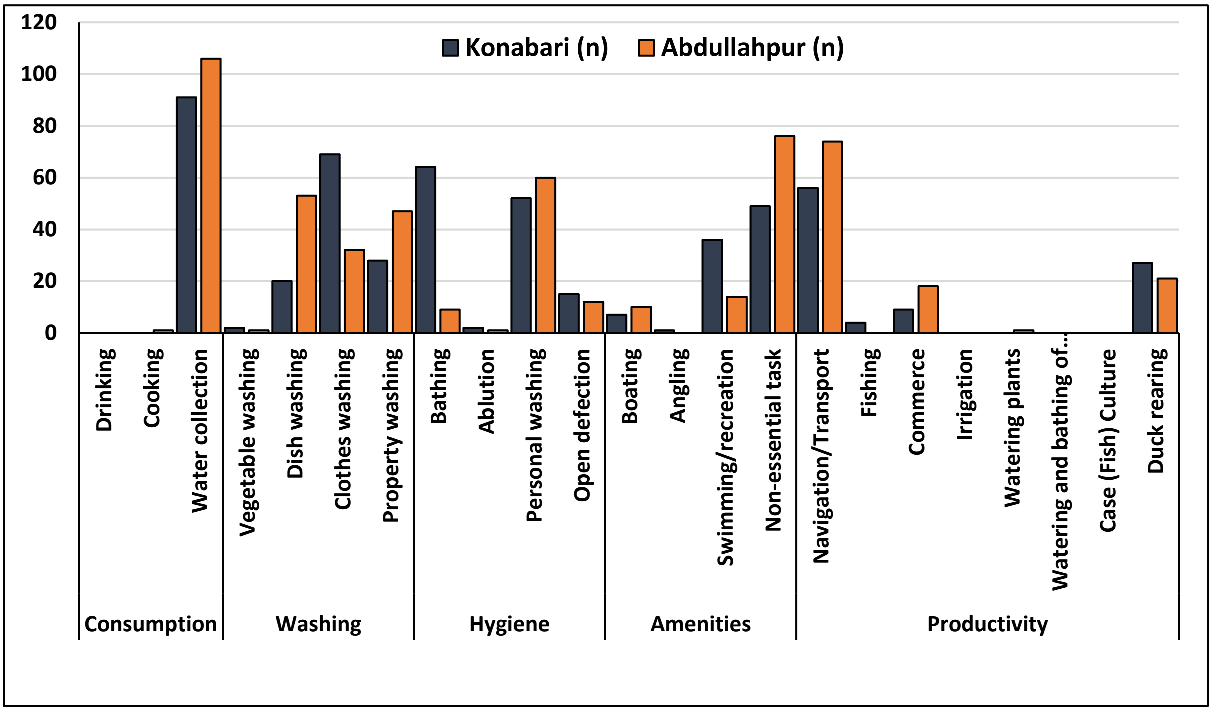


Figure 7.7: Site disaggregated interactions (%)

7.7.1.iv.f Other activities

In this part, other unusual but noticeable activities were noted for more specific information. Besides, in the above discussion, various activities were found which can define the interaction of people with the river water such as children defecating on the bank of the river and their granny washing them by using this water. Elderly men were seen to wash fish scales collecting from the nearby fish market wash in river water and sundried in the riverbank for selling. Also, people mainly elderly women were seen collecting plastic bottles from the river.

Floating house/Boat house: The observed community people are leading an extremely poor economic condition. Some of these people do not have land for living moreover these people are living in boats as they cannot afford better accommodation. They are staying like this from decade to decade. Some old man said that this boat was their birthplace. It has also been observed that boys and girls are going to school from their boat house. They do not have water supply facility, washroom facility even no organized cooking facility in those boats. They are collecting drinking water from the supply standpoint and depend on all other household activities on polluted river water. Bede communities (Snake charmers) used to float over the river and stay at different points of the river for earning their livelihood. As the livelihood opportunities of the Bede communities have been shrunk over time and they have started resettling at the given location beside Turag (Photograph 3j).

Hanging Toilet: According to a report of ADB (2009), an estimated 40 percent of households in Dhaka resort to using unsanitary hanging latrines. Though open defecation in the present study is reported in very negligible frequency but confirms the existence of many hanging toilets along the stretches of Turag River of both observation sites deposits fecal materials directly into the river. The community people living in low land area and in the boat set bamboo made hanging toilets over the river as they do not have any proper place for defecation and thus contributing to river pollution. This is also substantiated that 35 percent of the surveyed households in Abdullahpur, respectively used hanging latrines or practiced open defecation (Photograph 3d).

The findings clearly show that some of the traditional river water use activities like bathing, cooking, fishing/angling, fish culture, irrigation, watering plants were completely absent or recorded in minimal frequency during the survey. Increases in pollution of the Turag River over time may be an important reason. The study findings also revealed that some activities have been frequently practiced by the observed communities and among these, water collection is very commonly practiced by the observed communities in both sites. Interacting with the river for various washing purposes (cloth/dish/properties) of which personal washing got the highest rank, navigation/transportation, commercial use, duck rearing, bathing, and river use for recreational purposes are also the most frequent river use activities recorded during the survey (Figure 7.8).

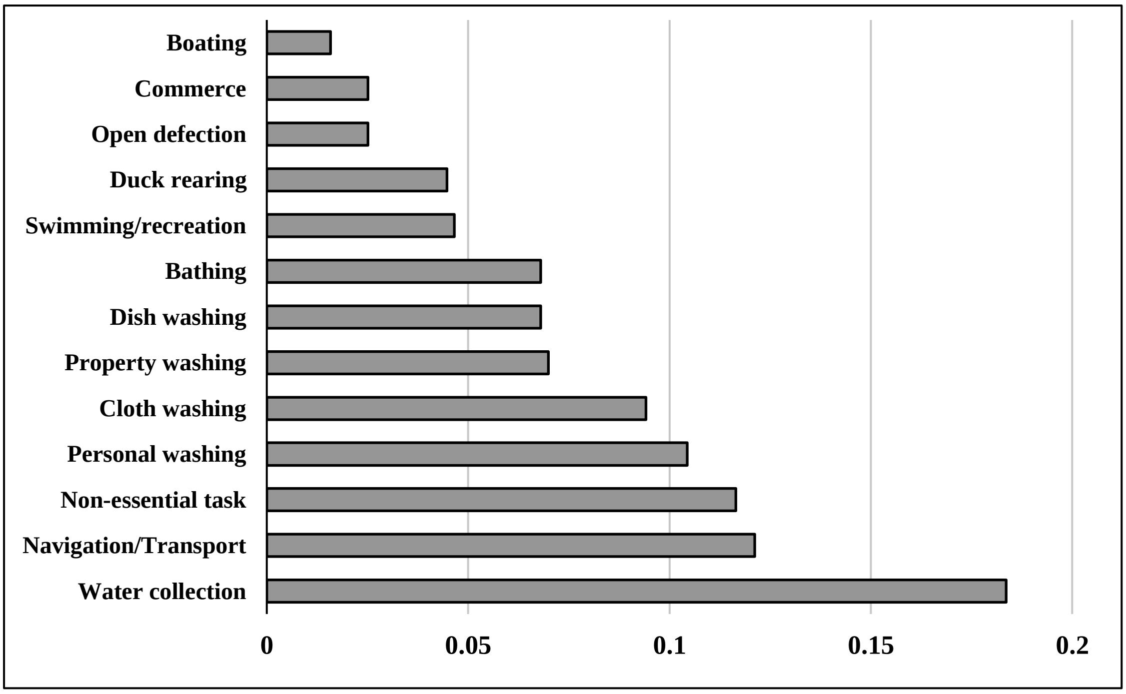


Figure 7.8: Most frequent water uses activities

7.7.1.v Gender disparities in river use

Housing location, damaged infrastructure, and delays in repairs are reasons for people's turning to open water sources mentioned by the respondents. Therefore, this section focuses on gender group exposure to pollutants as they use open water for various domestic activities. Gender analysis of the water use behavior observes that women (56.9%) interact with rivers more than men (43.1%) and indicates the visible prevalence of gendered division of labor throughout the observation period (Appendix table E3 & E6).

7.7.1.v.a *Most dominant Gender group vs Interaction category*

For women washing utensils, cloth, bathing, and personal washing with contaminated, or polluted water has become a rule rather than an exception. The present paper documented the highest water use activities as water collection, navigation, or transport, washing, and bathing, most of which are done by women.

-Women-

Total women (n=610, 56.9%) were counted interacting with water in three major categories which shows adults (77%) were more active than elderly women (5%) or female child (18%) and presented in Figure 7.9 and Appendix table E6. In fact, they are the most active group in the Turag River area and ranked highest in all categories of water use activities.

∞ ***Consumption:*** Water-use for "Consumption" was the least prevalent of the categories except that of water collection. Water collection was the most common activity and was significant for adult women (27%).

∞ ***Washing:*** Water-use for "washing" was incredibly significant and mainly practiced by adult females for dishwashing (56%) and cloth washing (43%).

∞ ***Hygiene:*** Water-use for "hygiene" was another significant activity. Bathing practice is quite common among adults (20%) and personal washing remains highest in both adult (58%) and elderly (12%) groups. Ablution is recorded only for the elderly (3%) group.

∞ ***Amenities:*** "Boating/Swimming/Recreational and various non-essential tasks" is significant amongst children and adults (Appendix table E6).

∞ ***Productivity:*** Water-use for "Productivity" was nearly non-existent. Except that of the "Navigation/Transport and Duck rearing" is the activity with participation from only adult females with a percentage of 26 and 22 percent, respectively.

-Men-

Considering men (n=462, 43.1%) more adults (67%) were observed than elderly men (17%) and boys (16%) interacting with the river (Figure 7.9, Appendix table E6).

∞ ***Consumption:*** Water-use for "consumption" mainly existed for water collection and was significantly practiced by adult males (22%).

∞ ***Washing:*** Water-use for "washing" was significant in cloth and dishwashing and practiced mainly by adults and elderly males (Appendix table E6).

∞ ***Hygiene:*** Water-use for "Personal washing" in this category is significant for adults (34%) and elderly (17%) males.

∞ ***Amenities:*** "Swimming/Recreation" is significant amongst children (5%) and adults (17%).

∞ ***Productivity:*** "Navigation/Transport (55%), Commerce (22%) and Fishing (2%)" are the activities with only participation from adult males. Duck rearing in this category is practiced by only the elderly (5%).

7.7.1.v.b ***Most frequent river use activities vs Age group***

Total gender counted (N=1072) interacting with the river has been divided into three major categories such as child, adult, and elderly. Data presented in Figure 7.5 portraits that women (46.6%) remain highest in interacting with water than men (36.4%) followed by girls (10.3%) and boys (6.7%) (Appendix table E4). In terms of age-specific gender relations both adult men and women were found interacting with water more than the elderly and children (Appendix table E6). The observations revealed modest interaction among elderly women than men.

Seven most frequent activities performed by men are water collection (22%), cloth washing (29%), property washing (26%), personal washing (34%), non-essential task (36%), navigation (55%), and commerce (22%) (Figure 7.9, Appendix table E6). Apart from all these activities, men were also seen transporting goods such as sands, fish, vegetables, bricks, bamboos, etc. for commercial purposes.

Ten most frequent river use activities of women are collection of water (27%), dishwashing (56%), washing cloth (43%), washing belongings (37%), personal washing (58%), bathing (20%), swimming/recreation (27%), various non-essential tasks (53%), navigation/transport (26%) and duck rearing (22%). Various minor tasks were very much significant amongst adults rather than children and the elderly. During their free time, both men and women were observed to travel in groups to the river for gossiping, relaxing, and as a means of their social gathering. Use of the river for navigation in the productivity category was the highest recorded activity across both genders.

Boy's interaction with the river is not as significant as other groups. However, boys primarily engaged with the river for water collection (5%), cloth washing (7%), open defecation (8%), swimming (5%), and various non-essential task (17%) whereas girls were documented for water collection (6%), cloth washing (8%), property washing (7%), non-essential tasks (10%) and others. Boys were mainly found playing in groups along the riverside and sometimes helping their parents.

Girls were observed interacting more than boys as they were mostly accompanied by their mother to the river to help in household chores such as cloth washing (8%), bathing (3%), swimming/recreation (3%), and nonessential task (10%) like boys.

The elderly from each group was the less represented group in this study compared to the adult and children group. Therefore, interacting with the river for personal washing is noticeable among both groups.

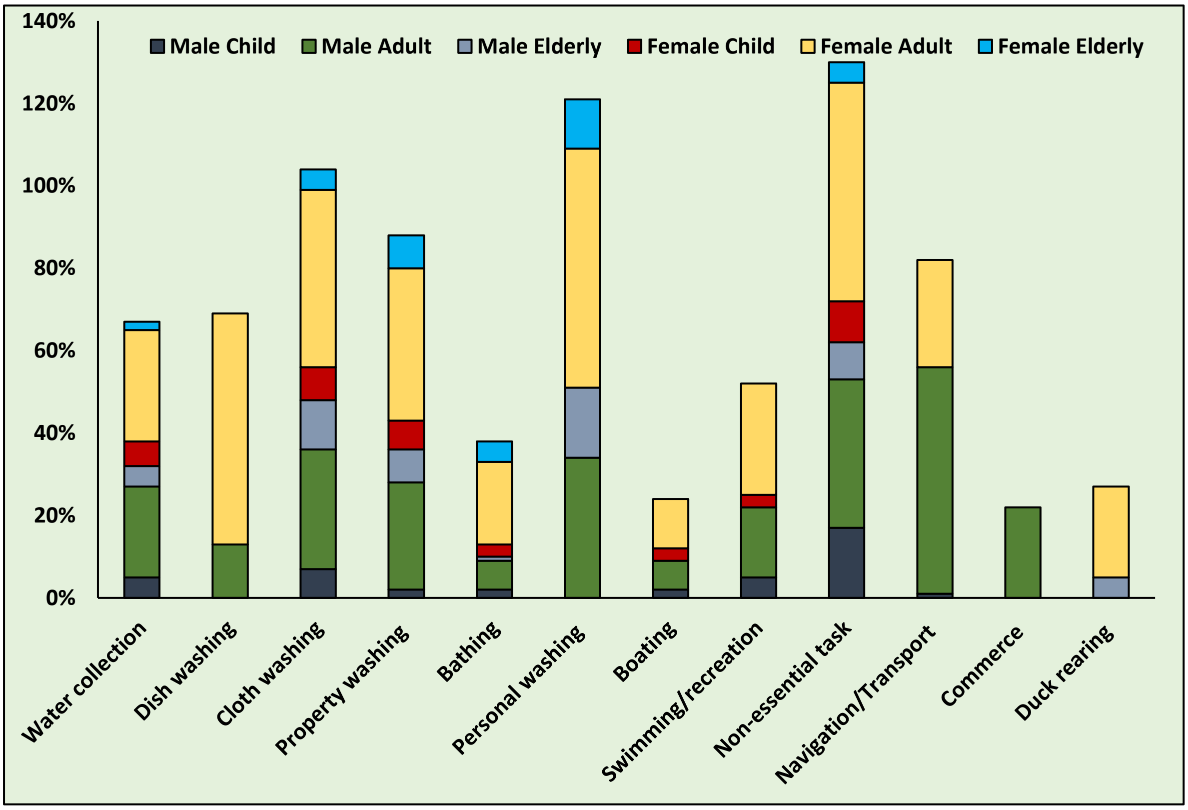


Figure 7.9: Age group (%) for different interactions with Turag River

7.7.2 Qualitative study of Turag River (FGDs and KIIs)

The findings from six FGDs and twelve KIIs have been explained under the following themes and later incorporated into the results obtained from the water use behaviour survey in the discussion section.

7.7.2.i Purposes of river use

Participants from FGDs and KIIs mentioned various types of river interactions (Appendix table D1). The result shows that they not only use the river for household or productive purposes (irrigation and navigation) but it also adds pollution by releasing or dumping wastes and sewerage. Participants also mentioned that general people who lived beside the riverbank usually interacted with the river most. Profession wise- farmers, transport workers, boatmen, fish traders, and merchants are common users of the Turag River.

- Bathing
- Washing clothes
- Washing utensils
- Drinking and cooking during the rainy season
- Irrigating the paddy fields (Photograph g)
- Navigation and transportation
- Crossing the river for fish selling
- Dumping waste in the water
- Using toilet elevated over

"Even during 1984-85, the launches used to go through this route; we got colossal, supply of fresh fish from the river. However, after the 1988 flood, most people could not use the river's water."

- Daniel Correa (54), Mausaid

"10-15 years ago there were so many fish in the river, that is why a fish market was grown on the other side of the river, and so many of us were involved in the fish business. However, there is no more fishes left in the river."

- Abdus Salam (57), Abdullahpur

"Due to lack of oxygen – fish floats over water. Not even Paddy can properly be cultivated in these lands due to decrease in water level, as well as surface water being that much polluted."

- Abdul Kuddus (45), Abdullahpur

7.7.2.ii Seasonal variation and reasons for variation of river use

7.7.2.ii.a Seasonal variation of Turag River water use

Results of FGDs and KIIs show that there is a clear seasonal variation of water use by the dependent community (Appendix table D1). Frequency and variations of river use increase in the wet season than in the dry season. Notable variation other than usual uses as brushing, cooking, drinking, and recreational use of Turag River during monsoon are practiced by the dependent community (Table 7.4). Bathing in the river during the dry season is mainly avoided due to long queues in water point and as they were in hurry, they take a short bath in this polluted water. Some cited that they are bathing in river water regularly irrespective of the season. Using polluted river water after toileting is spotted round the year. Respondents have acknowledged the following as seasonal variation-

Table 7.4: Seasonal variation of river water use

Dry Season	Monsoon/Wet Season
• Washing clothes (3) • Cleaning utensils (3) • Bathing (if there is long queue) (3) • After coming from the toilet (regular basis) • Irrigation (1) • Swimming (1)	• Washing clothes (5) • Cleaning utensils (3) • Bathing (5) • After coming from the toilet (regular basis) • Brushing (1) • Cooking (1) • Drinking (1) • Recreation (2)

Source: FGDs & KIIs, 2018

7.7.2.ii.b Reasons for seasonal variation

Reasons for seasonal variations of using river water has been identified by the respondent's as-

- During the monsoon season water flow of the river increases, as a result, all the black water gets washed away brings back addled water
- Better water quality in monsoon than the dry season

Therefore, according to the respondent's

"...rain washes away the filth from the river. As a result, the smell, color, and flow of the river water changes."

- Daniel Correa (54), Mausaid

"When I was a kid, we used to depend on the river for our water demands and it was dated 30 years back. Now it is almost impossible to imagine for us. This place was like heaven then."

- Suniti Sarkar (53), Mausaid

"Turag's water remains clear for 2-3 months during monsoon season."

- Raja Miya (35), Abdullahpur

"...flow of the river increases hugely during rainy season and the current washes away the pollutants of the water and making it clearer, thus water becomes better."

- Mohammad Jibon (38), Abdullahpur

"Every year, during the monsoon period, people of Sandar Parr (West Abdullahpur) get inundated due to overflow of the river water. But they still would not move."

- Mohammad Moshtak (70), Abdullahpur

7.7.2.iii Reasons for interacting with Turag River

While interviewing (FGDs & KIIs) respondents specified the number of reasons for interacting with the Turag River. The distance of the household from the main source of safe water, lack of affordable piped water, and larger household size influenced households to use river water (FGDs & KIIs). Sometimes the water point is in a remote area that is not accessible to all the community and tough to reach and collect water. Also, in case the water point is not working or gets damaged by anyway local people must search for other water sources. Sometimes it takes a long time to repair the damaged infrastructure; it also creates a problem for those who are completely dependent on heavily polluted open sources of water for various washing purposes (Appendix table D1).

Following reasons have been pointed out by the respondents for river water use ---

- Near where they live (2)
- Availability (4)
- quick accessibility of water (3)
- No cost (5)
- Groundwater is expensive (2)
- Recreation (2)
- Water quality becomes better in monsoon due to an increase in the water flow of the river (2)
- Un-limited use (3)

"They (merchants of Sandar Parr) have been living in water for most of their lives. Without the river, they are nothing. That's why regardless of how much bad the water quality is they would still use the river water and they will live near or in the river"

- Noor Mohammad (40), Abdullahpur

7.7.2.iv Reasons for not interacting with Turag River

Respondents have identified the following reasons for not using river water ---

- Black color of the water
- Odor
- Availability of alternative, better quality water source
- Health consciousness

"Undrinkable, black, odorous water; along with safe water source interventions established by the City Corporation means that there is no need to use river water."

- Noor Mohammad (40), Abdullahpur

"People have also been educated about the complications of drinking the river water. They are now more conscious about their health safety which means a change in river water use was bound to happen."

- Raja Miya (35), Abdullahpur

7.7.2.v Community perception of causes of Turag River Pollution

Some notorious reasons for river pollution had been pointed out by the respondent community-

- Chemicals from the industries in Tongi
- Dyeing from garments factories
- Hospital waste released in the river

"Waste released from garment factories dyeing and industries without ETP purification… causes this problem."

- Abdus Salam (57), Abdullahpur

"Trash and disposals from various hospitals in Tongi are also thrown into the river, making the river water more polluted than ever before."

- Raja Miya (35), Abdullahpur

7.8 Discussion

The discussion section is divided and explained into three sub-sections:

• Bourdieuan understanding of the findings, and

• Justifying river pollution with changes in community welfare over time.

7.8.1 Incorporating Bourdieuan theory into study findings

To apply a Bourdieuan lens to this study's results, Bourdieu's definition of practice has been applied to each component (practice, habitus, capital, and field) of the findings that are captured for each demographic group. This framework integrates the different types of findings (quantitative & qualitative) into one analysis, providing insight into some of the determining factors influencing water-use behaviors by various demographic groups. The results can be found in Table 7.5.

Women groups are ahead in dealing with the Turag River for three principal purposes: hygiene, washing, and productivity. They spent maximum time while doing household washing chores with the river. Bathing and personal washing are also highest for this group. Engagement in productive work as navigation and duck rearing is also high for the adult male. ***Adult men*** are found to be the active group for productive use of the Turag. Their use of the river for navigation and commerce was the highest recorded activity across both genders. Other productive works such as fishing, and watering plants were also recorded in this group. As part of their jobs, men transport goods (sands, vegetables, bricks, pipes, etc.) or people (for crossing river or pleasure cruises).

Girls' engagement with the river is slightly higher than boys. Girls have sole tasks to accompany their mother for various water-related household activities. Interacting with the river for swimming or other recreational activities are also seen in groups or sometimes alone.

Boys' were primarily engaged with the river for bathing, swimming recreationally, other non-essential tasks such as playing, "splash around" in the waters, etc. Open defecation on the riverbank is also quite common for them.

The elderly was the least represented group in this study's findings. The observations revealed little regarding their water-use behavior, except for a few ***elderly women*** bathing and doing laundry and personal washing. ***Elderly men*** are also seen interacting with Turag for laundry and property washing and productive work as duck rearing. For practical purposes, they have been omitted from Table 7.5.

Table 7.5: Bourdieu's social theory practice applied to the water use behaviour survey findings

Components	Practice=	[(Habitus)	(Capital) +	Field]
Child males	•Cloth washing (7%) •Swimming/recreational/non-essential tasks (22%) •Open defecation (8%)	•Consider river as their partner entity • Less or no education •Interacting alone or in group •Learning seasonal variation	•Economic: No significant capital •Cultural: No significant capital •Social: neighbourhood, relatives, community bonding, school friends	• River • Family • Friends
Adult males	•Cloth washing (29%) •Property washing (26%) •Bathing (7%) •Personal washing (34%) •Boating (7%) •Swimming/Recreation (17%) •Navigation/Transport (55%) •Commerce (22%)	•Rural to urban migration •Less education/non-educated •Personal perceptions of rivers evolving conditions/rising industry •Employment/production requires proximity to Turag •Established understanding of seasonal variation	•Economic: non-fixed employment, non-ownership of housing (renting), ability to pay for safe water •Cultural: non or limited schooling •Social: neighbourhood to collect water from, community connection	• River • Family • Colleagues • Relatives
Child females	•Cloth washing (8%) •Property washing (7%) •Bathing (3%) •Swimming/Recreation/non-essential task (13%) •Open defecation (2%)	•Offended by parents to the river in fear of being teased •Interacting in a group or accompanied by adults •Learning seasonal variation	•Economic: No significant capital •Cultural: No significant capital •Social: neighbourhood, school friends	• River • Family • Friends
Adult females	•Dish washing (56%) •Cloth washing (43%) •Property washing (37%) •Bathing (20%) •Personal washing (58%) •Boating (12%) •Swimming/Recreation (27%) •Navigation/Transport (26%) •Duck rearing (22%)	•River as working niche •Less education/non-educated • Overlook rivers evolving condition •Considering river as an entity itself •Established understanding of seasonal variation •Performing social norms •Knowledge about increased river pollution	•Economic: No significant capital •Cultural: No significant capital •Social: neighbourhood, community bonding	• River • Family • Neighbour • Relatives

Adopted from: Villanueva A., 2016 (MSc in WSPM, University of Oxford)

7.8.2 Justification of increased river pollution with changes in studied community's welfare over time

For centuries, riverbanks have been the prime support for establishing settlements, contributing to trades and commerce, transportation, food, recreation, etc. (Mary, 2006). Many of the world's major towns are located on fragile river deltas because they provide ideal commerce and transit access, as well as abundant fresh water, fish, and wildlife, and excellent agricultural land (Mary, 2006). The prosperity or perils of Dhaka is connected to fading away rivers, canals, and wetlands. Unplanned urbanization and ineffective control of development allow encroachment and severe environmental degradation (Rahman & Ara, 2016). Freshwater biodiversity is a vital source of food, income, and livelihood security for rural communities, particularly in developing nations like ours. Rapid population expansion, economic development, and industrialization have resulted in unprecedented changes in freshwater ecosystems, resulting in biodiversity loss, which we have exacerbated in the last 50 years.

The survey result shows that many people of the observed sites still dependent on the heavily polluted Turag River for various purposes (Appendix table E5). Konabari and Abdullahpur being a semi urban area, the HCR of poverty in Konabari, is higher (28.8) than the national HCR of poverty 24.3 (HIES, 2016)[89] whereas the estimated HCR of poverty of Abdullahpur (10.9) is higher than the district HCR of poverty of 6.9 (HIES, 2016). These poverty levels can be an indicator of why these community people interacting with open sources of water. Together with the poverty level, the higher water tariff (11.02 taka/1000 litre) from WASA is beyond the affordability of these communities. It has also been evident that community people mainly the displaced group living in slums are more dependent on river water despite knowing that it is highly polluted. They even cannot afford only 50 (0.45 GBP) to 100 (0.90 GBP) takas as tariff to avail pipe water.

Though the establishment of Industries in the studied sites contribute to economic growth and increase in employment opportunities but the direct discharge of toxic chemicals from industries into the Turag River increase pollution of both the terrestrial and aquatic environment and thereby lessen water-based uses such as bathing, cooking, washing, fisheries, and navigation (Rahman, 1994) and other productive uses (Appendix table E5).

[89] http://203.112.218.65:8008/WebTestApplication/userfiles/Image/LatestNews/Infographic_HIES_2016.pdf

The impacts of pollution have also been documented in another way, such as endangered rivers threatened the livelihoods (Rahman et al., 2012; Meghla et al., 2013) of the local community together with occupation loss, health and agriculture impacts due to lack of pollution-free water for irrigation and so on. Likewise, the use of the river for boating, commerce, and duck rearing were also reported in moderate frequency in the observed areas. The river which was once surrounded by agricultural land and water was used mainly for fishing, irrigation and transportation, and other household activities, the deadly poisonous toxic industrial effluent is creating a crisis for clean water resulting in agricultural lands becoming inundated with toxins, fish stocks dying, and overall, people are suffering from detrimental health impacts (Halder & Islam, 2015). Respondents (FGDs & KIIs) interviewed also claim that water pollution is impacting the crops. Farmers are sometimes compelled to irrigate their land with this polluted water due to groundwater shortages or lack of access to tube wells. These problems they state are reduced in yields on some plots of land and given the crops a bad taste.

Fisheries is potentially an important economic sector in Bangladesh and considered livelihood-supporting resources by providing substantial employment opportunities. However, degradation of water quality particularly in the dry season the fisheries sectors in Turag face a great threat as the physico-chemical parameters are below the living standard of aquatic fauna (Table 7.1). It has also been reported by the respondents (FGDs & KIIs) that fish stocks in the areas have gone down, therefore, fisherman can no longer fully depend on fishing and have to look for alternative income-generating activities.

As a Riverine country, Bangladesh has traditionally relied on water transport but due to heavy pollution and gradually narrow down together with a reduction of river depth by siltation, navigation or transportation is severely hindered which is also supported by the survey data. Other productive uses of which river has been used traditionally like irrigation, watering plants, and livestock, etc. were completely absent in this water survey. Also, the use of already contaminated river water with industrial toxic greatly affected and reduced agricultural production (Table 7.1). It reveals that the Turag River is not useable for recreation purposes such as angling, swimming, etc.

Although the water is certainly unfit for any kind of household activities but still is considered quite acceptable and widely used by a large group of studied people. As, many of the poor support safe water for drinking and cooking, again many of them use river water for cooking and household uses. Using these deadly poisonous river water for daily household purposes result in various diseases like diarrhea, skin diseases, typhoid, jaundice, various mosquito-borne diseases (REACH Survey, 2018) as water is loaded with chemical from industries and *E. coli* discharging from sewerage, open defecation, hanging toilet, etc. Using this polluted water for bathing, dish and cloth washing and personal hygiene increase the health risks of the users, which is also evident from the DoE report where the level of water quality parameters such as pH, BOD, DO, COD, TDS, Chloride, Alkalinity level of this river is below the standard of domestic use. As men, women, and children of this group do not have access to the minimum requirement of safe water result in putting the whole community at risk.

Thus, the social cost of increased emissions of the Turag River over time can be summarized: as toxins are discharged into the atmosphere (Turag River), the resultant social costs are measured by how far the pollutant flows and how the pollution affects downstream water quality by changes in physical, chemical, and biological indicators. In essence, how does decreased water quality impact environmental resources in downstream areas, such as clear water for cooking, bathing, fishing, sources of accessible drinking water, or healthy water that protects a variety of natural flora and fauna, and the depreciation of the dependent community's resources such as fisheries, navigation, transportation, irrigation, recreation, and so on.

The pathways through which pollutants eventually affect humans and contribute to the societal cost of water pollution are represented in a simple conceptual diagram adapted from Freeman, Herriges & Kling (2014, p. 31)-

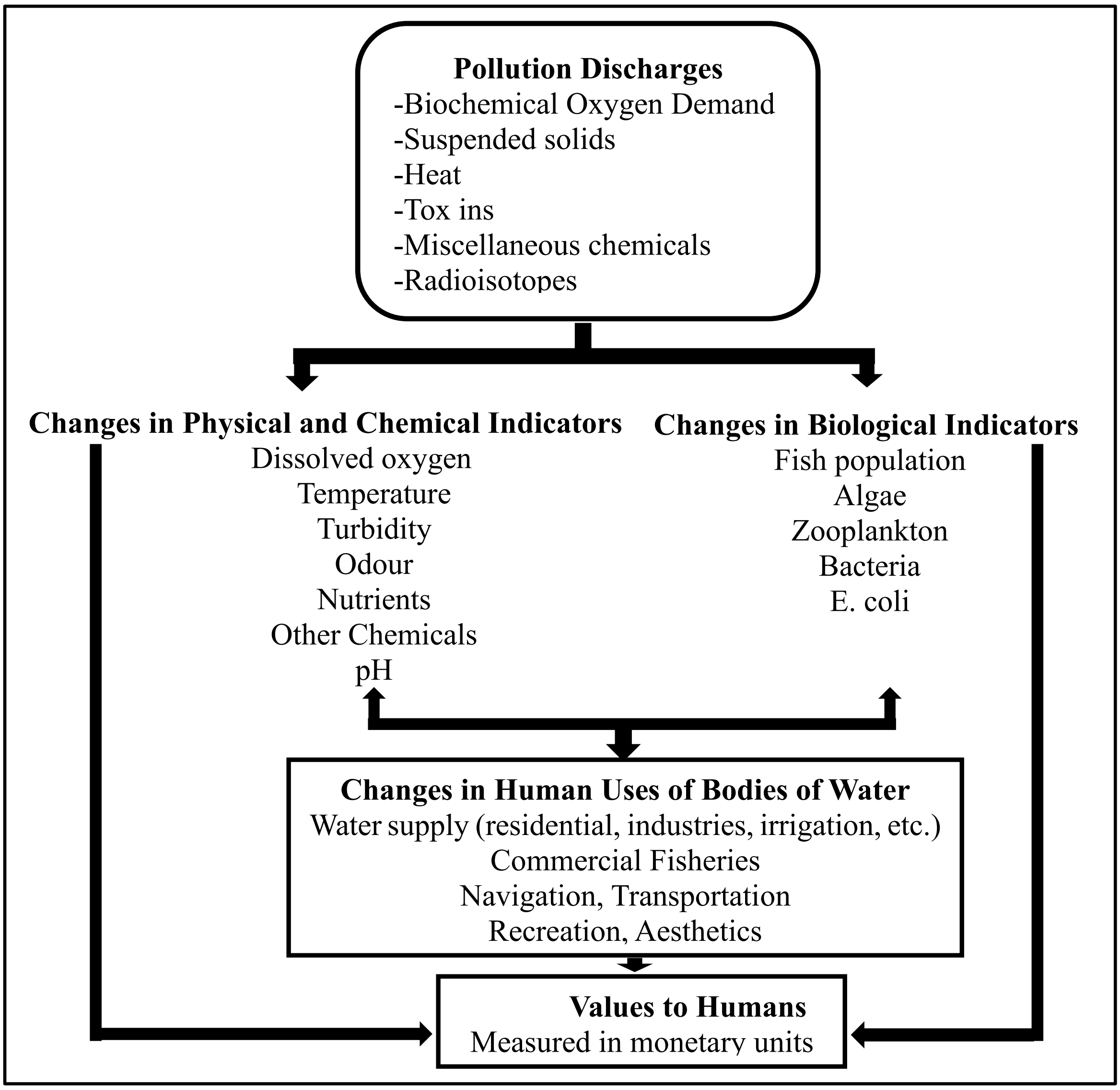


Figure 7.10: Conceptualize the welfare benefits from ambient water quality

7.9 Conclusion

Although Bangladesh has achieved success in MDG in water-related issues still there are challenges related to the shortage of ground and surface water particularly during the dry season, access to safe water, and controlling water quality. Because water resources are inextricably related to economic growth and poverty alleviation, there is a need to strike a balance between their usage and exploitation. Transitioning to a more water-secure environment has been shown to spur economic growth. This study aids in selecting the best alternatives for managing water resources, as well as the implementation of efficient pollution-reduction strategies.

Photograph 3a: Interacting with Turag River for various purposes

The photo represents all most all perspectives of water use by local community specially those who has no alternative sources of water. Almost all the household activities like washing clothes and utensils including personal washing and collecting water for intimate washing are also showed up. All categories of gender group including men, women, elderly, girl, and boy are found to interacting this polluted water for their own purposes.

Photograph 3b: Washing clothes and utensils in extremely polluted river water (feacal materials surrounding around)

Photograph 3c: Taking bath in river

Photograph 3d: Hanging toilet over Turag River

Photograph 3e: Children playing with river water as part of their recreation

Photograph 3f: Using River as a route of navigation

Photograph 3g: Transporting people from one place to another

Photograph 3h: Duck rearing in Turag River by the neigbouring community

Photograph 3i: Using River water for irrigation

Photograph 3j: Boat houses on Turag

Chapter 8: Urban Water Use: A Gendered Analysis

This section focuses on how water insecurity affects men and women differently in the context of urban water use. Specifically, the study investigates gender-specific roles of women and men in the household water management which may create specific challenges for safe water access. This report analyzes the gendered impacts of water insecurity in some selected Turag River areas of Dhaka, Bangladesh. The overall purpose of this research is to generate findings that can be useful in developing evidence-based policies for gender sensitive water management.

8.1 Introduction

The last century embarked on a global water crisis urging to advocate for safer water access around the world. At present, around 785 million people in the world (every 1 to 9) are living without access to safe water of which nearly 144 million people are dependent on surface or open sources of water to meet their basic needs (WHO, 2019). The basic elements driving this crisis are rapid economic expansion, population growth, urbanization, and climate change variability (Hoff, 2009; Bogardi et al., 2012). The water issue has serious consequences for people's lives and livelihoods, as well as for the general economic growth and social prosperity of those impacted, especially women (Fonjong & Ngekwi, 2014). The rapid growth of slum populations, particularly in developing countries, outpaces local and national governments' ability to provide adequate water and sanitation facilities in those communities, resulting in an increase in the number of people without access to safe water and sanitation in urban areas (WWAP, 2015).

Women, girls, and children in developing countries altogether constitute two-third of the people currently struggling daily to locate and transport water for drinking, cooking, and washing purposes (UN-Water, 2013), along with for maintaining personal hygiene, cleaning as well as for some subsistence production in homestead gardening or raising of poultry and goats (Crow et al., 2002; Nasreen, 2012). Women are considered as protectors and managers of water sources, they also monitor water quality and devise strategies to conserve water supplies in times of scarcity for their families and community (World Water Vision, 1999). Fulfilling everyday water requirements for domestic purposes is generally the responsibility of women and girls in almost all developing countries, where water scarcity creates a hindrance to meet their demands. In a developing country like Bangladesh, it becomes more complicated due to the presence of a hierarchical household structure with a clearly demarcated gendered division of labor (Sultana, 2012). Access to potable water remains a nightmare to marginalized urban populations with women and children bearing the burden. Women's central role in water providing, management, and safeguarding was highlighted in Principle 3 of the 1992 Dublin Statement on Water and Sustainable Development (ICWE, 1992) (Fletcher et al., 2015).

Gender and water interaction in a peri-urban terrain evolve and manifest through revised roles and responsibilities that challenge the stereotypical social construct of men and women. In the social context of Bangladesh, women and men have unequal access to water resources due to their differentiated roles. Here women are the only ones who are concerned with domestic water fetching and storage; regarding decision making, control over water resources, productive water use men play their roles. Because of the transitory nature of the landscape, altering the lifestyles, aspirations, and access to commodities, access to water becomes crucial in peri-urban locations. Consequently, women’s involvement in multiple tasks increases due to male migration for daily wage work outside the village. Peri-urban areas being outside the formal administrative system, where water supply is dependent on elements such as electricity, the physical condition of pipe networks, distance, and location of the water source, gender relations may affect accessibility or inaccessibility to water there. Because of the changing nature of the peri-urban terrain coupled with the institutional and planning vacuum within which they are located, gender roles surrounding water constantly evolving (Sing et al., 2016).

Globally in almost three-quarters of households and some countries, the proportion is more than 90 percent, access to drinking water on the premises is not available (UNICEF-WHO, 2011). According to WHO (2019), in 2017 about 71 percent of the global population (5.3 billion people) used a safely managed drinking water service which includes a source, one located on premises, available when needed, and free from contamination. Furthermore, 90 percent of the world's population (6.8 billion people) used at least one essential service (improved drinking water) that can be accessed within 30 minutes (roundtrip). Women and girls in poor nations travel an average of 6 kilometers (3.7 miles) each day, spend an estimated 40 billion hours hauling water each year, and work up to 8 hours per day (CAP-NET & GWA, 2006; UNDP, 2006; Caruso, 2017). Ensuring enough water to satisfy household requirements has a direct impact on women's health, education, and career opportunities. The adverse health effects of daily water carrying are becoming more widely acknowledged, and small-scale studies have been conducted to explore them (Geere et al., 2010; Evans et al., 2013; Geere, 2015). Fetching water also takes time and limits the economic productivity of women. Adolescent girls who help their mothers in carrying water and other household chores often become dropped out of school (Nasreen & Tate, 2007). The city's water condition is impacting women and girls, as well as having a far-reaching influence on the municipality's growth and socio-economic development. (Fonjong & Ngekwi, 2014). When water sources are far from homesteads, women and girls are more exposed to danger, such as the possibility of sexual or other forms of assault. This study, therefore, facilitates finding out gaps in gender policy and gender specific challenges which can be helpful to draw policies on how women's skills can be utilized in a more productive way that can contribute to the national economy by ensuring water security[90].

8.2 Objectives of the Study

This study aims to understand the differential impacts of water insecurity on gender-specific roles in water management and to identify sustainable solutions to their everyday water problems. The specific objectives are as follows:

i. to evaluate household water insecurity and gender division of labor in managing everyday water needs;
ii. to find out gendered responsibility and time taken to fetch water;
iii. to find out various challenges faced, and health risk associated with fetching water; and
iv. to formulate policy lessons regarding the issues.

8.3 Methodology of the Study

This study uses both primary and secondary sources of data. To collect **primary data** on gendered issues four primary data collection methods have been applied, such as-

i. HH questionnaire survey**:** A total of 1826 samples has been drawn from twelve selected areas namely, Konabari, Kashimpur, Ichharkandi, Palasana, Gutia, Gusulia, Bhakral, Bhadam, Rashadia, Kathaldia, Abdullahpur, and Mausaid (***Map 3***) based on proximity of Turag River and level of river pollution. Households were interviewed with a standard semi-structured questionnaire.

ii. Water use behavior survey**:** The selection of this tool aims to find out community interactions and purposes of river use. Eight (08) days of water use behaviour survey

[90] A summary of the gender-based research findings titled ‘Water security is not gender neutral’ can be found in the REACH blog: https://www.grripp.net/blog

research (observation) had been conducted at two sites, Konabari and Abdullahpur. The observation started at 7 am and ended at 5 pm every day.

iii. Focus group discussion (FGD): Six (06) Focus Group Discussions (FGD) had been undertaken at the area of Kashimpur (Male group), Konabari (Female group), Bhadam (Mixed group), Bhakral (Male group), Abdullahpur (Female group) and Mausaid (Mixed group). In total forty-two (42) adult (age >18) participants attended these six FGDs.

iv. Key Informants Interview (KII): Twelve (12) Key Informants Interviews (KIIs) had also been conducted at the same site selected for FGDs. Stakeholders included personnel from local government, youth leader, health official, user group etc.

The relevant information has also been collected from various **secondary sources** such as books, journal articles, national and internal documents/reports, gender policies etc.

*Details about data collection tools have been well discussed in **Chapter Three of Methodology**.*

8.4 Data Analysis

Quantitative data collected through the ONA survey questionnaire were converted into excel form and analyzed using the Statistical Package for Social Sciences (SPSS) version 23. Cross tabulation test has also been utilized to find out the relation between different variables, frequency, percentage, mean, standard deviation etc. Data from FGDs, KIIs were categorized and discussed under three broad themes of water-related household activities, gendered responsibilities, and associated risks or challenges (Appendix table D1, D2 & D3). A water-use behavior survey has been conducted using GIS Cloud software and the CSV file generated was transferred into an excel file. Tables, graphs, and photographs are used to present data.

8.5 Analytical Framework

Developed by Norman long (1988,1992) the "Actor oriented theory", mainly used for development studies, can also be of great implication on gender analysis. The actor-oriented approach implies that the division of labor and responsibilities, social attitudes, and unequal access to resources all contribute to a situation where policies and programs have a different impact on women and men. Actor oriented theory focuses that male and female have their different activities to do for their family which has been decided by society. In this paper gender dimensions of water insecurity[91] (Long, 1988 & 1992; Long & van der Ploeg, 1989; Long & Van der Ploeg, 1994) and the concept of water security[92] (GWP, 2000; Grey & Sadoff, 2007; Vörösmarty et al., 2010; Cook & Bakker, 2012; Lautze & Manthrithilake, 2012) are analyzed using the actor-oriented approach. The analysis of gender dimensions of water insecurity at a micro-level using the actor-oriented approach has shown that households, men, women, girls, and children play different roles in ensuring household water availability. An actor-oriented analysis explains social actors referring to individuals, households, groups, and institutions act to provide water security (Magadlela, 2000). More specifically, social actors are households and individuals within households who are negatively impacted by water scarcity and who actively participate (in this case, by fetching water for household consumption) in ensuring household water availability.

8.6 Study Findings

8.6.1 Household water insecurity and water sources

As mentioned earlier, the main water sources of studied areas are electric/motor tube well (73.8%, n=1348), public pipe and tap water (23.3%, n=426), shallow and deep tube-well (2.6%, n=48), and various open sources of water (2.8%, n=51) (Appendix table C2). The community people also collect water from other sources (0.7%) such as neighbor's households, compressor pump, madrasas, or mosque submersible, etc. as they do not have the access to other main sources of water. Besides, among 1826 households only 23.3 percent has been supplied with water from government sources such as tap and pipe water, where most of the households (76.4%, n=1396[*MR]) depend on privately installed sources (shallow or deep tube well, electric or motor tube well/borehole) and rest 4.2 percent (n=68[*MR]) depend on various vended/open sources/other non-fixed sources of water (Appendix table C2). Among those who are dependent on shallow and deep and electric/motor tube well, only 41.1 percent (n=574) households had owned the apparatus, whereas the rest 58.9 percent (n=822) collect water from the sources of their extended families (cousin, relatives etc.), unrelated families (neighbor, landlord), group of families (collective), community level installation (Table 6.2). Therefore, there is an existing pressure of water insecurity among non-ownership (water resource) households or groups.

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[91] Water insecurity refers to unavailability and inaccessibility of enough water of good quality to meet households' domestic, productive, and environmental needs (Webb & Iskandarani, 1998).
[92] Water security refers to the availability of, and access to water in sufficient quantity and quality to meet every day needs of all households throughout the year (GWP, 2000).

8.6.2 Gender division of labor in household water management

8.6.2.i Water-related household activities and gendered responsibility

Women in a household is the main actor of different water-related activities starting from cooking, washing, and to the collection and storing of water having an unequal social division of labor. In the present study, the participants of FGDs (n=6) and KIIs (n=12) named cooking, washing (vegetables, clothes, utensils), collecting, and storing water, and bathing of children as their most common water-related household activities (Appendix table D3). In the present study, findings of FGDs and KIIs (Figure 8.1) revealed that water-related tasks were being performed by female members of the families in 50 percent of cases whereas female children represented 30.3 percent. The involvement of adult male and male children was found to be represented by only 16.7 and 3.0 percent (Appendix table F1).

"Women have always been doing the most work related to water in the household. There is not much change in that aspect, however, I do think that men try to help women in the house as much as they can, but still, women do the most work."

-Robert Correa (41), KII, Mausaid

Dependency on the river, canal, pond, and lake for drinking (2.5%; Appendix table C4) and to serve for other domestic functions (Appendix table C9) has also been documented at a diminutive but very admirable rate. But the problem exists in, river water which is not that standard for community consumption. Community people only use this water for washing purposes such as cloth washing, vegetable washing, property washing, bathing, and other household activities but they collect cooking and drinking water from nearby accessible sources. According to an intra-household questionnaire survey, among 1826 households surveyed interacting with the river for domestic purposes were mainly performed by the adult female (2.1%). Adult male (0.4%), female children (0.4%) and male children (0.3%) interaction with the river for domestic purposes have also been reported (Appendix table F2).

Data from the river use behavior survey (observation) also shows that women (46.6%) remain the highest in interacting with the river than men (36.4%) followed by girls (10.3%) and boys (6.7%; Appendix table E4). They interact with the river for various activities such as water collection, dishwashing, cloth washing, washing of belongings, personal washing, and bathing (Appendix table E6).

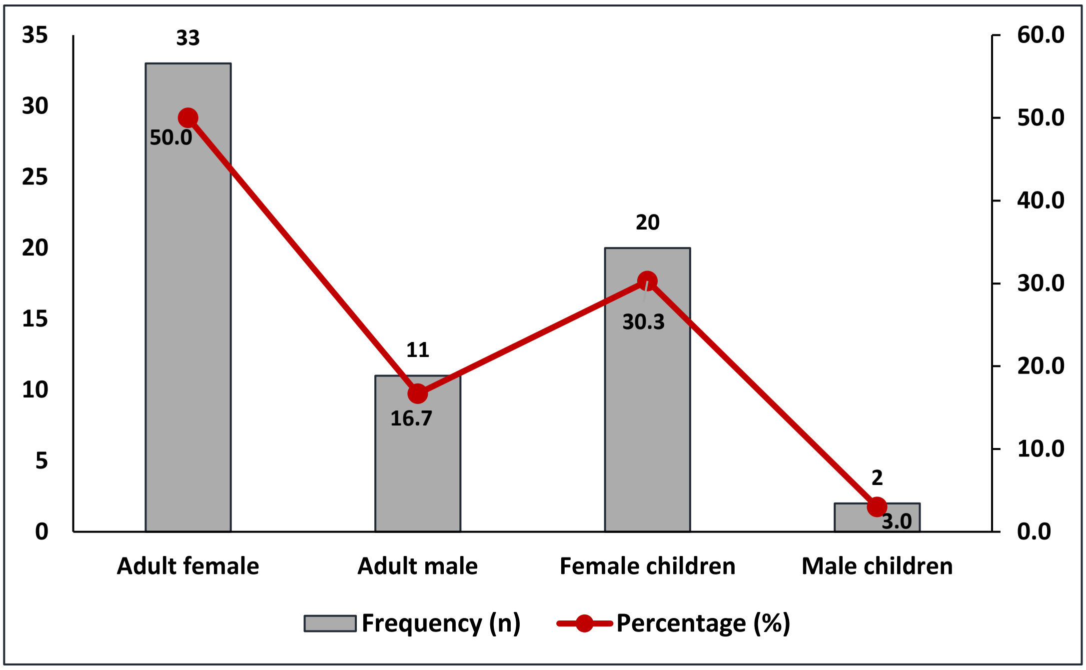

Figure 8.1: Gendered responsibility (%) of water related household activities

8.6.2.ii Time of the day to do household tasks

Likewise, in other communities, the studied population also appears to perform almost all the water-related domestic activities such as cooking, washing clothes and utensils, collecting, and storing water, and child bath in the morning (36.2%) and at noon (38.3%; Figure 8.2; Appendix table F1). Among those household activities, water collection is noted to be carried out all day long whereas, cooking (including vegetable washing) and utensils washing are done two times of the day- in the morning and at night (Appendix table F1). Afternoon (4.3%) and evening (6.4%) seem very inactive time that later increases again at night (14.9%; Figure 8.2; Appendix table F1). Washing clothes and bathing children are mainly performed within the period of 6:00 am to 1:00 pm (in between morning and noon)[93]. Preference to do most of the household activities in the daytime specifically from 6:00 am to 1:00/2:00 pm is very well noted in the studied communities. Activities like cooking and utensils washing are seen to perform both in the daytime and at night (Appendix table F1).

Mumtaj Khatun (49) whose daughter works in a garment's factory, stated that-

> "I have become aged. So, my daughter brings water before going to work. She also brings water at lunchtime and after finishing her work."

[93] Time slots for morning (6:00-10:00 am), noon (10:00 am-1:00 pm just before Dhuhr azan), afternoon (1:00 pm-4:00 pm, just before Asr azan), evening (4:00-6:00 pm/just after sunset, in between Asr and Magrib time) and night (7:00-10:00 pm) is set as per the respondent's community

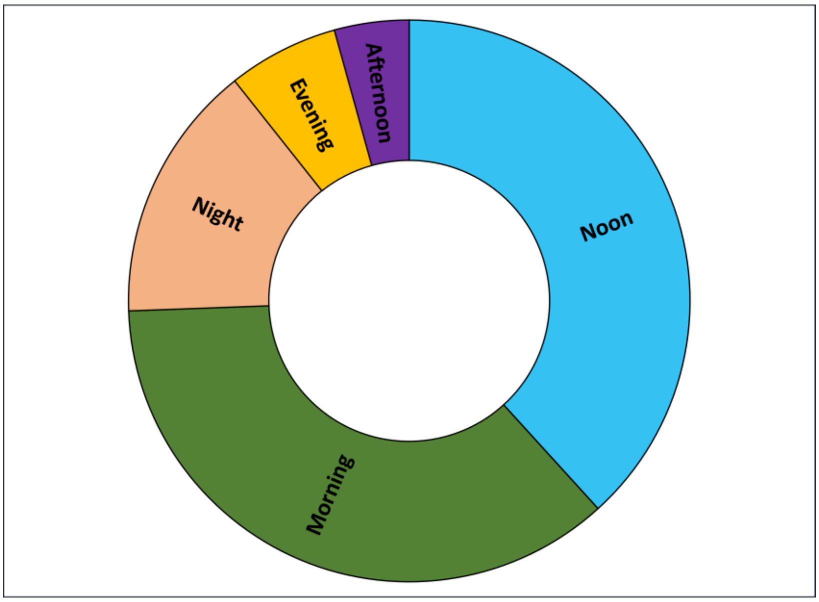

Figure 8.2: Prioritized time by the communities to do their household tasks

8.6.2.iii Time taken to carry out the tasks

Findings of FGDs show that cooking takes a maximum time of 1.30 hour to 2.30 hour among other household activities. Time taken to collect and storing water is a minimum of ten minutes to a maximum of two hours. This time variation may be due to several round trips of water collection depending on the distance of the water source. Bathing, washing clothes, and utensils take on an average of 10 to 35 minutes. Differences in time used to accomplish each of the domestic tasks are due to ownership of water services, the distance of water source, volume of water needed, family structure etc. All other activities as washing clothes, utensils and bathing take 10 to 35 minutes (Table 8.1).

Table 8.1: Time is taken to do various water-related household activities

Activities	Time is taken
Cooking	1.30 to 2.30 hours
Washing clothes	10 to 30 minutes
Washing utensils	20 to 35 minutes
Collecting and storing water	10 minutes to 2 hours
Bathing	10 to 30 minutes

Source: FGDs (n=6), 2018

8.6.3 Gendered responsibility of fetching water and time taken

8.6.3.i Household members responsible for fetching water

People mainly collect and store water for various purposes starting from drinking, cooking, washing, and sometimes for bathing. Water fetching behavior is observed in both groups who have their water services and who do not have. Fetching practices from their own sources are common due to the more convenient use of water whenever it is needed, in this case, water service installation is located outside the home but in a common place in their premises. Water fetching increases the burden to those who do not have their water services. Among the respondent's 58.9 percent (n=1075) (Appendix table G14) admit that they store large quantities of water for at least a few hours due to difficulties in fetching water as and when needed. Of the total 1826 households surveyed, the total gender count is 7134, where males represent 50.1 percent and females represent 49.9 percent (Table 5.2). Study findings also revealed that females (97.1%) are mainly responsible to collect water for household necessities more than their male counterparts (29.6%; Figure 8.3). Female children (10.4%) are also engaged in collecting water sometimes alone or accompanied by their mothers more than that of the male children (5.0%) (Figure 8.3; Appendix table F3). According to the MICS report 2019, about 98.5 percent of the population in Bangladesh uses improved drinking water sources, with 98 percent of household members using improved sources of drinking water from their dwelling/yard/plot. Nationally, 17.6 percent of household members do not have access to drinking water on the premises whereas in Dhaka it is 10.4 percent.

MICS[94] report also shows that in most households in Bangladesh water sources are not available on the premises, water is usually collected by an adult woman (85%) followed by adult male (9.7%), male children (0.7%), and female children (3.0%), these gendered group variation on water fetching practices strongly support the present study findings (Appendix table F3).

As stated by Momtaj Begum (52), a garments worker from Konabari

"We have to stand in lines thrice a day to fetch water from the tap. Girls go more often to collect water as men remain busy at industrial work and can't manage time for household activities"

[94] According to MICS (2019), adult male and female are in the age of 15+ whereas male and female children are under the age of 15

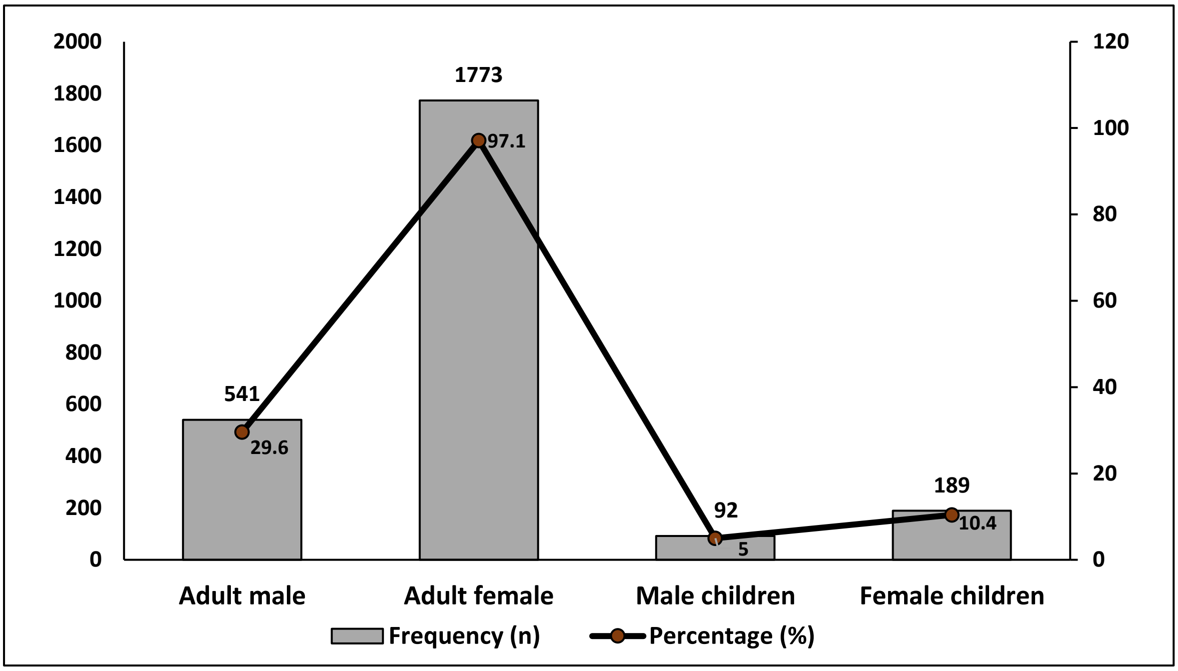

Figure 8.3: Gendered responsibility of water collection

8.6.3.ii Time spent to fetch water

If water services are not accessible on the premises, it has previously been mentioned that women and girls' children undertake most of the water collecting. Water collection and transportation takes time. Time spent may be a better indicator to detect the burden of fetching water in some locales. Walking to water sources, waiting in line, and carrying water may take up to four hours a day and are undertaken primarily by women and girls (UNDP, 2006), time that may be better spent on productive tasks or childcare (WHO, 2003). In the present study, less than 5 minutes has been spent by the majority of studied communities (69.8%) as they collect water from their premises. Also, 5 to 30 minutes is spent by a considerable percentage (29.5%) of respondents where they collect water either from combined or community sources or from the nearest water point where they live. More than 30 minutes up to 1:30 hours (0.6%) are recorded in a very minimum percentage depending on the distance of water sources from their residence in an urban setting (Figure 8.4; Appendix table F4). During the dry season, the burdens of fetching water to serve the household need considerably increase (FGD), though the results do not consider the season or the number of trips per day.

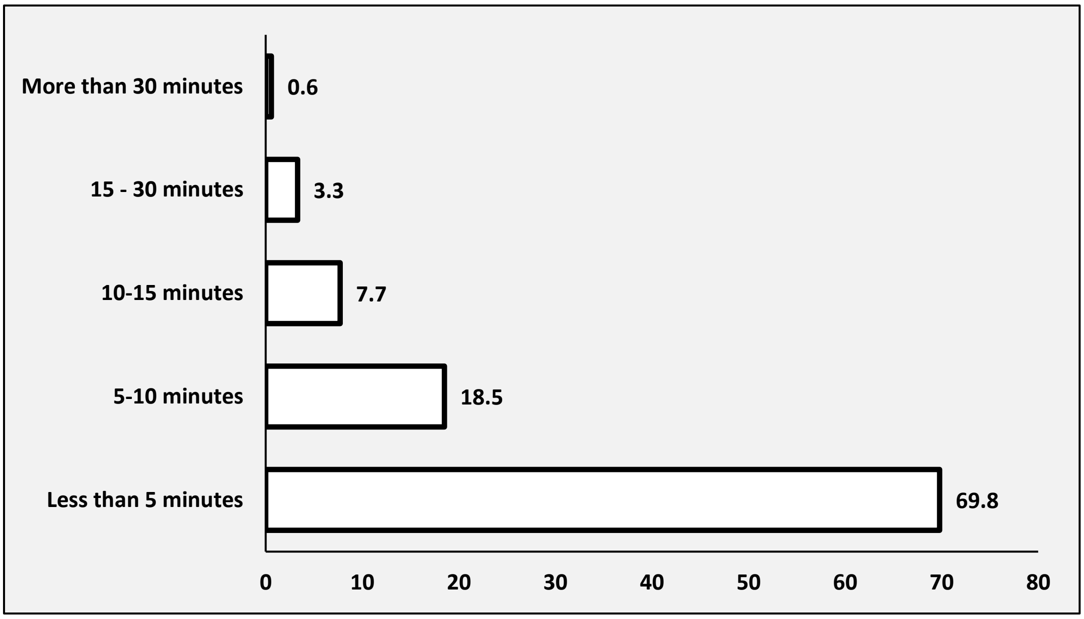

Figure 8.4: Time spent (%) to fetch water

8.6.3.iii Time spent by gender group

As mentioned in the earlier section that water fetching is the main responsibility of females (97.1%) followed by the male (29.6%), female children (10.4%), and male children (5%) (Figure 8.3; Appendix table F3). From Figure 8.5, it is apparent that the female group spent more than double time in fetching water than other gender groups of the respondent households (Appendix table F5). Time breakdown by gender group shows that less than 5 minutes to fetch water has been spent by 68.3, 23.4, 3.7, and 7.5 percent of adult male, adult female, male children, and female children, respectively. Moreover, 5 to 10 minutes are spent by 17.4 percent female, 3.7 percent male, 1.8 percent female children, and only 0.8 percent male children (Figure 8.5). Again, 10 to 15 minutes are spent by 1.3 percent male, 7.6 percent female, 0.3 percent boys, and 0.5 percent girls like that of the 15 to 30 minutes spent by gender groups. Spending time for more than 30 minutes is exceptionally low but remain highest as usual in case of adult female (0.6%) and only 0.1 percent has seen for both adult male and male children (Figure 8.5; Appendix table F5). A systematic review of studies of water-fetching finds that the task of getting water causes physical and mental stress on female water carriers, including higher risk of injury, micronutrient insufficiency, and gender-based abuse (Geere et al., 2018). More time spent in collecting water results in less time for productive use amongst the female group.

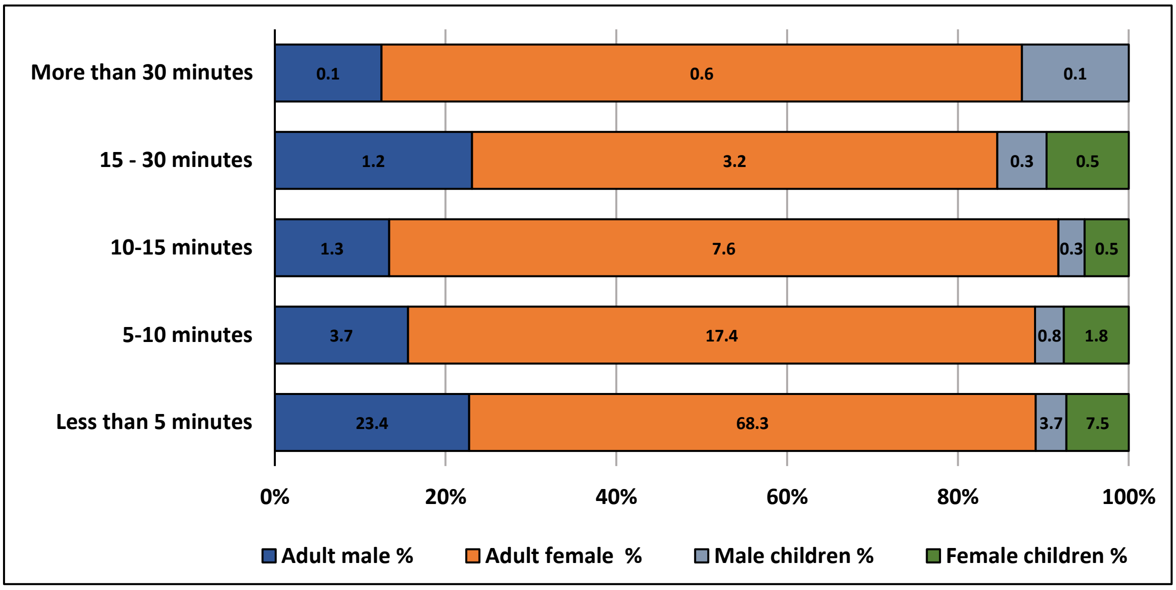

Figure 8.5: Time spent to fetch water by different gender group

8.6.3.iv Time of the day people go for fetching water

It has already been mentioned that people fetch water round the day (Appendix table F1) to meet their household needs. Findings of FGDs (n=6) and KIIs (n=12) also reveal that people go for fetching water mainly in the morning (n=11), an afternoon (n=5), in the evening (n=4), and at night (n=2). Respondents who work in garments are mainly seen to collect water two times a day that is in the morning and then in the evening, and others usually collect water three times a day or whenever it is needed (FGDs & KIIs) (Appendix table D3 & F1).

"Most of us collect water in the morning. However, since the majority of us now own individual submersible or motor pump, we can collect water at any time."

- Suniti Sarkar (53), FGD, Mausaid

"Most people collect water in the morning, noon, and evening. Collecting water once in a day does not fulfill the requirement of water in a family."

- Bashir (32), FGD, Abdullahpur

8.6.4 Challenges and Health problem associated with fetching water

8.6.4.i Challenges associated with fetching water

The majority of the respondent's household (82.6%) stated that they did not experience any challenges while fetching for water but a certain percentage of them mentioned challenges like a dispute with neighbors over water collection (8.4%), feeling uncomfortable (4.3%) in using someone else's sources as they did not have any entitlements on this resource, and long queue (0.9%) ranked highest as their major challenges while going for fetching water

(Table 8.2). Some very gender-specific but mention-worthy challenges mainly documented in the case of females such as unsafe feeling (1.3%) and go through sexual harassment or eve-teasing (0.1%) while going for collecting water have also been stated by the respondents (Appendix table F6). Other challenges reported include insufficient water (0.3%), interrupted water supply (0.2%), risk of accident as they have to cross the road (0.2%), etc. (Table 8.2).

Table 8.2: Challenges faced by the community while fetching water

Challenges faced while fetching water	Frequency n	Percentage %
No Problems	1509	82.6
Quarrels/conflict with neighbors	154	8.4
Felt uncomfortable using someone else's source	78	4.3
Felt unsafe	23	1.3
Physical/sexual harassment/eve teasing	2	0.1
Long queue	17	0.9
Water is not sufficient	6	0.3
Interrupted electricity supply	3	0.2
Had to cross the road	3	0.2
The physical burden associated with carrying heavy water containers	187	10.2
Total	**1982*MR**	**108.5**

Source: HH Survey, 2017-18; *MR=Multiple Responses

Survey result of FGDs and KIIs also confirms similar challenges together with some additional challenges like bullying while using other sources of water without asking, the burden of carrying heavy loads of water containers for elderly, poor or undrinkable water quality etc. Dispute or clash with people in the line who should go first, it may be that one person is in a hurry and wants to go first, another person may object is quite common and occurred on regular basis (Appendix table D3).

Some good practice has also been stated and practiced by the community of Abdullahpur (FGDs & KIIs) where they have gender-specific separate spaces and tanks for collecting, bathing, and other domestic activities. Men and boys do their works in their assigned space whereas women and girls do their activities in their assigned spot. Due to this practice, teasing or other types of violence are not experienced by the women in this area according to the participants.

8.6.4.ii Health problem of fetching water

HH survey shows those who fetch water from different sources face a physical burden for carrying heavy water containers (10.2%) and thus resembles the findings of FGDs and KIIs (Table 8.2). According to the participants of FGDs and KIIs, back pain is the most common physical problem they encounter as carrying a heavy load of the water container. Women's health is particularly affected by the burden of carrying water, and the problem is severe for elderly and pregnant women also; therefore, they must depend on other family members to do it. Carrying a heavy load of containers and completing roundtrip more than twice a day is also very tiring for the women (FGDs & KIIs). In its worst (FGD, n=1), carrying heavy water containers results in abortion for pregnant women (Appendix table D3).

8.7 Discussion

Revisiting the research objectives in this section, I will try to give an overview of how participants were or were not answered and if the result fits or does not fit with prior research.

8.7.1 Household water insecurity and water source

Though most of the studied community used improved sources of drinking water (electric tube well, piped, and tap water), non-ownership of water services (58.9%) makes women be in a disadvantageous position and exert pressure on convenient water use in time of need. Lack of home water connections, round-the-clock water service, and adequate water storage infrastructure intensified water insecurity at the household level (Ansari et al., 2011). Where water supply is a fixed system and if water supplies become scarce or contaminated or fall into disrepair, women and girls need to look for alternative sources (CAP-NET & GWA, 2006; Chipeta, 2009; IFAD, 2012; CAP-NET & GWA, 2014) and need to travel long distances over many hours to meet their families' water needs (WSP, 2010). To fulfill everyday household water needs for drinking and other domestic uses, women feel pressure to search for convenient sources. Their search for sources not only depends on availability, proximity, and purpose of use (Sultana & Crow, 2000) but also on negotiating with neighbors on daily basis (Sultana, 2012). This, therefore, puts women in a more disadvantaged position in the family than their male counterparts.

8.7.2 Gendered responsibility of household activities and fetching water

It is widely recognized that women in most societies are charged with the responsibility for domestic water management for drinking, cooking, and washing, it being an intrinsic part of their daily chores in the home and taking care of the family (IDRC, 1985; van Wijk-Sijbesma, 1998; DAW, 2005; UNDP, 2006; Bouwer, 2006; Ghosh, 2007). Likewise, the present study also reveals that in 80 percent of cases, the water-related task is being performed by female members of the families where male involvement (including male children) is seen in very minimum extents (19.7%) and mainly in the tasks of collecting water and washing clothes (Appendix table F1). The affluent are more likely to have drinking water on their property, whilst the impoverished are obliged to spend more time gathering water from public or other outside sources (UNICEF, 2020). This, therefore, puts women in a more disadvantaged position when water is scarce or supply systems in metropolitan areas are disrupted (Chipeta, 2009).

In terms of the burden of responsibility and distances traveled to access water sources, water collection is a cultural and gender-related activity (Makoni et al., 2004; Coles & Wallace, 2005; UNDP, 2006; Franks & Cleaver, 2007). In general, there is a clear link between water shortage and women working as water fetchers (Sorenson et al., 2011). In Bangladesh, as in many developing countries around the world, women are the most prevalent water carriers and spend a significant amount of time supplying water to their households (WHO & UNICEF, 2011). The present study shows women are the main collector of water (97.1%) together with girls (10.4%) of the families (Figure 8.3; Appendix table F3). Only 29.6 percent of adult males along with 5 percent of boys are involved in water collection (Figure 8.3; Appendix table F3). The male group usually does not participate in fetching domestic water for drinking and cooking as that is deemed to be a feminine task, one especially suited to younger women and girls (Crow & Sultana, 2002). Similarly, UNICEF 2013 survey shows that 89.6 percent of women collect water for families, compared to 4.6 percent of men who do the same (UNICEF, 2020). Women collect 70 percent of household water in poor regions like Africa and Asia, whereas males collect 30 percent (Andajani et al., 2015).

Research elsewhere has also confirmed that women, girls, and children are the most common water carriers around the world, and they spend considerable time supplying water to their households (Sorenson et al., 2011). In the present study, the studied population reports spending a minimum of 5 minutes (69.8%) to a maximum of 1:30 hours (0.6%) per day to fetch water depending on the distance of water sources from their residence in an urban setting (Figure 8.4; Appendix table F4). Where on average 5 to 30 minutes has been spent by 29.5 percent of household members on daily basis (Appendix table F4). The present study also reveals that the female group spends more of their time fetching water than the male group (Appendix table F5). Time breakdown to fetch water by female and male group shows, 'less than five minutes spent' by 75.8 percent female and 27.1 percent male, '5 to 30 minutes spent' by 31 percent female and by only 7.6 percent male, 'more than 30 minutes spent' by 0.6 percent female and only 0.1 percent male (Figure 8.5; Appendix table F5). This time is comparable to that established by the MDG and the work of Benneyworth et al. (2016) where water collection trips took 20 min or less (one roundtrip) in 81 percent of cases. Regarding using basic drinking water services in urban Dhaka, about 89.9 percent of users are found to have a water source directly on their premises, in the case of 83.2 percent of users it takes less than 30 minutes to get to improved drinking water sources, and for 12.4 percent it takes more than 30 minutes which is 31 minutes to 1 hour by MICS (2019). According to WAB (WaterAid Bangladesh)[95], the time required to collect water should be within 30 minutes that includes going to the source and coming back home including waiting for the time and condition of the facility. HDRC (2017), baseline study on WASH for community development in Banglabazar, Gazipur reports that 41.8 percent of the households take less than 5 minutes, and another 12.4 percent takes 6-10 minutes to collect water for their daily need which also complemented the present study. On average, the time is taken for water collection to travel, queue to get it, and return to home is 2.6 minutes, the meantime to fetch water varies greatly, and gender differences are noted in the time spent fetching (Sorenson et al., 2011).

In the case of the present study, distance and time spent are not facts and do not create any hardship, but the non-ownership, non-accessibility of sources, and unavailability of sufficient water have a great impact on everyday water security.

8.7.3 Associate Challenges and Health Risk

Non-ownership (58.9%), unfixed or irregular, damaged, or repairing of water services force people to collect water from other alternative sources which may create challenges and possibilities of health risks. Conflict with neighbors over water (8.4%), uncomfortable (4.3%) and unsafe (1.3%) feeling and long queue (0.9%) are identified as major challenges by the respondent households together with insufficient water, sexual harassment, risk of

[95] https://www.wateraid.org/bd/sites/g/files/jkxoof236/files/baseline-study-on-wash-for-community-development-in-banglabazar-gazipur.pdf

crossing road during water collection (Table 8.2). In densely populated urban areas, improved water sources might be nearby, but women and girls may spend hours (an hour or more) queuing or waiting in line for intermittent water supplies (WEDO, 2003; Ray, 2007). People who collect water from a standpipe must queue for a long time, yet they constantly fail to collect the required amount of water (Yeazdani, 2016), which is consistent with the findings of this study. Long queues at water stations can lead to confrontations with other users, with women and children being the primary focus of these disputes due to their obligation to gather water (HPN, 2014). Lack of enough public water points is responsible for this long waiting lines and conflict (CAP-NET & GWA, 2014). Fetching water can also be dangerous for women and girls, since they may confront conflict and the possibility of physical or sexual assault at water points (Geere et al., 2010; HPN, 2014; Caruso, 2017). In addition, while fetching water from other private wells, women are occasionally subjected to abuse (Shah, 2002; IFAD, 2007).

Despite the fact that women and children in developing countries are required to carry large containers of water over long distances on a daily basis, no comprehensive research on the impact of this on musculoskeletal health have been conducted (Hunter et al., 2010). But some research shows that the daily burden of fetching water for families has direct negative effects on women's and girls' health (Sandys, 2005; IFAD, 2007; Geere et al., 2010; Andajani, 2015). These activities have been proven to take up to 30 percent of a woman's or a girl's daily energy and cause physical problems to the spine, neck, back, and knees (Page, 1996; Ray, 2007). Women and girls in some countries spend up to eight hours a day carrying up to 40 kg of water on their heads or hips, resulting in injuries (CAP-NET & GWA, 2014.).

Regarding health problems, the qualitative results documented back pain, tiredness, and skin-related problems as the main health risk of carrying heavy water loads. Injuries to the back, neck, or other joints while carrying water are treated as side effect or a one-time occurrence (Bimla et al., 2003; Sorenson et al., 2011). There is evidence that years spent hauling heavy loads of water over long distances can injure the back and neck (Geere et al., 2010). Continuous back pain can result in spinal injuries (WHO, 2001), which can cause loss of feeling or paralysis in the legs, arms, or entire body (WHO, 2013). It is also suggested that the heavy loads they carry may cause skeletal deformation and accelerate the deterioration of joints (WHO, 2001). Multiple trips must be made each day to obtain sufficient water for the household, thereby increasing caloric expenditures at a time when health is likely already compromised. Fetching water from a distant source may also use up a person’s energy (Chikava et al., 2013). Due to the energy expended in collecting water, many women in developing countries suffer from malnutrition and iron deficiency (Buor, 2004). According to a research in Zimbabwe, collecting water consumed more than 30 percent of the average daily calorie intake per capita (Mehretu et al., 1992). If women have walk over uneven and hilly terrain or on busy roads while carrying such loads over long distances, they may suffer from strained backs, shoulders, and necks, as well as other ailments. Women who are pregnant or who are carrying young children have an even greater burden. Furthermore, pregnant women worry that transporting these heavy loads would result in early labor, miscarriage (Caruso, 2017) or complications in childbirth (WaterAid, 2020).

As previously stated, water fetching may be quantified in terms of time, distance, caloric expenditure, and opportunity costs, but not all of these factors have been addressed simultaneously (Sorenson et al., 2011). Variables such as the vessel's weight, terrain condition, and drudgery of the labor (for example, the number of trips), among others, would raise awareness of the task. In addition, future study might assess the probability of road fatalities, assaults, and attacks, as well as linked health issues. Such research would yield a full picture of the expenses of water fetching as well as a better understanding of the fetchers' views of the task (Sorenson et al., 2011).

8.8 Tendering findings to Actor-oriented approach

The study findings clarify that water-related activities are socially defined activities for women, but men's activities are to the management of the water system, repairing the structure, installation of the new structure, and the place where a new set up has been installed entirely ignoring women’s needs and demands. Thereby how the issues of actor-oriented approach suit the study findings are presented in the table below:

Table 8.3: Setting study findings on the actor-oriented approach

The gender dimension of water insecurity	Who (negatively affected by water insecurity)	How
Non-ownership of water source	Women and girls	The burden of search and make availability of household water
Non-coverage of government water supply		Increase water cost, installation of private water services, maintenance
Household-level water-related activities		Cooking, cleaning, hygiene
Water fetching		Time spent the possibility of violence, health risk, lesser time for education and leisure period and other productive and economic use
Poor quality and inadequate water		Expense in water treatment, health risk
Damage/failure, repair, insufficient water service, inadequate infrastructure		With the burden of searching for an alternative water source, women spend more time on household work
The action of social actors to provide water security	**Who (will take active roles)**	**How**
Individuals	Women	Supporting women's interests and concerns and their roles within the water system
Households	Women and Men	Taking part in decision making
Groups	Community	Extensive social efforts and the use of appropriate technologies and continued support to build a sustainable community water management system.
Institutions	Government ministries or departments, water supply institutions, NGOs, etc.	Installation, the extension of coverage, and management of water interventions

8.9 Policy implications

Since providing physically accessible clean water is critical for achieving sustainable development, women's involvement in water-related decision-making may affect change and make a difference in society. This study recommends-

- Significant infrastructural expenditures are being made to provide potable water to the expanding metropolitan areas.
- The setting of a standard water tariff system for different income groups.
- Establishment of gender-sensitive water points that can be easily accessed for those in need with special consideration for the disabled and elderly group.

- Creation of awareness campaign for not wasting water at the household level.
- Increase in the number of govt. water points depending on the area and need with strong management policy (reducing disparities and enhancing services).
- As women have accumulated substantial knowledge about water resources, quality, and storage methods due to their dependence on water resources, therefore women's participation in water management interventions should make sure.
- Technical and social measures can also help to decrease risks and different water-related security concerns.

8.10 Conclusion

Women work in both household and income-generating sectors but enjoy very minimal rights compared to men. So, there is a necessity to incorporate women's needs into gender policies and programmes. When the water infrastructure is insufficient, women spend more time on household chores. Therefore, future research can be based on Government and NGO interventions on water security for the urban poor to find out if there is any govt. or NGO working to help the underprivileged or water poor to ensure their access to water-related interventions. This would allow the future researcher in designing interventions for inclusive members where women needs are to be prioritized to improve the sustainability of water services with gender-sensitive water allocation.

Chapter 9: Urban Water Use and Health Risk

"Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity."

-Kofi Annan, United Nations Secretary-General

This chapter is aiming to find out the causes of disease occurrence focusing on water sources and their quality, reviewing the related literature, and adopting the theoretical and conceptual framework fit for the study. The main themes to discuss are sources and uses of water, the relation of disease prevalence with water sources, household-level water management approaches, and treatment-seeking behaviour exercised by the studied communities. The second section has been written based on the conceptual framework adopted for the study. The study reviewed the disease ecology model by Meade & Emch (2010). The framework described the characteristics of each component and the relevance of the model in the dispersion of diseases through the interactions among the population, habitat, and behavior of the people in the study area. Some recommendations have also been extracted from the responses received, which the policymakers may find useful and can incorporate into national-level policies.

9.1 Introduction

A safe, reliable, affordable, and conveniently available water supply is critical for good health, yet almost one billion people in developing nations have lacked access to such supply in decades (Hunter et al., 2010). High population growth rates in developing countries, insufficient rates of capital investment, difficulties in appropriately developing local water resources, and the ineffectiveness of institutions mandated to manage water supplies are all reasons for the slow progress toward universal access to an adequate water supply (Hunter et al., 2010).

Every year 35,75,000 people die from water related diseases[96]. In the year 2000, more than 2.2 million people died because of contaminated water (WHO, 2000). Each year, it is estimated that 4,85,000 people die from diarrhoea due to contaminated drinking water across the world[97]. According to Gleick (2002), between 34 and 76 million people, primarily children, would die from avoidable water-related illnesses between now and 2020. Because of the city's growing population, diminishing groundwater supplies, and pollution of river

[96] https://www.theworldcounts.com/challenges/planet-earth/freshwater/deaths-from-dirty-water/story
[97] https://www.who.int/news-room/fact-sheets/detail/drinking-water

water, access to clean water is a serious problem in Dhaka (Nahar, 2014). Bangladesh has made tremendous progress in terms of universal access to improved water sources, with over 97 percent of the population having access in 2013, but safe drinking water availability remains low, at 34.6 percent (UNICEF, 2020).

In Bangladesh, surface water used to be the major source of water but is heavily contaminated by industrial and urban pollutants, as well as agrochemical and sewage wastes. Surface water in the country is heavily polluted by human feces and agrochemicals, in addition to industrial sources (Alam, 2017). A variety of manmade and natural causes contaminate Bangladesh's groundwater. Infiltration of industrial effluent and municipal trash deposited on the ground or in surface water bodies pollutes groundwater (Alam, 2017). While the Dhaka Water Supply and Sewerage Authority (DWASA) supplies 70 percent of the Dhaka metropolitan area, Bangladesh has a significant problem in providing safe, reliable water to the capital city's rapidly expanding population (ABD, 2013). Despite the fact that the DWASA is in charge of delivering pipe water in Dhaka city, many people who reside in informal settlements such as slums or squatter settlements do not have access to enough water, and many are completely without it. As a result, these impoverished people must rely on alternative sources of water to satisfy their needs, such as tube wells, local ponds or rivers, dug wells or rainwater, or rely on water vendors (Roy & Dutta, 2017). Large numbers of households in peri-urban areas in Bangladesh get water from unsafe sources, such as rivers, canals, and ponds, which are typically contaminated by industrial effluent that has percolated through the subsoil (ABD, 2013), resulting in a variety of health consequences. Pharmaceuticals, endocrine disruptors, and microplastics can enter drinking water, and their concentrations are commonly reported in drinking water, posing a severe health concern (WHO, 2012; WHO, 2019). Water-related diseases are overburdened on the population and health services of many countries worldwide, and on those in developing countries (WHO, 2000). Unsafe drinking water, along with inadequate sanitary conditions in the home and community, continues to be a major cause of disease and malnutrition. Unsafe drinking water contributes to approximately four billion cases of diarrhea each year, which leads to two million deaths annually (WHO & UNICEF, 2000; Rosegrant et al., 2002).

The expense of providing water for domestic and industrial usage is likewise quickly rising. According to Rogers, de Silva & Bhatia (2002), Asian Development Bank research found that between 1993 and 1997, the average tariff charged by water utilities in 38 major Asian cities increased by 88 percent. Dhaka Water Supply and Sewerage Authority (DWASA) has raised the tariff per unit (1,000 litres) of water from Tk. 10.50 in 2017 to Tk. 14.46 per unit in 2020, a rise of 22 percent for residential users[98, 99]. The hike in water tariffs added more suffering to the lives of city dwellers. Even among the 83 percent of the world's population who have access to improved water sources, some drink water that has been polluted either at the source, or through seepage of contaminated run-off water, in the piped distribution system, because of unhygienic handling during transportation or at home. The unserved 17 percent have no alternative but to bring water home from unsafe sources. S simple approaches for purifying water at home and keeping it in secure containers might save thousands of lives each year (WHO & UNICEF, 2005).

Providing sufficient, safe water to all people and fostering personal, household, and communal hygiene would enhance the health and quality of life of millions of people (WHO, 2019). Therefore, this study intends to find out how water sources and uses of water have contributed to disease occurrence at the community level.

9.2 Objectives and Hypothesis

9.2.i Objectives of the Study

The specific objectives of this study are-

i. to find out prevalent diseases of the studied community in the past one year;
ii. to explore the link between water sources with disease occurrence;
iii. to identify other potential factors that may be responsible for disease happening;
iv. to find out the measures taken to make water safe at the household level; and
v. to investigate the treatment-seeking behaviour of the studied communities.

9.2.ii Hypothesis of the study

The present study assumes the following hypothesis-

H_O: There is no connection between the sources of water on which a population relies and the occurrence of disease

Ha: There is a positive connection between the sources of water on which a population relies and the occurrence of disease

[98] https://www.thedailystar.net/frontpage/news/dhaka-wasa-80pc-tariff-hike-1869448
[99] https://unb.com.bd/category/Bangladesh/now-dhaka-wasa-hikes-water-tariff/45588

9.3 Theoretical and Conceptual Framework

9.3.i Disease ecology theory: To understand and explain how people get infected with diseases associated with the use of water in their communities; disease ecology has been adopted in this study. Disease ecology commonly includes features of the environment, population, and culture in the explanation of patterns of disease, in answer to the questions of "why is this disease here?" or "why is this disease prevalent in places like this? According to Meade & Emch (2010), disease prevalence is usually affected by the interaction of three variables, namely **Habitat, Population, and Behaviour** as shown in Figure 9.1.

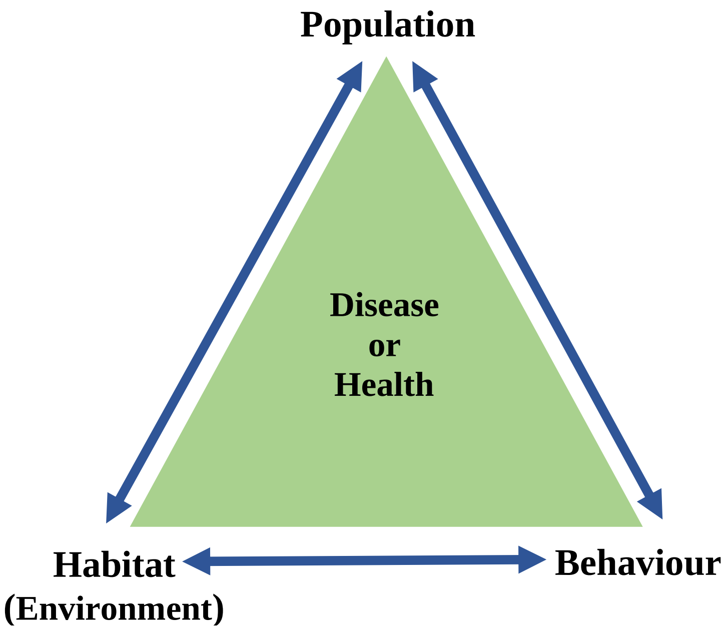

Figure 9.1: Disease ecology model adopted from Meade & Emch (2010)

Figure 9.1, **Habitat** as explained by Meade & Emch (2010) is the aspect of the environment within which people live and work. The components of the environment include houses and workplaces, physically and naturally occurring biotic and abiotic component phenomena, health care services, transportation system as well as the government. As stated by Meade & Emch (2010) the **Population** part focuses on the human organism as the potential host of the disease. Population components of the disease ecology model represent the communities in the studied areas who have been the potential host of any disease prevalent in the area due to the uses of resources of their basic needs such as water sources. In Figure 9.1, **Behaviour** as the third and last component of the disease ecology model is the observable characteristic of culture (Meade & Emch, 2010), people's choices, activities, and interactions (Uzoma, 2020). It stems from cultural precepts, economic constraints, social norms, and the individual. ***How this model fit with the present study and its implication has been discussed later in section 9.7.i.***

The study of disease ecology hopes to help to achieve an understanding of the relationships between diseases (pathogens), host (community), and environments or resources (water sources and usages) they usually depend on.

9.3.ii Behaviour change theory: Thereby, this study also adopts behaviour change theory to understand how people can prevent infections or disease occurrence through some changes or practices. Behaviour change occurs when someone is confronted with a familiar circumstance but suddenly does something new or different. For example, if a household has always practiced open defecation but then builds a toilet and starts using it, it is an example of behavior change.

The process of changing one's behavior is a linear and gradual one. There are several behaviour change theories in the literature, with over 100 being recognized. Here the adopted "Transtheoretical or stages of change model of behaviour change" also known as the stages of change model, assesses an individual's readiness to act on a new healthier behaviour and provides strategies, or change processes, to guide the individual, is one of the most widely used in public health and hygiene (Prochaska et al., 2005). Behaviour change occurs through five steps process as presented in Figure 9.2.

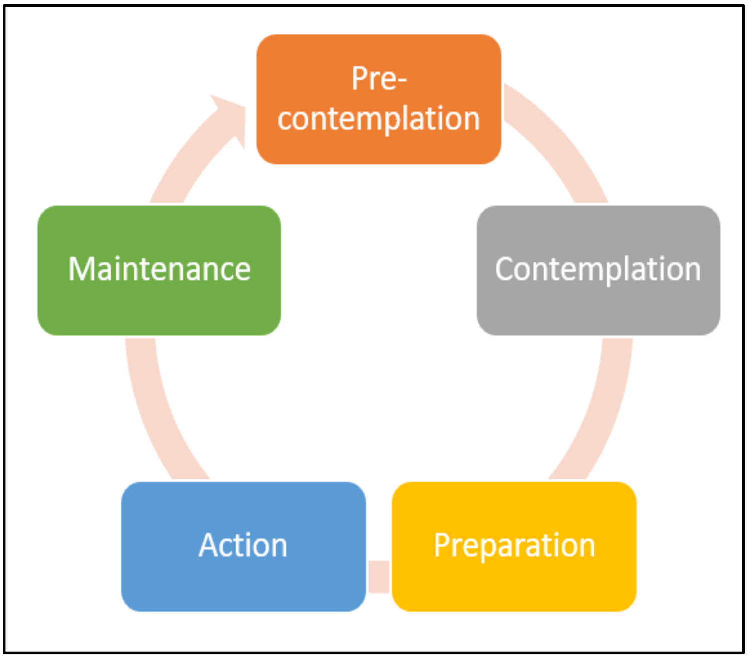

Figure 9.2: The Transtheoretical Model of Behaviour Change by Prochaska & DiClemente, 1983

1. ***Pre-contemplation*** (the individual has not even thought about changing their behaviour)
2. ***Contemplation*** (begins to think about changing behaviour)
3. ***Preparation for action*** (begins planning to change behaviour)
4. ***Action*** (begins practicing the behaviour)
5. ***Maintenance*** (the behaviour is performed regularly).

A review of the prevention strategies reveals that each involves changing behaviours. Some changes must come from community and government leaders, while others will require the involvement of health professionals; many will demand intersectoral collaboration, and all will necessitate a shift in community priorities as well as individual and collective public behaviour (Jenkins, 2003).

9.4 Methodology

This part uses both primary and secondary sources of data simultaneously. The following are the data collecting tools that had been used to satisfy the study's objectives:

9.4.i. Primary data collection: Both quantitative and qualitative data collecting techniques were used to obtain primary data.

9.4.i.a Quantitative data collection includes the Intrahousehold Semi-structured questionnaire survey to clearly understand available sources of water and health risks communities faced. 1826 households had been surveyed across twelve sites namely Konabari, Kashimpur, Ichharkandi, Palasana, Gutia, Gusulia, Bhakral, Bhadam, Kathaldia, Rashadia, Abdullahpur, and Mausaid along the Turag River area.

9.4.i.b Qualitative information has also been collected from the households through focus group discussion (FGD) and key informants interviewing (KII). A thematic checklist has been developed to collect information while interviewing. Six FGD’s and twelve KII’s had been conducted in six sites namely Konabari, Kashimpur, Bhakral, Bhadam, Mausaid, and Abdullahpur along the Turag River area. To collect information on interactions and uses, a river use survey was also carried out through researchers’ observation.

9.4.ii Secondary review: Relevant national and international books, reports, journal articles on related issues have been reviewed extensively. Relevant legal (e.g., BBS, HIES, MICS, BDHS, SVRS, BNHA), policies (e.g., Water policy, WHO, UNICEF, World Bank), and institutional framework (e.g., current administrative system for water supply services, DWASA) have also been studied enormously.

There are diverse public sources of data on various health indicators. *Some important sources of health data in Bangladesh are being discussed below*[100]:

1. ***HIES*****:** Household Income and Expenditure Survey are designed for measuring poverty, income, expenditure, and asset structure at the household level. The household-level questionnaire contains a section related to health is available.
2. ***BDHS*****:** Bangladesh Demographic and Health Survey is an important source of health statistics. It contains a vast statistic related to health but contains less information on morbidity. However, still, it can give us some important information.
3. ***Seventh Five Year Plan*****:** Under the seventh-five-year plan, a background paper on health has been prepared. The document is rich in health statistics and future health targets in Bangladesh.
4. ***Health Bulletin*****:** The Health Bulletin is a comprehensive document of health statistics in Bangladesh.

Details about data collection tools have been broadly discussed earlier in ***Chapter Three of Methodology***.

9.5 Data Analysis and Interpretation

Compiled data that has been collected using ONA software from the field was recorded into the Statistical Package for Social Sciences (SPSS) 23 and analysed using cross-tabulation, Chi-square, spearman correlation. Calculation of central tendency such as frequency, percentage, mean±SD is calculated using both SPSS 23 and Excel Microsoft 365 version. The graph has been generated using Excel Microsoft 365. The generated data were then presented in tabular form, in graphs and figures. Besides, relevant pictures have also been used to support the analysis.

9.6 Study Findings and Discussion

This section is further discussed under two main parts. The first part provides a general discussion on findings to support the result that has been generated. The second part attempt to set the study findings on adopted theory.

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[100] Khaleque, M. A. 2018. Health Statistics in Bangladesh. Department of Development Studies, University of Dhaka, Dhaka-1000.

9.6.1 Water source, usages, and disease occurrence

9.6.1.i.a Diseases incidence among studied communities in the past one year

The community had been asked if their family members are suffering from any major illness for the past one year, the answer was no for 72 percent (n=5155) of family members where only 27.5 percent (n=1968) family members had been suffered from various diseases (Appendix table G1).

Among those who were suffering from various diseases in past one year, gastric/ulcers/stomach pain ranked highest (36.6%) followed by skin disease (12.6%), dysentery (12.5%), mosquito-borne disease as chikungunya/dengue/malaria (11.1%), jaundice (9.2%), typhoid (6.0%), tuberculosis/pneumonia (5.4%), and cholera (0.8%) (Appendix table G2). Various other illness such as body pain, back pain, respiratory problem, gynaecological problem, tonsil, fever is most frequent under other categories which represent 30 percent of total count (Appendix table G2 & G3). According to Preliminary Report on Household Income & Expenditure Survey 2016, gastric/ulcer remains the disease with the most incidences among the urban population both at the national level (20.5%) and urban level (20.3%) which is supported the present findings although the prevalence of skin disease mentioned in the literature remains the lower than the study findings (2.8% at the national level and 2.4% in the urban area) (BBS, 2017).

Area wise highest disease concentration has been recorded in Abdullahpur (21.8%), Konabari (16.4%), Mausaid (14.1%), and Kashimpur (12.5%) among other areas studied (Appendix table G4).

Age-wise disease distribution (Figure 9.3) remains highest among the most active group of 26-35 yr (27.6%), 16-24 yr (24.3%), and 36-45 yr (22.4%). The result is such perhaps because they are the most active group and highly exposed to and interact with water related activities and water sources (Appendix table G5).

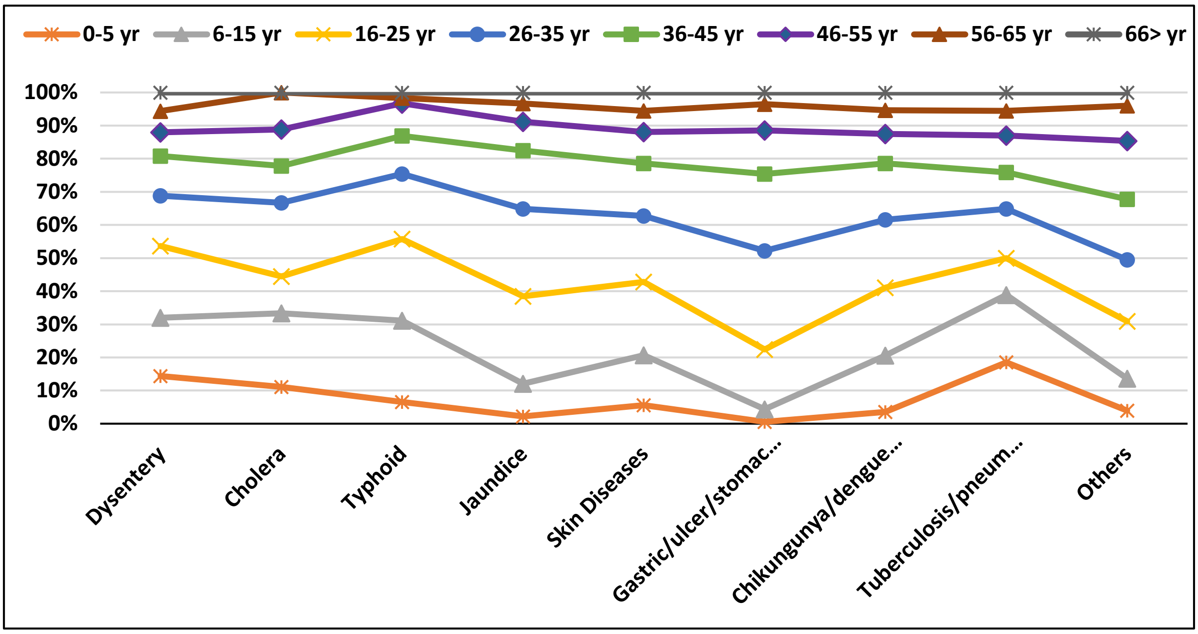

Figure 9.3: Age wise disease distribution of the studied communities

Also, the result of FGD's and KII's in selected areas shows that the locals suffered a lot of water and vector bone (mosquito) diseases like skin diseases, dysentery/diarrhoea, dengue/chikungunya, respiratory problem/asthma, typhoid, cholera, fever, jaundice, gastric and are identified as their greatest health risk (Table 9.1). Skin problems are quite common among the communities in the study area. Almost all participants of the interview claimed to have experienced skin problems because of their frequent contact with river water. They willingly showed the skin lesions in their bodies, particularly in hands and legs like the findings of Halder et al. (2015). Also, as women are the main actor of water-related activities frequently interacting with polluted river water for household chores their suffering from various skin problems is high (FGDs & KIIs; Appendix table D2). Women as they bath and using polluted river water after toileting, the problem of itching of intimate part is also documented (FGD & KII; Appendix table D2).

Respiratory problem or asthma is also very frequent in the studied communities and found in the percentage of 10.6 percent in the national wise and 9.4 in urban areas according to the Preliminary Report on Household Income & Expenditure Survey 2016 (BBS, 2017), which may be due to dumping of textile dyes into the nearby river (Ahmed et al., 2005) and contaminated groundwater through infiltration.

Table 9.1: Health profile based on FGD's and KII's

Greatest health risk identified by the community	Score	Rank
Psora/skin disease/itching	11	1
Stomach upset/dysentery/diarrhea	10	2
Respiratory problem/asthma	4	3
Dengue/chikungunya	4	3
Jaundice	3	4
Typhoid	2	5
Cholera	2	5
Fever	2	5
Gastric	1	6
Kidney problems	1	6
Body swelling	1	6
Mean±SD	**3.73±3.52**	

Source: FGDs & KIIs, 2018

KII of a Doctor (Md. Masud Rana, 37) at Shaheed Ahsan Ullah Master General Hospital, Tongi, Gazipur revealed that in May 2017 at least 350 people were admitted to this hospital within three months due to Diarrhoea from the Morkoon area (consisting of Arichpur and Machimpur at Abdullahpur). The main reason identified is that the sewerage line somehow got connected with the DWASA water pipeline which has resulted in such serious repercussions. The interviewed doctor also mentioned that,

> *"... I find men coming more with waterborne diseases as most of them work in dyeing in factories as well as involved with the fish business, every day they deal with more water than others."*

Diseases primarily transmitted through the faecal-oral route include infectious diarrhoea, typhoid, cholera etc. Transmission can occur through a number of methods, including ingestion of contaminated water or food, as well as direct contact between people (Bradley, 1977). The disease may also result from the consumption of water containing toxic levels of chemicals from groundwater (shallow or deep tube well) such as arsenic, fluoride, lead etc. Recorded diseases from the survey have been classified into three water related diseases as discussed by Bradley (1977) and presented in Table 9.2.

Table 9.2: Categorization of recorded diseases in the studied communities

Category	Description	Example diseases
Waterborne disease	caused through consumption of contaminated (faecal) water	Diarrhea/dysentery, typhoid, cholera, jaundice, hepatitis
Water-washed disease	caused using inadequate volumes for personal hygiene	Diarrhea disease, infectious hepatitis/jaundice, typhoid, skin and eye infections
Water-related diseases	spread through insect vectors associated with water	Malaria, dengue fever /chikungunya

Source: Bradley, 1977

9.6.1.i.b Malnutrition

The degree of malnutrition is directly related to the risk of death (Chen et al., 1980; Van den Broeck et al., 1993; Pelletier et al., 1993; Man et al., 1998; Black et al., 2003). Malnutrition occurs when the body's protein or energy requirements are not satisfied due to either under-consumption or inadequate nutrient absorption and assimilation (WHO, 2018). Greater water scarcity is expected to worsen food security and exacerbate malnutrition (Wheeler et al., 2013). Conversely, the high prevalence of bacterial and parasitic diseases contributes significantly to malnutrition (Rice et al., 2000; Dickson et al., 2000; Brabin et al., 2003; FAO, 2004) and is thus the most important risk factor for disease burden in developing countries (Murray et al., 1997). Müller et al., 2003 and Black et al., 2003 estimate that it is the direct cause of about 3,00,000 deaths per year and is indirectly responsible for about half of all deaths in young children.

Therefore, collection and analysis of malnutrition data are important as it increased the susceptibility of disease occurrence. Malnutrition can also increase vulnerability to the effects of exposure and raise the risk of various illnesses induced by water pollution.

Lack of water can also lead to disease via malnutrition indirectly (Hunter et al., 2010). Among the surveyed people (N=7134), 18.2 percent (n=1298) are recorded as malnourished (Appendix table G6). More females (51.3%, n=666) are found malnourished than males (48.7%, n=632) as shown in Figure 9.4 and Appendix table G7. It is also found that malnutrition remains highest among the most active age group of 16-25yr (20%), 6-15yr (18.2%), 26-36yr (16.1%), 36-45yr (12.9%), and 46-55yr (10.3%) while it is lowest among infant (>5yr) and elderly (<66yr) group (Figure 9.5; Appendix table G7).

According to a study by Prüss-Üstün et al. (2008), an estimated 50 percent of malnutrition is associated with repeated diarrhoea and other infectious diseases due to the intake of unsafe water and inadequate hygiene practices. It has also been reported by various works that about 45 percent of all child deaths are linked to malnutrition (Erlanger et al., 2009). Malnutrition also leads to increased morbidity and mortality in children, as well as a lower IQ (Intelligence Quotient), lower academic achievement, lower adult productivity, and lower wages. Undernutrition is expected to cost Bangladesh more than Tk. 70 billion (US$10 billion) in lost productivity and even more in health-care expenditures per year (FAO, WFP & IFAD, 2012).

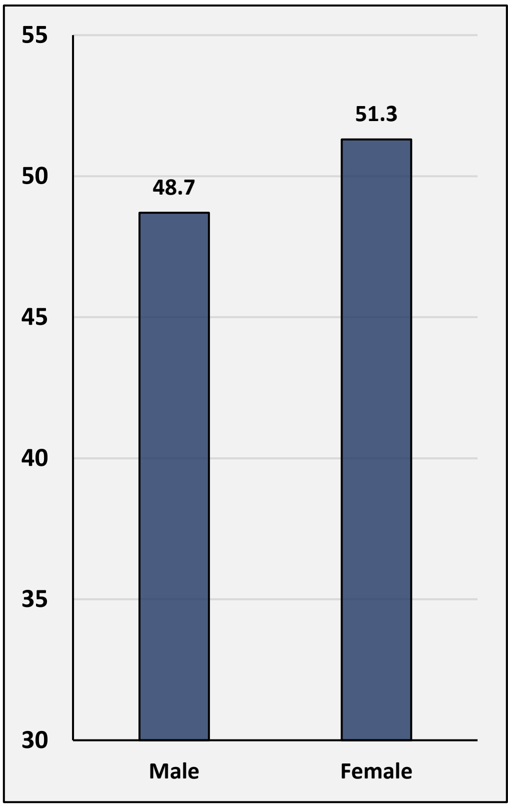

Figure 9.4: Male (%) and female (%) having malnutrition

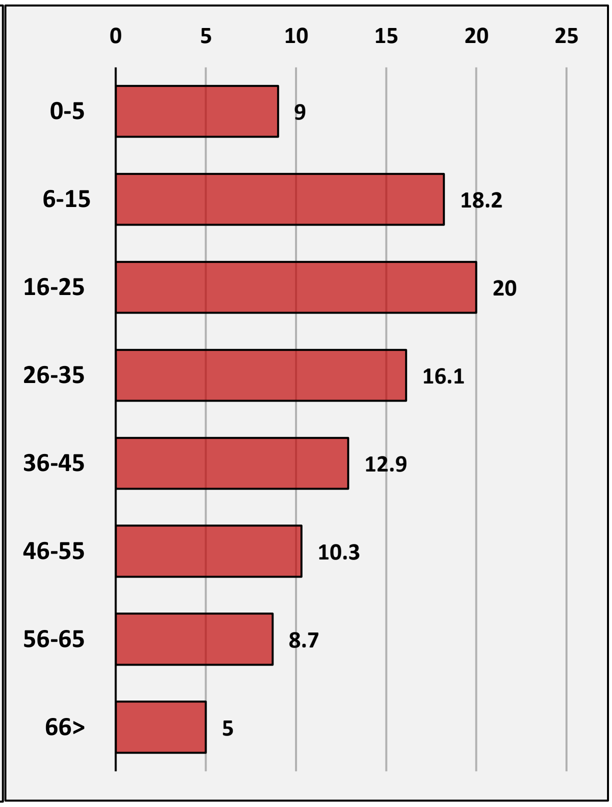

Figure 9.5: Age-wise (%) malnutrition distribution

9.6.1.i.c Gendered disparities in diseases occurrence

Gender wise types of illness did not show any significant variation although the female is found to get affected more (64.8%) than their male counterpart (59.5%) (Appendix table G2). Gastric ulcers have been identified as a major health problem for both males and females in the studied area although it remains highest in the case of females (20%). The doctors and health professionals interviewed believed it was linked to irregular eating patterns, the amount of time between meals, and the consumption of contaminated water which also confirms the findings of Halder et al. (2015). Diseases like psora (skin disease), dysentery, and cholera remain remarkably high among males than females in the studied communities (Figure 9.6). Though disease does not show any significant difference, but women are more vulnerable to disease occurrence as they spend more time to household work and have direct exposure to poor sanitation, such as diseases caused by poor drainage, contact with human faeces, and decomposing rubbish (UN Women Watch, 2009). Also, as women and children supply most water for the household, polluted water affects them the most because of the increased contact they have with unsafe water (Cap-Net & GWA, 2006).

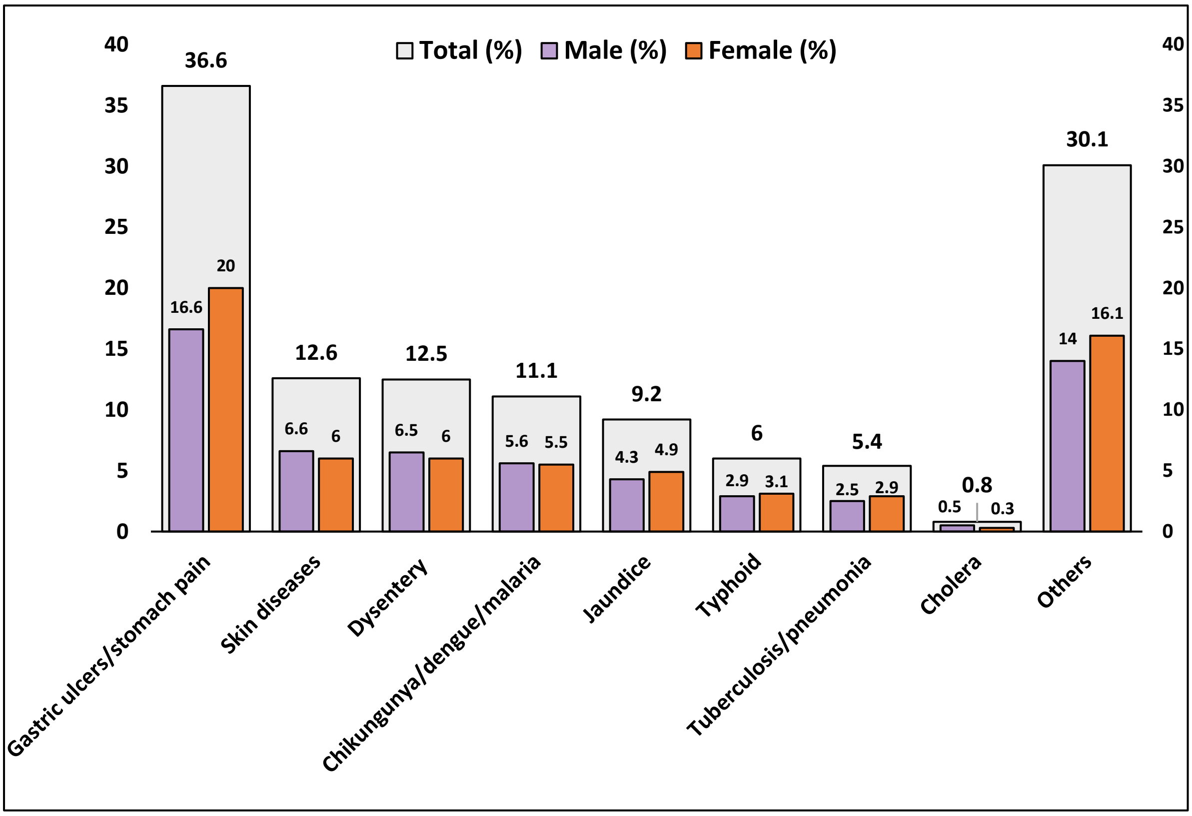

Figure 9.6: Gendered variations (%) of disease occurrence

This finding is also supported by the qualitative result. An FGD participant, Shanti Begum (60) at Mausaid told that

"………although women do most of the water related work, there are no differences between men and women in terms of disease occurrence."

Qualitative analysis revealed that women are more affected as they are involved in most water related activities. FGD statement of Selina (23) from Konabari like

"Female and children are more susceptible to these health issues as they interact with water and water sources much more than the male ones."

But KII argument of Md. Daud Hossain (31) from Konabari was

"…women do most of the water related activities in the household, so they might be more affected… I have not seen any substantial variation."

Qualitative information suggests that anyone in the household affected by a waterborne disease means that it is likely that all the members of the household will also be affected by it. The disease does not consider gender or age variation, anyone and everyone can get affected (Appendix table D2).

9.6.1.ii Water sources and usages

9.6.1.ii.a Sources of drinking water

It is important to review all the recorded drinking water sources to find out the causes of disease incidence in the studied communities. Available drinking water sources of the studied area have broadly been discussed in ***Chapter Five***. Figure 9.7 shows that the motor tube well (73.8%) is the most common source of water supply among the communities studied. The next commonly used drinking water sources are piped water into the dwelling and yard (21.2%), deep and shallow tube well water (2.6%), and tap water (2.1%) (Appendix table C2). Communities are also found to depend on bottled water/tanker truck/cart tank etc. vended water sources (0.8%) while there are no alternative sources. Although there has been a clear shift of water intake behaviour from river water to tube-well water, a certain percentage still depends on unsafe surface water for drinking and domestic purposes. In the studied communities' 2.8 percent still uses unsafe open water sources such as rivers, lakes, ponds, and rainwater for drinking purposes (Appendix table C2).

According to the World Bank (2018), 3 percent of Bangladesh's population relies on unimproved water sources, implying that almost four million Bangladeshis continue to drink from ponds, rivers, streams, or unprotected wells and springs. Similar findings were observed in Jinnah's 2007 study, which revealed that 62.7 percent of slum residents get their drinking water from municipal taps, 33.4 percent from tube wells, and 3.8 percent from other sources like as rivers, ponds, lakes, and canals.

According to BBS (2017) report, the main sources of drinking water in urban areas are supply water (23.7%) and tube wells water (60.2%) whereas according to the SVRS (2019) report tap water (27.5%), tube well water (75.5%, which in Dhaka is 67.1%) are the main sources of urban drinking water and other unprotected sources of drinking water are well, pond or ditch, river, canal, and rainwater which altogether comprise 1.8 percent of the total use. According to Bangladesh MICS 2012-2013: Water Quality Thematic Report (2018), the main improved drinking water option used in Bangladesh is the tube well/borehole (90.6%), though used more by rural household members (96%) than those in urban areas (70.1%) and there is also a disparity in the use of piped water between urban (28.7%) and rural (1.3%).

From the survey data, it is proved that almost all the communities depend on safe water sources for drinking purposes, and dependency on open sources of water recorded in very minimal percentages among the communities.

As stated by Mumtaj Khatun (49) in a FGD at Konabari-

"Most of the people use supply water for drinking, cooking, and bathing. People are getting more aware of."

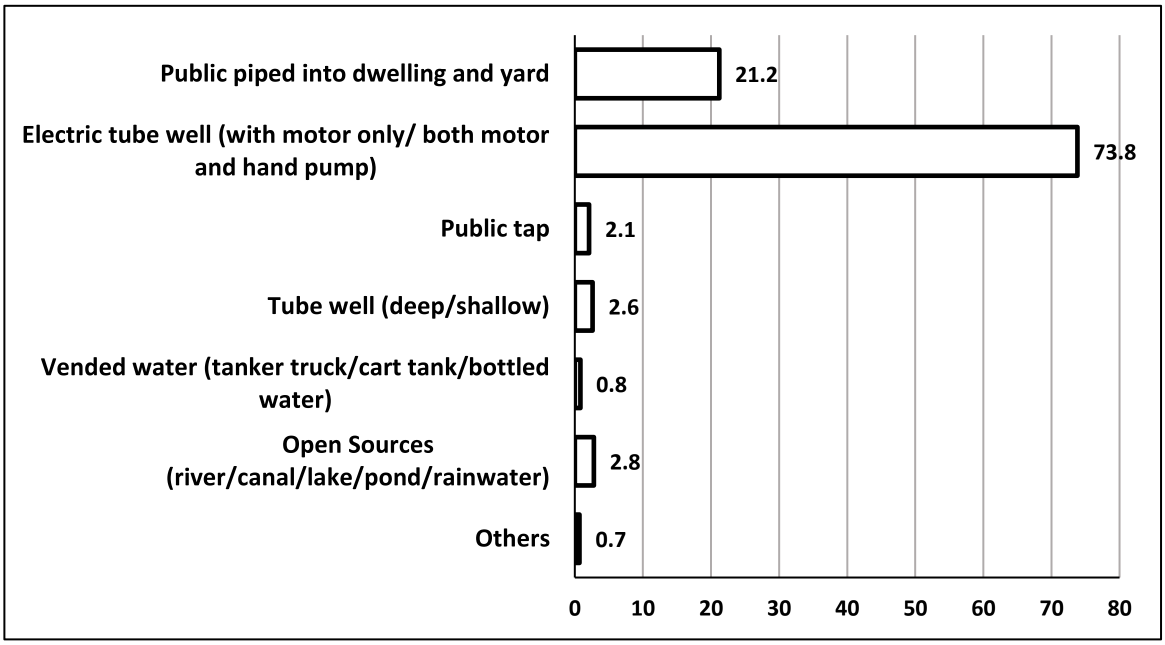

Figure 9.7: Main sources (%) of drinking water in the studied area

9.6.1.ii.b Sources of water for domestic use

The household survey also shows that communities' main sources of water for domestic use which includes cooking, washing (cloth and dish), and bathing is motorized tube well followed by piped water, tap water, and deep and shallow tube well water (Appendix table C9). A noticeable percentage of people also dependents on unsafe sources like river/canal, pond, rainwater, lake water for various domestic usages. The use of water from these unsafe sources can have a potential impact on the health of the studied communities. As stated by Selina (23), Konabari-

"In our community, some of us somehow manage to collect drinking and cooking water from the supply tap but rest of the works like- bathing, washing clothes, plates are done by river water mostly."

9.6.1.iii Community perception of drinking and domestic water quality

The quality of water drank is well acknowledged as a key pathway for infectious illness transmission (WHO, 1993). Consumption of water containing microbial components or high amounts of toxins can also cause disease. Therefore, it is important to find out how community perceived or thinks of the water they consume and use for domestic purposes.

9.6.1.iii.a Quality of drinking water

Despite motorized tube well and pipe water being the main sources of drinking water among the studied communities, disease frequency remained high which clearly indicates the fact that the quality of safe water sources affects public health. The majority of respondents thought that the water they consume is safe (92.8%) while 3.0 percent is not sure about the quality of water, they intake (Figure 9.8; Appendix table G8). Only 4.2 percent (n=77) feel that the water they drink is not safe (Appendix table G8). The presence of iron (2.9%, $n=53^{*MR}$), germs (1.3%, $n=24^{*MR}$), bad smell and taste (1.0%, $n=18^{*MR}$), etc. are the three main reasons for their belief (Figure 9.9; Appendix table G8). Unpleasant tastes or odours are quite common if the water is from unsafe sources but also may arise from either the iron content of groundwater or associated with chlorination in water supplies. The presence of bad smell and taste in safe water sources may also act as a restriction to use those sources and expose the users to unprotected water sources and thereby increasing health risks (Hunter et al., 2010).

About 1.3 percent of respondent households complained about the presence of microbial components in their drinking water sources (Appendix table G8) which according to MICS report 2019, 84.1 percent of households in Dhaka and 81.9 percent households in Bangladesh used water sources with *E. coli* in household drinking water. Recent studies in Bangladesh have demonstrated that up to 65 percent of tube-wells contain indicators of faecal contamination (More, 2017). Faecal pathogens that have been detected in tube well water include rotavirus, adenovirus, *Shigella*, Vibrio cholera, and toxigenic *E. coli*. WHO standard for faecal and total coliforms for drinking water is 0 CFU/100 ml of water samples (WHO, 2004). The risk level of the presence of faecal materials in water between 11-100 CFU/100 ml is considered high risk whereas more than >100 per 100 ml is considered as extremely high risk (MICS, 2019). The presence of these components beyond these ranges in the studied drinking water sources may be a factor in the occurrence of diseases like diarrhoea, dysentery, or cholera.

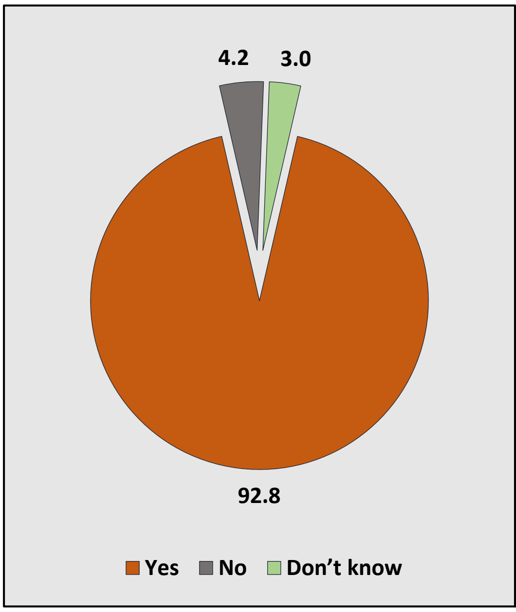

Figure 9.8: Percentage (%) of respondents consider water safe to drink

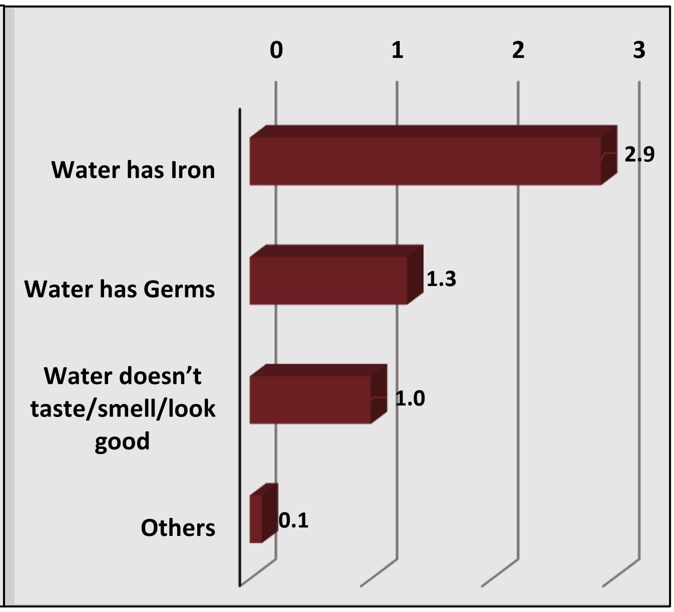

Figure 9.9: Reasons (%) why water is not safe to drink identified by the respondents

9.6.1.iii.b Quality of water for domestic use

While communities are asked about their concerns regarding water sources they used for domestic purposes, from 73.8 percent (n=1345*MR) of the responders, 6.9 percent (n=126) stated that the water they use for domestic purposes is dirty (Appendix table C15). Both cross-tabulation and standard deviation analysis has been undertaken to find out which water supplies they identified as dirty for domestic use on seasonal basis. The result shows that communities found supply or ground sources especially motor tube well water much dirtier than unsafe/unimproved sources which they have been using for cooking, washing, and bathing practices irrespective of season (Appendix table G9).

The use of safe or improved sources of water for cooking remains the same in both seasons (Wet and Dry) but the use of open sources of water for the same purposes remain high in the dry season (0.6%) in dry season comparable to wet season (0.1%) (Figure 9.10; Appendix table G9). It has also been revealed that communities use surface water more for washing and bathing purposes than safe sources of water. Although the percentage of using safe sources of water for domestic purposes is high, the quality of water of these sources is not at a satisfactory level as mentioned by the communities studied. Still, a considerable percentage using open dirty sources water and rate of increase of these sources remain highest in the dry season than the wet, and the findings can be considered as an important factor of disease occurrence (Figure 9.10).

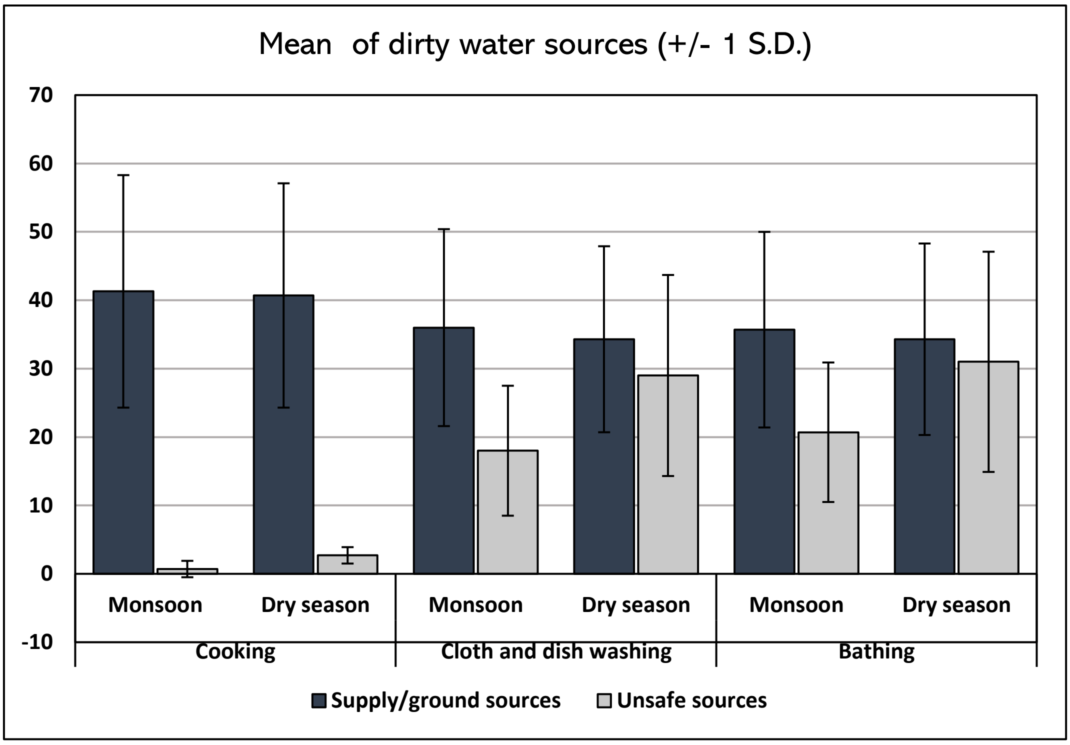

Figure 9.10: Mean±SD score of dirty water sources identified by the community for domestic usages

9.6.2 Linking disease occurrence with sources and quality of water

In the study mentioned earlier, the use of safe sources of water remains the highest in the studied area. However, despite using safe sources of water, the frequency of disease occurrence in the studied communities is extremely high. Rate of intaking unsafe water is the highest in Ichharkandi and Palasana with a percentage of 1.4 and 1.1 respectively (Table 9.3) than other areas studied but disease incidence of these areas remains lower than other areas respective to the total population surveyed (13.1% in Ichharkandi and 15.8% in Palasana). People who are not being served by piped systems generally rely on tube wells, ponds, and other sources of doubtful quality. The highest interactions with these unsafe water sources result in various water related diseases like skin disease, cholera, typhoid, chikungunya/dengue, etc. more in these communities (Figure 9.6; Appendix table G2).

Among other areas, the second-highest surveyed population (n=914; %=12.8) were documented in Kathaldia though the incidence of disease occurrence remains lowest (14.8%; Table 9.3). The main sources of drinking water of this community were piped water into the yard and dwelling (7.2%) and motorized tube well (4.9%), no interaction with unsafe water is documented (Appendix table C3).

The main sources of water use in the studied areas for drinking and domestic purposes are piped water, tap water, tube well water, and motorized supply water (Appendix table C2 &

C9). Communities also depend on unsafe or open sources of water such as lakes, ponds, canals, rivers, etc. for drinking purposes (2.8%) (Table 9.3; Appendix table C2) as well as for domestic uses (Appendix table C9). Likewise, it has been estimated that 2.1 billion (29% of the world) people across the world have no access to safe drinking water and are responsible for 1.2 billion deaths each year[101]. Therefore, sources of water are important as the presence of microbial or chemical contaminants on surface and ground and supply water with degraded quality has been identified as major causes of disease occurrence, in the case of studied communities this statement has been proven. According to a recent study, inadequate water supply combined with a lack of appropriate hygiene (WASH) caused 58 percent of diarrheal illness in 2012, resulting in an estimated 842,000 fatalities (Prüss-Üstün et al., 2014).

Table 9.3: Area wise disease occurrence and sources of water

Area	Population		Disease		Disease incidence (%)	Sources of drinking water			
						Supply/ groundwater		Open sources of water	
	n	%	n	%		n	%	n	%
Konabari	1040	14.6	400	5.6	38.5	248	13.7	0	0.0
Kasimpur	786	11.0	306	4.3	38.9	204	11.3	1	0.1
Ichharkandi	582	8.2	76	1.1	**13.1**	163	9.0	**25**	**1.4**
Palasana	411	5.8	65	0.9	**15.8**	109	6.0	**21**	**1.1**
Gutia	435	6.1	78	1.1	17.9	104	5.8	0	0.0
Gusulia	279	3.9	60	0.8	21.5	65	3.6	1	0.1
Bhakral	362	5.1	132	1.9	36.5	85	4.7	0	0.0
Bhadam	590	8.3	171	2.4	29.0	197	10.8	0	0.0
Kathaldia	914	12.8	135	1.9	14.8	222	12.1	0	0.0
Rashadia	270	3.8	145	2.0	53.7	69	3.9	0	0.0
Abdullahpur	832	11.7	533	7.5	64.1	221	12.1	3	0.2
Mausaid	633	8.9	344	4.8	54.3	140	7.7	0	0.0
Total	**7134**	**100**	**2445***	**34.3**	**34.3**	**1827***	**100.2**	**51***	**2.8**

***MR; Source: HH Survey, 2017-18; Safe water: motorized tube well, pipe water, tap water, deep and shallow tube well etc.; Unsafe water source: river, lake, pond, rainwater etc.**

Approximately half of the world's population is currently affected by freshwater (drinking water) contamination. Polluted water is defined as water that has been changed from its original form in terms of physical condition, chemical and microbiological composition, and the presence of which causes disease (Alam, 2017). There are around 250 million instances of water-related illnesses each year, with approximately 5 to 10 million fatalities (GP, 2005). Water pollution causes a number of waterborne diseases like diarrhoea, cholera, typhoid,

[101] https://ourworldindata.org/water-access

hepatitis, etc., and is primarily transmitted through the faecal-oral route. The intake of contaminated water and unhygienic drinking water production practices have been linked to the prevalence of these illnesses among the population (Mead et al., 1999).

Good water quality is important for everyone's health, but especially for women's health. According to the World Health Organization, around five million people die each year as a result of unsafe drinking water, which is frequently linked to water shortages (CAP-NET & GWA, 2014). Contaminated water, whether drunk or used to cook food, harms people’s health. According to the MICS 2019 report, 99.6 percent of the urban population using improved drinking water sources (Nationally 98.5%) of which main improved drinking water source in Dhaka are tube well/borehole (70.7%), piped water (28.6%), and others improved sources (0.9%). The percentage of household members with an improved drinking water source located on premises, free of E. coli and available when needed at the national level is only 47.9 and in Dhaka 41.9 percent (MICS, 2019). In urban areas, the existing water services heavily rely on groundwater. In Dhaka, about 78 percent of the water produced by DWASA is currently sourced from aquifers. When faecal contaminants reach the water supply, it is the most dangerous kind of water pollution. Pathogens shed in human and animal faeces such as *Salmonella* sp, *Shigella* sp, *Vibrio cholerae,* and *E. coli* eventually make their way into the water supply by seepage of improperly treated sewage into groundwater (DiPaola, 1998). Therefore, using water for drinking and domestic purposes from these sources are the main causes of disease occurrence among the studied communities.

Water quality is directly related to pathogens, and chemical components in water are well-known as a major pathway for infectious disease transmission (WHO, 1993; Hunter et al., 2010). Consumption of unsafe water can have a dangerous impact on health when it contains pathogenic or disease-causing microorganisms. Though in the present study rate of consumption of safe sources of water among surveyed communities is high, but disease occurrence also remains high among those who consume water from those unsafe sources (Table 9.3).

The presence of germs and iron in supply water has been confirmed and labelled as unsafe to drink by the studied community (Figure 7.9). According to the MICS 2013 study, about a third of urban households' drinking water has high levels of E. coli bacteria. The MICS investigation revealed that when water is transferred from sources to homes, the microbial contamination process intensifies. In a report presented to the High Court on May 16, 2019, the Dhaka Water Supply and Sewerage Authority (DWASA) acknowledged that the water it supplies to 57 locations across 10 zones is contaminated[102]. Mahbub et al. (2011) found that the distribution lines of the Dhaka WASA supply chain surpassed the BDS standard and WHO drinking water guideline owing to the presence of *E. coli* and Coliform, and that they may be the primary cause of microbiological contamination of drinking water. The presence of microbiological organisms (coliform) in DWASA supply water has also been confirmed by the research conducted by DiPaola, 1998; Nitol et al., 2016; Fan et al., 2017 etc. The reason for the availability of microbial indicators in water from house taps can be said due to the leakage in supply pipelines and liquid with bacteria which can leach from the sewerage line to the water pipeline. Hence, wastewater infiltration through leakage in the Dhaka WASA supply chain might be a cause of microbial contamination of drinking water.

Aside from the iron (Fe) reported by the communities, arsenic and fluoride (naturally present in many groundwaters), lead (from domestic plumbing components), and nitrate (from sewage contamination or agricultural runoff) are also substances that people are exposed to through drinking water (WHO, 2017) and causes serious illness. According to BNDWQS of 2009 (2011), the high average concentration of Fe present in the shallow (2.65 mg/L) and deep tube well (1.37 mg/L) water throughout the country exceeded both WHO and DOE (1997), Bangladesh standards 0.3 mg/L and 1.0 mg/L, respectively. Iron deficiency can cause anaemia and fatigue while individuals who consumed >30 mg of iron per day in their drinking water had a lower risk of anemia (Merrill et al., 2012). But excessive consumption of iron is potentially hazardous and can cause multiple organ dysfunction such as liver fibrosis (Heming et al., 2011), diabetes (Swaminathan et al., 2007; Heming et al., 2011), lung and heart disease (Milman et al., 2001), anaemia and hemochromatosis (Toyokuni, 2009) etc.

Studied communities have been found seen to suffer from dysentery, skin disease, gastric or ulcers or stomach pain, chikungunya or dengue or malaria, jaundice, typhoid, tuberculosis or pneumonia, cholera etc. diseases (Appendix table G2). Presence of microbial contamination in drinking water is responsible for typhoid, dysentery, cholera, and hepatitis (Shar et al., 2007; Parveen, 2008). The problems of diarrhoea and dysentery are likely to be caused due to the direct use of Turag River water for various domestic usages that has

[102] https://www.thedailystar.net/country/water-pollution-in-dhaka-wasa-water-polluted-in-57-areas-1744423

already been polluted by the industrial effluent, and the source of microbial contamination. According to the work of Kamal et al. (1999), the presence of *E. coli* in the Turag River was found in 6.08×10^4/100m and Total coliform (CFU)/100m found 75-7500 and $25\text{-}2.0 \times 10^4$ and responsible for intestinal diseases while interacting with this river for domestic uses. Four species of bacteria were identified in the river water through bacteriological analysis such as *E. coli*, *S. typhimurium*, *Shigella* spp. and *Salmonella* spp., by the work of Rabbi et al., 2016. Interacting with this water for bathing or other domestic purposes can result in health problems like dysentery, skin disease, respiratory problem etc. According to the study of Oguntoke, 2009, there is a strong link between the microbiological quality of water and gastrointestinal diseases. Diet and the effects of pollution on crops and fish ingested by individuals living near the Turag River may be linked to stomach ulcers and other similar gastrointestinal disorders. Dysentery/diarrhoeal disease is transmitted mainly by the faecal–oral route, caused by the ingestion of pathogens, especially in contaminated drinking water or from unclean hands (WHO, 2019). Malaria is the most important water-borne disease with 217 million malaria cases and 4,51,000 deaths globally in 2016 (WHO, 2019). Dengue/chikungunya fever is the most rapidly spreading mosquito-borne viral disease in the studied community. The vector breeds in clean, man-made, and sometimes natural water bodies close to human dwellings. Respiratory problems have also been reported in the qualitative study, it occurs when toxic materials accumulate in the body and cause long-term health implications (Nishat et al., 2001; Motlagh, 2013; Mohiuddin, 2019).

Though there is no documentation of arsenic contamination of studied population, but according to the MICS report 2019, the percentage of the household population with arsenic in source water containing over 10 parts per billion (ppb) Arsenic concentration is 18.6 nationally and in Dhaka 14.3 whereas the percentage of the household population with Arsenic in source water containing over 50 ppb Arsenic concentration is 11.8 nationally and in Dhaka 9.3. The allowable concentration of arsenic for drinking water indicated by WAB (Water Aid Bangladesh) is <0.001 mg/L and by WHO is 0.01 mg/L where 0.05 mg/L is permitted in Bangladesh (Bangladesh Standards, ECR 1997) but studies found that 8.4 percent of tube wells in Bangladesh contain more than 0.3 mg/L arsenic (Smith et al., 2000). The WHO and Bangladeshi government have different standards for arsenic, which are 10 ppb and 50 ppb, respectively (MICS, 2019). Chronic exposure to high levels of arsenic has been linked to a variety of health problems, including cancers, cardiovascular disease, and skin lesions (Joseph et al., 2015); diabetes, high blood pressure, and chronic disease (Yunus et al., 2011); melanosis, keratosis, hyperkeratosis, dorsum, and gangrene (Karim, 2000); lung cancer, renal cancer (Flanagan et al., 2012); has also been associated to impaired fetal growth and low birthweight (Huyck et al., 2007), as well as cognitive development and early childhood development outcomes (Haque et al., 2017).

9.6.3 Statistical analysis

To support all the arguments mentioned and discussed in this section and to find out the link of water sources with disease occurrence statistical analysis has also been carried out. Statistical studies enable us to examine and rationalize the analytical facts as well as their interrelationships. Both the Pearson chi-square (χ^2) test and Spearman's rho analysis (r_s) have been carried out to support the hypothesis and to find out the link of disease occurrence with water sources (Appendix table G10 & G11).

Both Spearman rho and Chi-square test shows some significant association of water sources with disease occurrence. Among all diseases that the community had been suffering for the last one-year dysentery shows significant relation with piped water into the dwelling (0.016); cholera with pond water (0.001); typhoid occurrence with rainwater (0.005); jaundice with deep tube well (0.009) and vended cart/container water (0.017); gastric ulcers or stomach pain shows significant relations with piped water into the dwelling (0.002), piped water into the yard (0.032), river water (0.002) and pond water (0.018); chikungunya/dengue/malaria shows significant relation with piped water into the dwelling (0.001), piped water into the yard (0.001), shallow tube well (0.001) and motor tube well water (0.003); tuberculosis or pneumonia with river or canal water (0.001). The relationship also shows, although most of the disease's occurrence shows significant relations with safe sources of water but diseases like cholera, typhoid, and tuberculosis occurrence completely depend on the intake or uses of open sources of water such as pond water (0.000), rainwater (0.005), and river water (0.000) respectively (Appendix table G10 & G11).

Therefore, disease occurrence of studied area shows significant relation with the sources of water ($P<0.05$) at the confidence level of 95% and thereby, supported the alternative hypothesis (H_a) that has been set for the study and discussed earlier in this section.

Though the result of the chi-square test (χ^2 test) and Spearman correlation does not show any all-embracing association between disease occurrence with water source and revealed that safe water sources are mostly related to disease occurrence. Therefore, it is required to find out other potential causes of the disease manifestation and discussed them under the following headings.

9.6.4 Other potential factors of diseases occurrence

The relative significance of water quantity, water quality, sanitation, and hygiene in protecting and promoting health has been the subject of much discussion (Esrey et al., 1985; Cairncross, 1990; Esrey et al., 1991). As in the present study, both the statistical (Pearson correlation (r_s) and Chi-square (χ^2)) tests do not completely satisfy the fact that there is a strong association between disease occurrence and sources of water but shows positive correlation, notably with safe sources of water. Except for water sources, there may be some other factors or practices at the household level which affect public health. This section tried to find out other potential causes that are responsible for the occurrence of diseases under the following topics.

9.6.4.i Hygiene exercise at the household level

Handwashing, for example, is one of the most cost-effective treatments for reducing the global burden of illness (Cairncross & Valdmanis, 2006). Hygiene is not only solely dependent on the availability of water, but also on particular hygiene behaviours such as handwashing before eating and cooking, as well as after defecation (Sircar et al., 1987; Stanton & Clemens, 1987; Cairncross, 1993; Shahid et al., 1996; Petersen et al., 1998). In Bangladesh, two out of every five families, or 38.3 percent of the population, drink water that has been contaminated with disease-causing bacteria and viruses[103]. However, due to the poor hygiene practices in households, the number of individuals drinking microbially contaminated water has increased to 99 million[104].

Hygiene is especially important since it is one of the Sustainable Development Goals (SDG) objectives, which aims to provide universal access to a basic handwashing facility at home (SDG 1.4.1 and 6.2.1). Studied communities when asked about their hygiene practices before eating meals and after going to the toilet, it was found that they had been maintaining their washing practices at the household level. They use different materials to wash their hands before eating and after toileting. Soap (77.5%) is the main material to wash hand by the communities but a certain percentage of them also use mud (2.1%), ash (1.2%), detergent (0.5%), hand wash (0.1%), etc. (Figure 9.11; Appendix table G12). A considerable percentage of respondents use only water (18.7%) to wash hands which is a quite common

[103] https://www.unicef.org/bangladesh/en/better-access-safe-drinking-water
[104] https://www.unicef.org/bangladesh/en/better-access-safe-drinking-water

but unhygienic washing practice (Figure 9.11; Appendix table G12). According to MICS report (2019), handwashing facility observed in the household level with water only is 96.3 at the national level and in Dhaka, it is 98.3 percent, handwashing by soap is 89.2 nationally and in Dhaka 95 percent, with ash/mud/sand by 15 percent national and 7.5 percent households in Dhaka.

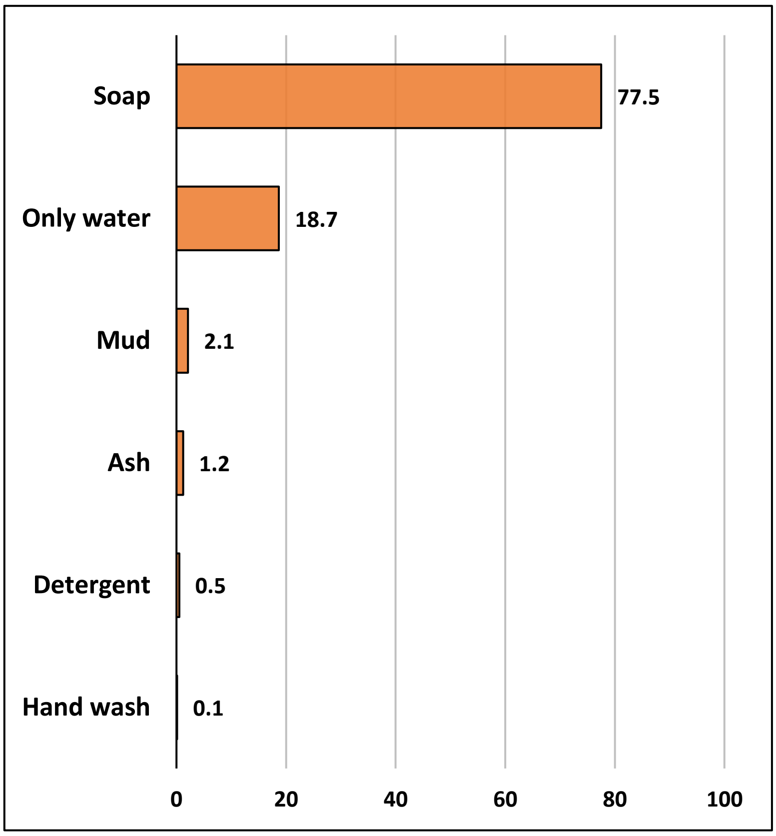

Figure 9.11: Agents (%) used by studied communities for personal hygiene

Handwashing facilities with soap and water are included as a hygiene indicator under the household SDGs. In 2017, 60 percent of the world's population had access to basic handwashing facilities such as soap and water at home[105]. Globally 3 billion[106] people still lacked basic handwashing facilities at home, 1.6 billion had limited facilities lacking soap or water, and 1.4 billion had no facility at all (WHO, 2019). Several studies (Khan, 1982; Cairncross, 1993; Hoque et al., 1995; Ghosh et al., 1997; Oo et al., 2000) suggested that handwashing with soap is extremely useful whereas hand washing only with water provides little or no benefit. Whilst less effective than the soap Hoque & Briend (1991) showed that the use of alternative rubbing agents such as mud or ash provided the same benefits as soap.

105 https://www.statista.com/statistics/1043461/hygiene-facilities-available-worldwide-by-region/
106 https://www.unicef.org/press-releases/fact-sheet-lack-handwashing-soap-puts-millions-increased-risk-covid-19-and-other

Proper use of materials like detergent and liquid soap (hand wash) are remarkably effective but are found to be used less by the studied communities.

Providing individuals with access to water and promoting its use for basic hygiene can have enormous health advantages. Lack of knowledge of using washing materials properly and usages of non-effective materials cannot protect individuals from microbe's invasion and contributes to disease confrontation. The *Shigella* bacterium causes dysentery or bloody diarrhoea and is a major contributor to the millions of deaths each year as a result of drinking contaminated water. Simple steps like handwashing with soap and water can lessen the risk of Shigella and other diarrhoeal illnesses by up to 35 percent (WHO, 2003; Hunter et al., 2010). Furthermore, the research shows that the efficient use of water and cleansing agents, as well as the timing of hygiene activities, are more essential than the volume of water utilized. Inadequate hygiene practices are estimated to be responsible for 13 percent of the entire burden of acute respiratory infections, resulting in about 3,70, 000 deaths in 2016 (Prüss-Ustün et al., 2019). More than 200 million individuals are thought to be infected with scabies, and personal hygiene is a crucial preventative measure (Bradley, 1977; Cairncross & Feachem, 1993; WHO, 2001; WHO, 2019).

Water-borne illness morbidity is successfully reduced by improved access to water and sanitation facilities, water quality, and personal cleanliness (Wolf et al., 2018). According to a UNICEF survey conducted in 2013, Bangladesh has a high level of awareness of essential hygiene messages, but the practice of efficient handwashing, the most effective hygiene behaviour, is extremely low. According to the MICS 2012-2013 thematic report, 59.1 percent of the households had water and soap at their handwashing station at the national level and 70.3 percent at the urban level. Furthermore, proper handwashing is dependent on the availability of facility as well as cleansing agents like soap or ash (MICS, 2018). There is a risk of contamination of drinking water during collection or storage if handwashing is not performed regularly or effectively.

9.6.4.ii Insufficient water supply

The amount of water that households gather and consume has a significant impact on their health. The lack of or inadequate household water supply has a direct and detrimental impact on the lives of women, men, and children (CAP-NET & GWA, 2014). Water is a basic human physiological necessity for sufficient hydration, as well as a distinct requirement for food preparation (WHO & UNICEF, 2005). There is also a need for water to assist the cleanliness that is required for good health. Therefore, improvements in the water supply are essential prerequisites for improved personal and home hygiene, as poor hygiene practice is the result of a lack of sufficient amount of domestic water supply (Cairncross & Feachem, 1993; WHO, 2001). This is important because the availability of sufficient amount of water ensures better hygiene practices at the household level. It is therefore reported that skin infections are solely been related to the quantity of water used to maintain personal hygiene (Cairncross & Feachem, 1993). Therefore, an attempt has been made to assess the health scenario of studied communities due to the constraints faced while accessing adequate water that is supplied to them.

Among all the household responses, only 8.4 percent (n=153, N=1345) mentioned that the quantity of water they collect or supplied to them for household use is not sufficient (Appendix table C15) and typically supplied only for 2 to 4 hours per day (FGD & KII). Though the results are contradictory with the findings of the MICS report 2019, where the percentage of the household population with drinking water available in sufficient quantities in Bangladesh is 96.6 percent which in Dhaka is 98 percent. But the same report identifying some main reason that the household members are unable to access water in sufficient quantities are:

i. Water not available from the source (at national level by 71.1 percent and in Dhaka by 72.3 percent households),
ii. Source not accessible (at national level by 17.2 percent and in Dhaka by 15.8 percent households),
iii. Water too expensive (at the national level by 4.3 percent and in Dhaka by 3.7 percent households) etc.

Although all project towns in Bangladesh had piped water supply systems using groundwater sources, the systems were insufficient, meeting only 10-30 percent of real demand through intermittent delivery only 3–8 hours daily. The current water demand is 2474 MLD, whereas the output is 2087.5 MLD (DWASA, 2014). In Dhaka, the daily need for water is about 2100 million litres. But the actual supply is nearly 1,600-1700 million litres only (FAO, 2016). Also, in the 6th Governing Council Meeting of Asia Pacific Water Forum (APWF), it was said that the water demand of Dhaka city is 2470 MLD but the actual supply is 1930 MLD and water demand in the year 2030 will be 4,990 MLD (Yeazdani, 2016). Only 625 pumps are now operational. In Dhaka city, approximately 31.43 percent of households do not have access to piped connections and must rely on standpipe connections or other sources to meet their minimal water consumption. The number of public standpipe connections is 1,727, which is inadequate (DWASA, 2014).

Health problems related to the inadequacy of water supplies are universal, but the problem is more acute and severe in developing countries. Domestic water usage is prioritized for drinking and cooking; water use for personal hygiene (for example, hand washing) and sanitation is likely to be neglected when supplies are scarce (Sorenson et al., 2011). A adequate quantity of water for drinking, cooking, and personal cleanliness is an essential need for health, according to Hunter et al. (2010). For more than one billion people across the globe, safe water is available in insufficient amounts to meet minimum standard levels of health. To meet basic human needs, enough water must be available to prevent dehydration. There must be enough water for cooking, bathing, sanitation, and hygiene. There are no universally accepted definitions of what constitutes an acceptable quantity of water[107]. According to Gleick (1996), 50 litres per person per day is required to satisfy basic human needs. The World Health Organization (WHO, 2003) recommends 100 litres of water per person per day for residential usage. Despite this, average daily per capita household water usage in some of the world's poorest countries ranges from 4 to 15 litres (Sorenson et al., 2011). To maintain a healthy life minimum requirement of drinking water is 2 liters in temperate climates to about 4.5 litres per day for people in hot climates (Howard & Bartram, 2003), for cooking 1.5-2 litres per capita per day (Thompson et al., 2001), for food preparation 2-10 litres per capita per day (Gleick, 1996; WHO, 2003), for other domestic uses 20 litres per capita per day (WHO & UNICEF, 2000).

Figure 9.12, adapted from Reed B & Reed B (2011), depicts the amount of water a person needs daily for various purposes in litres-

[107] WaterAid. 2012. Water security framework. WaterAid, London. https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/download-our-water-security-framework.pdf

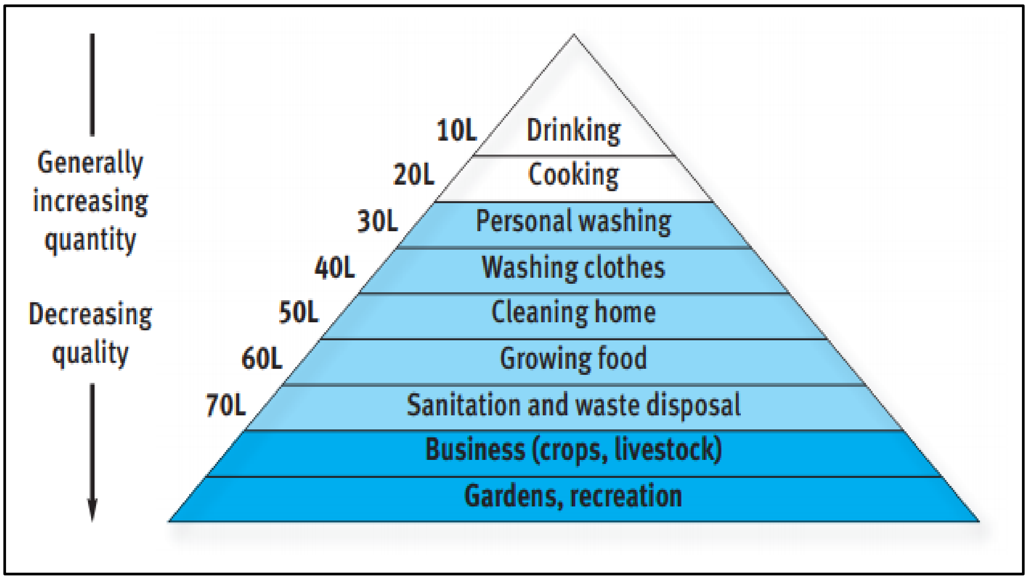

Figure 9.12: An outline of different quantities of water for different purposes

FGD findings of Abdullahpur and Konabari shows that when there is no submersible facility in these areas, the community use water from tube wells for drinking and cooking, where a certain group still uses river water for washing clothes, utensils, bathing, intimate washing after toileting, etc. purposes due to lack of adequate water supply.

As stated by Momtaj Begum (52) in a female group FGD at Konabari,

"In my community, there are 215 houses with more than six hundred people, supply capacity of one submersible pump is only 6000 litre and is very much insufficient, therefore we are bound to use river water, and sometimes we store rainwater in drums for using it later."

Limited uses of water may increase the potentiality of disease occurrence as hygiene practice is intricately linked to the availability of sufficient amount of water. Where water is scarce or beyond the threshold of 1000 m, bathing and laundry may become less frequent, thereby increasing the risk of contagious diseases (Thompson et al., 2001). As a result, not only the quality of the water but also the availability of sufficient drinking water is critical in the prevention of water-borne illnesses (WHO & UNICEF, 2005). WHO (2008)[108] has formulated standards in health care facilities serve as a basis for establishing national standards for the various types of health care facilities which are presented in Table 9.4 below-

[108] WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. 2015. Water, sanitation, and hygiene in health care facilities: Status in low- and middle-income countries and way forward. P. 13 https://apps.who.int/iris/bitstream/handle/10665/154588/9789241508476_eng.pdf;jsessionid=3BB07916A5545F976177F1C1077564E0?sequence=1

Table 9.4: WHO standards on water, sanitation, and hygiene in health care facilities

Items	Recommendations
Water quantity	5–400 litres/person/day
Water access	On-site supplies
Water quality	Less than 1 Escherichia coli/ thermotolerant total coliforms per 100 ml. Presence of residual disinfectant. Water safety plans in place
Sanitation quantity	1 toilet for every 20 users for the inpatient setting. At least 4 toilets per outpatient setting. Separate toilets for patients and staff
Sanitation access	On-site facilities
Sanitation quality	Appropriate for local technical and financial conditions, safe, clean, accessible to all users including those with reduced mobility
Hygiene	A reliable water point with soap or alcohol-based hand rubs available in all treatment areas, waiting rooms, and near latrines for patients and staff

9.6.4.iii Payment made for water by the respondent households

The cost of water may also be a limiting factor in the volumes of water used by the communities (WHO, 2003) which are also reported in a national report (MICS, 2019) as mentioned earlier that is valid for 4.3 percent of households at the national level and by 3.7 percent households in Dhaka.

Among 1826 households surveyed only 30.4 percent (n=556) of them stated that they had paid the water tariff (Appendix table G13). In the interview, 6.5 percent (n=118, N=1345) of respondent households also mentioned that the water they use is very costly to afford (Appendix table C15). On average, these community people need to expend monthly 296 BDT, a minimum of 30 BDT to a maximum of 4000 BDT with a mean±SD of 41.8±9.4 and 3053.4±667.4 respectively as water tariff (Table 9.5). The highest 12.2 percent (n=223) household monthly expend 51 to 100 BDT with a mean and standard deviation of 86.1±13.1. The highest water tariff between 2001 to 4000 BDT was recorded in a very lower percentage (1.1%) paid by the households (Table 9.5). Due to the high cost of water, households may be forced to use alternative sources of water of a poorer quality, which pose a greater health risk. It may also lower the volume of household water use, impair hygiene practices, and increase risks of disease transmission (WHO & UNICEF, 2005).

It has also been documented that 0.4 percent of the respondent household depends on vended water such as tanker truck/cart/bottled water to meet their need (Appendix table C2). As there is a costing issue, this water may only be used for drinking or cooking purposes undermine the needs of hygiene purposes. FGD results in Konabari show that the community of this area usually pays 50-170 BDT monthly, but few households pay up to 700 BDT. They also added that in their community nearly eighty (80) families could not afford any supply of water and depend on river water as they are not even able to afford Tk. 50 as water charge and therefore are exposed to serious health risks. This group mainly consists of the widowed, elderly couple, disabled, floating minor group e.g., snake charmers etc.

High water cost often acts as a limiting factor that prohibits using enough water needed for consumption and hygiene purposes and thereby increasing the health burden. Recognizing differences in the inability of the family especially the female-headed to pay for the water bill can reduce the impact by reducing the extra burden of water cost because if women cannot afford adequate water for their families, they may have to use dirty water and assume the burden of caring for sick family members who have been exposed to water-borne diseases (CAP-NET & GWA, 2014).

Table 9.5: Monthly water expense of surveyed households

Range of water costing at HH level (BDT)	Water expense at the household level		Mean±SD
	n	%	
<50	50	2.8	41.8±9.4
51-100	223	12.2	86.1±13.1
101-150	30	1.6	140.3±13.8
151-200	97	5.3	197.9±7.5
250-500	105	5.8	371.9±82.9
600-1000	25	1.3	786.6±152.6
1100-1700	11	0.7	1381.8±204
2001-4000	15	1.1	3053.4±667.4
Total	**556**	**30.4**	**296±530.7**

Source: HH Survey, 2017-18

9.6.4.iv Water storage practices at the household level

A further issue with intermittent water supply is that households may be required to store water on their premises, sometimes in unsanitary storage containers to have a sufficient supply of water (Renwick, 2013), leading to an increased risk from various water borne such as diarrhea, gastrointestinal illness, typhoid, cholera, hepatitis (Ercumen et al., 2015) and vector-borne diseases such as dengue/chikungunya fever. Water storage is required in houses that do not have their own or only have access to a basic level of service. Sometimes, they did not get enough water as there is a high tendency of power supply disruption, so they store it as a means of their preparedness (FGD; Appendix table D3).

Households were also asked if they are storing water for a few hours to make it available as or when needed, 58.9 percent (n=1075) responded positively (Figure 9.13; Appendix table G15). Though distance and non-ownership of water sources are the main cause of water storage, disruption of the power supply is another key factor that instigates people to preserve water (FGD & KII). They usually store water for drinking and other domestic purposes for less than 6 hours (24.4%) to more than two days (1.2%) (Figure 9.14; Appendix table G14). The studied community mainly store collected water in pitcher or kolshi (42.2%; Photograph 4a), in the jug (25.8%), in the bucket (12.2%; Photograph 4b), in jerry can (9.7%), and in plastic bottle (8.1%,) (Figure 9.15; Appendix table G14). In 48.6 percent of cases, storage containers have been covered with a lid whereas in 10.2 percent of cases have not been covered with a lid (Appendix table G14). Storage of water for more than 24 hours together with the covered and uncovered tactic of storage containers can be a potential source of disease incident for the studied communities because when water stored in uncovered containers at home had a higher *E. coli* risk (15.8%) compared to covered one (14.3%; MICS, 2018).

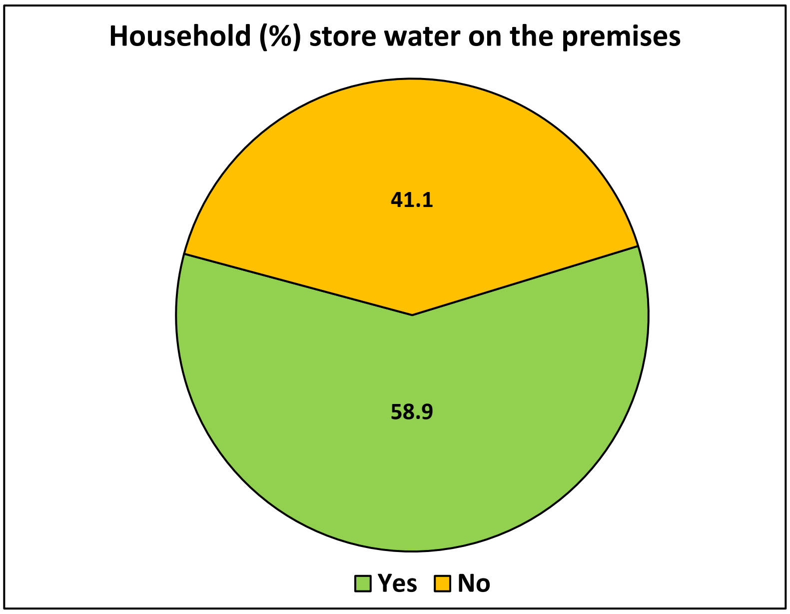

Figure 9.13: Percentage of household store water in their premises

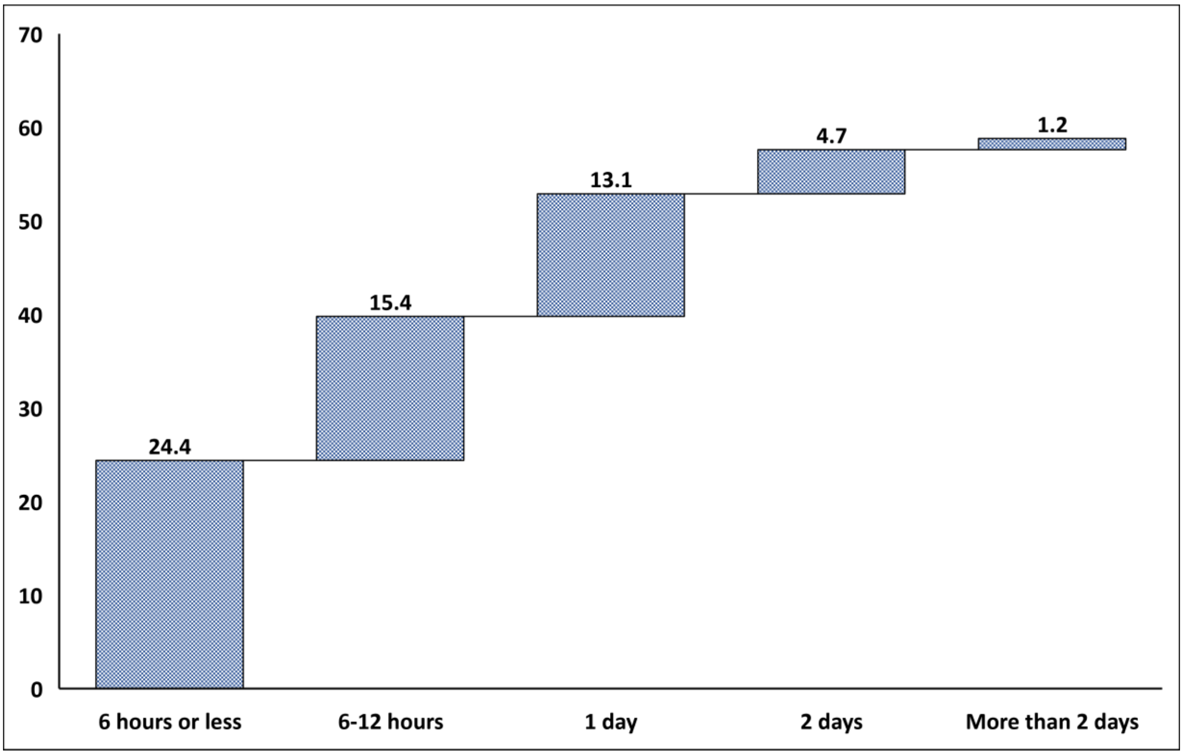

Figure 9.14: Duration (%) of water storage by the studied households

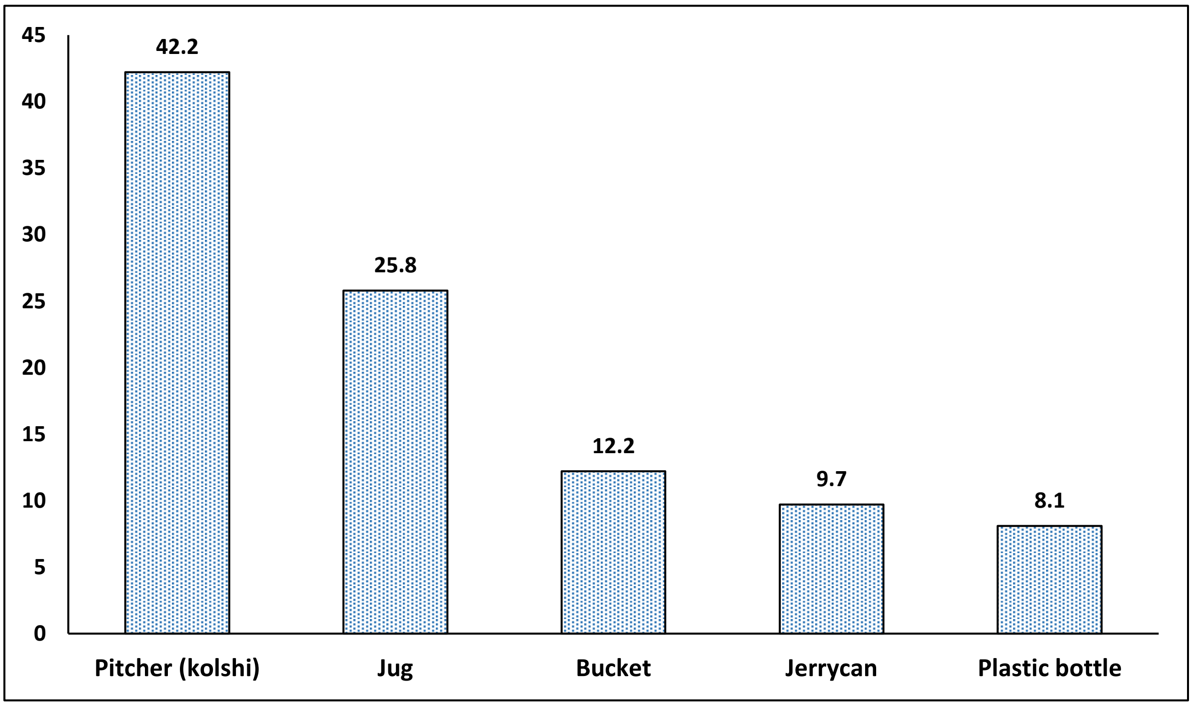

Figure 9.15: Containers (%) used to store water by the surveyed households

Photograph 4a: Collection and storage of water in pitcher (kolshi) from neighbours'

Photograph 4b: Water storage in plastic drums

9.6.4.v Washing practices of storage containers

Contamination of water stored in household containers is now recognized as a major factor in disease transmission (WHO & UNICEF, 2005). Washing practices and maintaining the hygiene of water containers are both crucial factors in health-related risks. Figure 9.16a shows that 34.8 percent of respondents always clean their containers before collecting water, some do not clean the containers on a regular basis but occasionally (23.6%) and a small percentage (0.4%) revealed that they never wash their water storage container (Appendix table G15). 38.7 percent of respondent households usually use soap to clean the containers but washing with only water (36%), ash (17.9%), and various other (1.9%) materials such as detergent have also been documented (Figure 9.16b; Appendix table G15). Cleaning activities are mainly practiced at the source of water collection (57%; n=1040, N=1067) but sometimes at home (1.2%; n=19) and some other places (0.4%; Figure 9.16c; Appendix table G15).

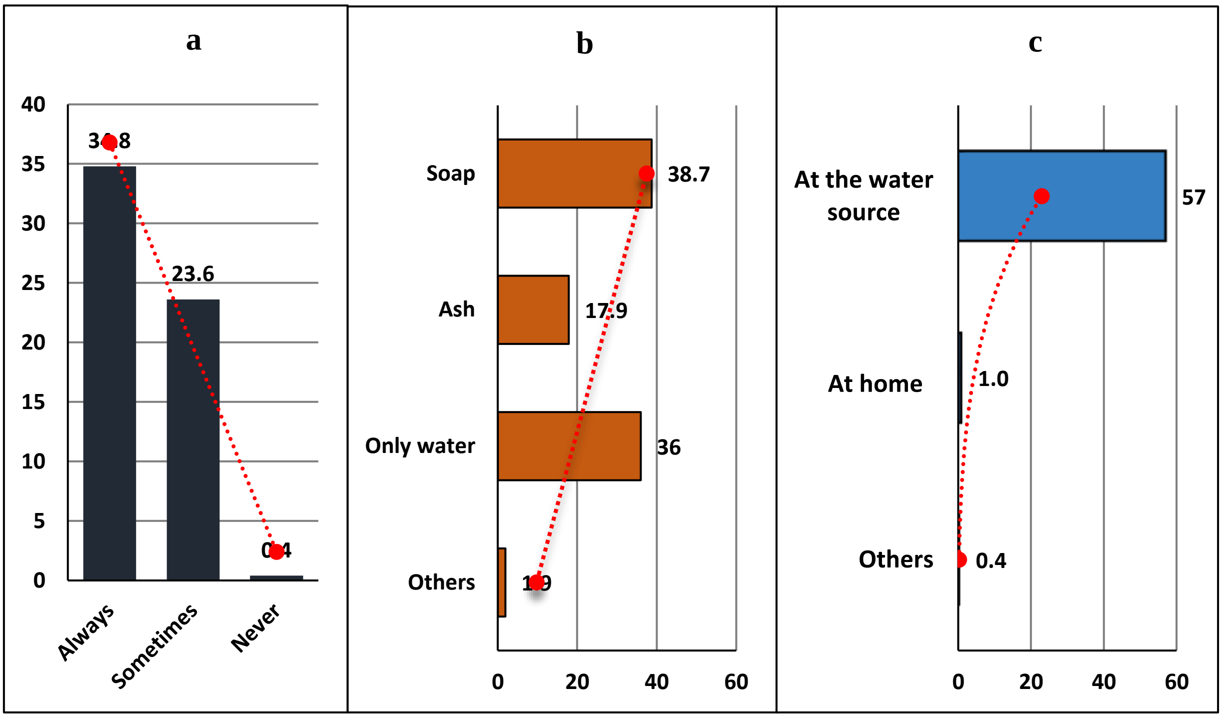

Figure 9.16: Shows in percentage (%) a) Containers washing practices, b) Materials used to wash containers, c) Places of container washing by the respondent households

Although a huge number of responders were found to wash their containers regularly, some households occasionally wash their containers, and some households never did it. This increases the risk of some microbes settling down after receiving a comfortable growth environment. However, the selection of washing materials sometimes is particularly important because some of these materials are ineffective into complete eradication of microbes from the containers and thereby increasing health risk. The combined effort on selecting proper cleaning agents and regular and effective washing practices can lessen the level of risk.

9.6.5 Water treatment method used in the household level

As it has been stated earlier that 92.8 percent of respondent households find their drinking water safe where 4.2 percent find it unsafe (Appendix table G8). Therefore, there is a need to make it safe before drink. However, only 3 percent of respondent's households were identified who take various measures to make water safe before drinking (Figure 9.17; Appendix table G16). Most of them boil water (1.8%) and filter water (0.8%) with measures as strain through cloth, add alum, solar disinfect, simply let it settle, add water purifying tablet (0.5%), etc. (Figure 9.18, Appendix table G17). Disease reduction using household treatment of water has been proved by the work of Sobsey, 2002 which shows that household water treatment appears to reduce diarrhoea incidence from zero to about 20 percent.

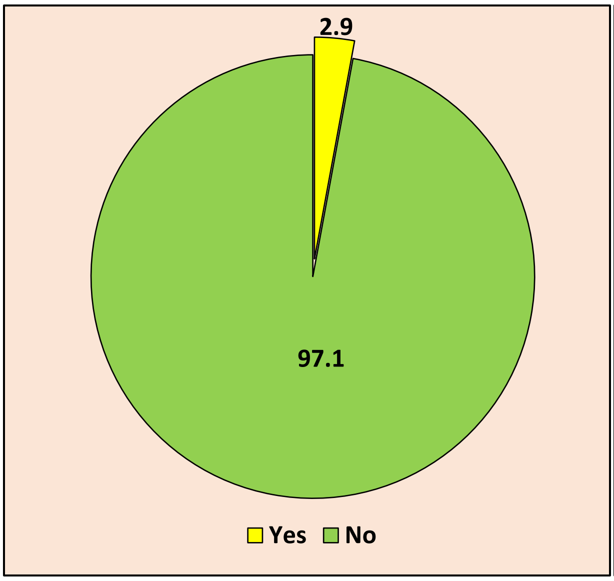

Figure 9.17: Percentage (%) of respondents take measure to make water safe

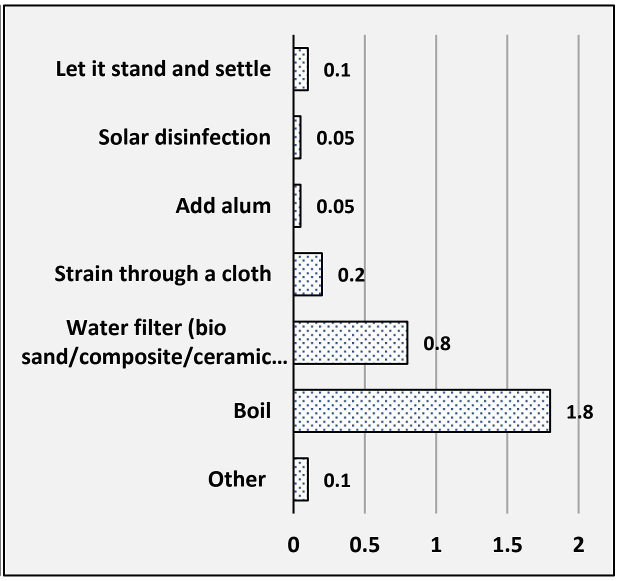

Figure 9.18: Measures (%) taken to make water safe

According to MICS survey report findings, 2019, the water treatment method used in the household is 89.5 percent at the national level and 79.0 percent in urban Dhaka but the percentage of household members in households using an appropriate water treatment method is only 9.7 percent nationally and 20.8 percent in Dhaka. Only roughly one-fourth of families with unimproved water sources used an appropriate water treatment technology (MICS, 2018). Treating water in the home can significantly enhance microbial water quality and eliminate harmful pathogens from drinking water. Relatively few households (8.0%) report in Bangladesh treating their drinking water where the majority of households do nothing (89.5%). Boiling is practiced by 5.0 percent, use water filter by 6.1 percent, strain through a cloth by 2.0 percent were the most common water treatment methods practiced by households in Bangladesh (MICS, 2019).

9.6.6 Treatment seeking behaviour of respondent's household

It has already been mentioned earlier that only 27.5 percent (n=1968, N=7134) of household members in the studied areas were found to suffer from various diseases in the past one year (Appendix table G1). Of which only 4.2 percent (n=298, N=7134) sought treatment from various sources (Appendix table G18). This section attempts to find out community members' treatment-seeking behaviour from various sources (Appendix table G19 & G20) and the cost it takes for the treatment purposes (Appendix table G21). It has been estimated that globally only 2 billion people are going to use health care facilities that do not have a protected source of water on-site (UNICEF & WHO, 2019).

9.6.6.i Modes of Treatment

Among those (n=298; Table 9.7; Appendix table C19) who are going to various places to get advice or treatment majority go to the nearby pharmacy to buy medicine for respective diseases (54.4%; Table 9.6). Remarkably people also go to medical college or specialized hospital (22.8%), private clinic (9.7%), self-treatment (5.4%), qualified doctor (5.0%) to find treatment (Table 9.6). According to Preliminary Report on Household Income & Expenditure Survey 2016, in the urban areas, the highest 34.1 percent received treatment from pharmacy/dispensary/compounder followed by qualified doctor's chamber 18.5 percent and non-qualified doctor's chamber 14.8 percent, private clinic/hospital 10.5 percent (BBS, 2017).

When viewed through a gender lens, it was found that treatment-seeking behaviour (Table 9.6) is more prominent among male (80.5%) members than female (32.9%) in the studied area which is slightly different from the findings of the Household Income & Expenditure Survey 2016 where female is found to get treatments more than male (BBS, 2017). This finding had been argued by Noor Mohammad (40) in a male group FGD of Abdullahpur as-

"I have seen in my area, women and children suffer from waterborne diseases the most and do visit to the pharmacy or doctors chamber more than men."

Table 9.6: Gender wise treatment seeking behaviour of respondent's households

Mode of treatment	Male		Female		Total	
	n	%	n	%	N	%
Upazila Hospital	8	2.7	3	1.0	11	3.7
District hospital	7	2.3	4	1.3	11	3.7
Medical college/specialized hospital	49	16.4	19	6.4	68	22.8
Private clinic	23	7.7	6	2.0	29	9.7
Mother and Child Welfare Centre (MCWC)	0	0.0	1	0.3	1	0.3
Union Health Centre (UHC)	0	0.0	1	0.3	1	0.3
Community clinic	1	0.3	1	0.3	2	0.7
Qualified doctor	8	2.7	7	2.3	15	5.0
Unqualified doctor	2	0.7	1	0.3	3	1.0
Pharmacy	**113**	**37.9**	**49**	**16.4**	**162**	**54.4**
Homeopathy	6	2.0	0	0.0	6	2.0
Ayurvedic	4	1.3	0	0.0	4	1.3
Self-treatment	13	4.4	3	1.0	16	5.4
Others	6	2.0	3	1.0	9	3.0
Total	**240**	**80.5**	**98**	**32.9**	**338***	**113.4**

Source: HH Survey, 2017-18; *MR=Multiple response, n=298

Disease wise treatment-seeking behavior has been found in considerable percentages among people suffering from gastric or stomach pain (37.2%), dysentery (11.9%), jaundice (11.6%), chikungunya (7.7%), skin disease (6.3%), and pneumonia (3.9%), etc. (Appendix table G20). This finding has also been proved by qualitative analysis that there is no good clinic in the community, so people have to go out for better treatment. As stated by Rohima, a 35-year-old housewife from Konabari (FGD, Female group)-

"There is no community clinic nearby for treatment. Either we have to travel to Konabari or Dhaka for treatment. For primary solution they go to nearby pharmacy and take medicines."

Apart from the treatment sources mentioned in Table 9.6, some nearby treatment facilities used by the communities compiled from FGDs and KIIs survey result (Appendix table D2) has been listed and presented as below-

- ICDDR'B, Mohakhali (FGDs & KIIs).
- Nearby Hospital: Tongi Government Hospital, Tongi; Shaheed Monsur Ali Medical, Uttara; Aichi Medical, Abdullahpur; East-West Medical, Dhour (FGDs & KIIs).
- Care Bangladesh Initiatives: Previously in 2015, Care Bangladesh was spotted to set up booth at the Abdullahpur area for a monthly free checkup,

where people with various diseases come and undergo basic examination and are prescribed by the doctors. Basic free medicines were also supplied (KII, Abdullahpur)

- Missionaries of Charity: In every Wednesday Missionaries of Charity with the assistance of the Mausaid Christian Multipurpose Co-operative Society spotted in a particular community in Mausaid to provide basic medicines for various diseases including water borne diseases as diarrhea, dysentery etc. More than 400 families get free medical checkups every time (KII, Mausaid).

9.6.6.ii Illness-related health care/treatment expenditure

Interaction with contaminated surface water not only increases health risks but also increases associated expenditures. Bangladesh started working on its commitment to achieving the Sustainable Development Goals (SDGs) by 2030, including ***Goal 3.8.1***, to attain Universal Health Coverage (UHC). In 2017, health expenditure per capita for Bangladesh was 36 US dollars an 8.22 percent increase from 2016 and is about 2.3 percent of the national GDP. The main sources of financing for the total health expenditure are out-of-pocket (OOP) spending (73.9%), followed by government spending (3%) [Source: WORLD DATA ATLAS]. The out-of-pocket expenditure as a share of the current health expenditure of Bangladesh increased from 62.4 percent in 2003 to 73.9 percent in 2017. According to the World Bank and World Health Organization's joint study, "Global Monitoring Report on Financial Protection in Health 2019," out-of-pocket health spending pushes 7.0 percent of Bangladeshi households into poverty every year.

As complained by Mumtaj Khatun (49) in a KII at Konabari

"I have spent a lot of money on buying medicines as I remain sick all the time."

Table 9.7 shows that health expenditure among studied households ranges from a minimum of 20 ($ 0.24) to a maximum of 50000 BDT ($ 589.78) with a mean±SD of 2157.9±4937.6. BDT 501-1000 remain the highest expenditure among 1.2 percent (n=88) of households (Appendix table G21). On average communities are found to expend a minimum of 135 ($ 1.59) and a maximum of 22000 BDT ($ 259.50) depending on disease severity.

Table 9.7: Household level treatment expenditure

Expenditure range (BDT)	Health expenditure at the household level		Sum of expenditure	Mean±SD
	n	%		
20-200	54	0.7	7306	135.3±59.8
201-500	68	1.0	27380	402.6±103.6
501-1000	88	1.2	84278	957.7±107.8
1001-2500	41	0.6	68000	1659±352.8
2501-5000	25	0.4	102100	4084±842.5
5001-10000	9	0.1	68000	7556±1667
15000-50000	13	0.1	286000	22000±9806
Total	**298**	**4.2*(n=7134)**	**643064**	**2157.9±4937.6**

Source: HH Survey, 2017-18

Sex-wise expenditure for treatment purposes always remains highest in the case of male members of the household (Figure 9.19; Appendix table G21). Male members are always given the highest priority at the household level in the social context of Bangladesh; therefore, their health problems are families one of the main concerns.

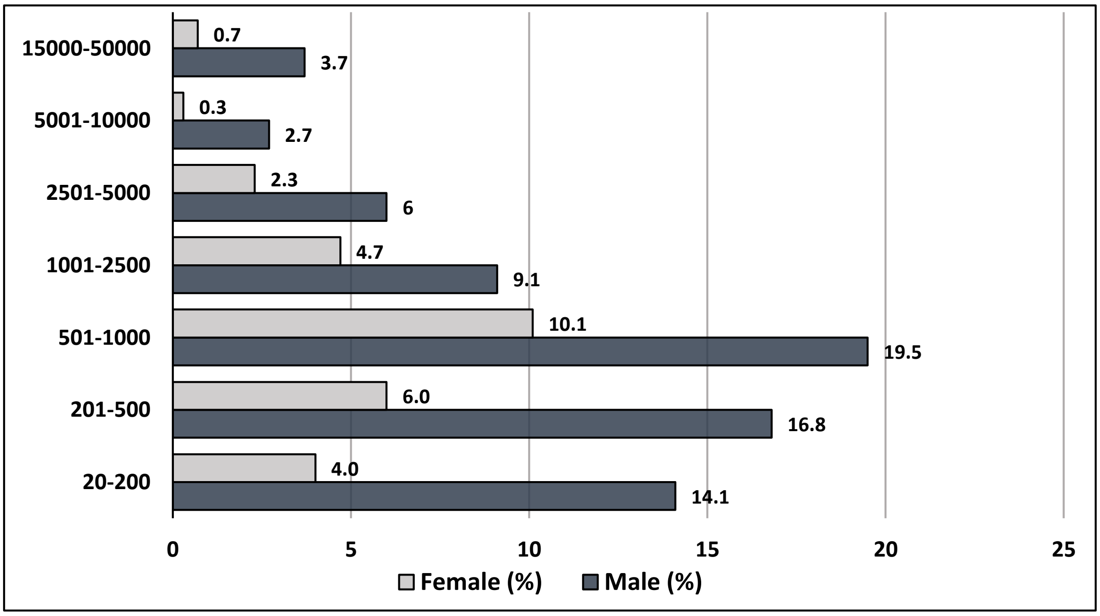

Figure 9.19: Health expenses (%) by sex

Site wise highest expenditure practices have been noticed among the people living in Abdullahpur (19.5%) and Konabari (16.4%). People living in Kashimpur have been found to spend the lowest money (1.7%) (Appendix table G22) but disease occurrence in this area is in the top-four position with the percentage of disease occurrence being 38.9 and total household surveyed is 786 (11.0%; Table 9.3). This is an incredibly unique finding and further research can be carried out to understand the underlying causes behind such practice.

9.6.6.iii Source of treatment expense

Treatment expenses of the majority (80.2%) of the households come from their monthly income. The expenses from loans (19.5%) and savings (18.8%) were also substantial. Households mainly took loans from local NGOs, relatives, relatives etc. Selling assets (1.3%) for treatment purposes was also recorded. Begging, support from the workplace (0.7%) is also recorded in other categories (Table 9.8).

Table 9.8: Sources of treatment expense

Source of expense	Frequency (n)	Percentage (%)
Monthly income	239	80.2
Savings	56	18.8
Loans	58	19.5
Selling assets	4	1.3
Others	2	0.7
Total	**359*MR (n=298)**	**120.5**

Example of others: begging, provided by the office

Source: HH Survey, 2017-18

9.7 Incorporating theoretical and conceptual framework into study findings

9.7.i Disease ecology theory: The disease ecology framework argues that any trait of disease is due to the intersection of three sets of factors – community, environment, and behaviour. To apply the disaster ecology model to the study's findings, the three components (habitat, population, and behaviour) of this model have been integrated with the findings captured in this study. This framework provides some insights into the determining factors that influence disease happening with water-use behaviours at the community level.

This framework views the ***human organism*** as the potential host of the disease, where susceptibility or resistance to diseases by the people is also greatly influenced by the age and sex of individuals. This is because as the person is noticeably young or grows older the body's natural defenses tend to break down, therefore increasing susceptibility to water-related diseases, sometimes genetic constituents of individuals either make them susceptible or resistant to water related diseases in this case. This statement is also supported by the study findings where the female is more susceptible to some disease than the male due to their different roles of water related household activities. Alternatively, age-wise water related disease occurrence remains highest (27.6%) among the most active group (26-35 yr) of the studied communities who are mainly responsible for various water related activities (Appendix table G5).

Habitat or environment is linked to the study area where respondents live and work. The environment consists of both man-made and natural resources which they depend on for their survival. One such resource in this instance in the study area is water bodies. The studied community uses various sources of water including pipe water, tube well water, supply water, and even river water (Turag River) for various purposes (drinking, domestic uses etc.). The utilization of these resources either exposes them to or protects them from any diseases that may emerge using such resources. Therefore, the health of the people depends upon both sources and uses of water.

Human ***behaviours*** itself may be said to be a risk factor for disease, in many ways humans may unwittingly increase the likelihood of disease by exposing themselves or others to risk factors of both the exogenous[109] and endogenous[110] variety[111]. Indeed, human behavioral factors play a role in every major category of disease causation, although their role is sometimes subtle or direct. In the present cases this can include household-level hygiene practices; water collection; storage and handling practices; waste disposal practices; lack of awareness etc. so many causes (***discussed in detail in section 9.7.ii***).

Therefore, the implication of study findings with the human disease of the ecology model shows that the interplay between humans and their environment (habitat) leads either to the production of or prevention of disease.

9.7.ii Behaviour Change Theory

Behaviours' of studied communities include unhygienic water collection and storage, household-level hygiene practices, poor household waste disposal, consumption of untreated water, insufficiency of water supply, lack of awareness may negatively affect communities' health. Complex behaviour changes, such as regular handwashing, good hygiene practices, and treatment of water in the home can further reduce the likely spread of disease. The full benefits of improved drinking water and sanitation services will be accrued only with effective and sustainable behaviour change (WHO & UNICEF, 2005).

Based on the behavioural patterns of the studied communities the following behavioural changes practices can be suggested:

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109 Exogenous risk factors are those that are extrinsic to the body of the human host

110 Endogenous risk factors are those that are biologically intrinsic to human host

111 *Medical Anthropology: Contemporary Theory and Method*. 1992. *Revised Edition* by Carolyn F. Sargent, Thomas M. Johnson. Chapter 10: Disease, Ecology, and Human Behavior by Brown, P. J., Inhorn, M. C., and Smith, D. J. 64(4), pp. 197-199. https://marciainhorn.com/wp-content/uploads/Disease-Ecology-and-Human-Behavior.pdf

- adopting and practicing good hygiene behaviours. Handwashing is effective when it is practiced, to achieve this, handwashing campaigns are effective in the short term therefore it must involve regular house visits, radio messages, and training of health-centre staff.
- mothers should dispose of their babies' faeces safely; wash their hands after defecation, after handling baby's faeces, after cleaning their baby's bottoms, and before preparing food to break the disease chain.
- to reduce E. coli contamination in household water, many of the point-of-use treatment options—including the use of disinfectants such as chlorine tablets, and household-level treatment such as boiling water before drinking—requires considerable behavioural change on the part of households.
- adopting the community led total sanitation (CLTS) approach to end open defecation and use sanitation facilities. Such efforts should be combined with campaigns for awareness raising, behaviour change, and availability of financing. However, Bangladesh's past successes in behaviour change, such as ending open defecation, are encouraging.

9.8 Policy Recommendations

1. To provide the urban poor with universal access to safe and affordable water, as well as investments in extended supply facilities, and sustainable water supplies.

2. Extended coverage together with quality and quantity of water should be a must maintain exercise by the government water service to ensure good health.

3. It is essential to evaluate public health policies to assist low-income people. Providing a "Health Card" can be an option.

4. Expanded water interventions program by Government and NGOs to ensure a satisfactory level of water supply for urban poor. Regular monitoring of these interventions should be prioritized.

9.9 Conclusion

Water is considered an extremely basic human need; therefore, it must be safe for drinking and other household uses. Goal 6 of Agenda 2030 covers concerns such as drinking water, sanitation, and hygiene, as well as the quality and sustainability of water resources across the world. Drinking water must be free of bacteria and parasites, as well as chemical and physical contaminants that might harm a person's health. Safe drinking water systems are essential to ensure cities and towns grow sustainably. Ignorance of extending water services to the millions of urbanites plays a key role in underpinning health. Improvements in access to safe, affordable piped water for urban communities could reduce health impacts and household expenditure. Improvements in access to safe, affordable piped water for ‘informal’ urban communities currently dependent on river water could reduce health impacts. This research, therefore, provides foundations for future studies about the influence of water on public health and will contribute to developing the theory of urban water challenge. This will improve everyone's health, as well as the health, safety, education, and income of women, who are the major water providers to homes all over the world. In many developing countries, a policy shift to incorporate better household water quality management as part of the ongoing expansion of coverage and upgrading of services might prove to be a low-cost and effective health intervention (WHO & UNICEF, 2005).

Chapter 10: Linking Illness with Productivity Loss

10.1 Introduction

Almost everybody dreads disease and poor health. One of the most valuable commodities is one's health, which is both a product and a determinant of labor and therefore income level (Aguayo-rico et al., 2005; Weil, 2005). Person productivity is influenced by their health where illness influences both the quantity of work (people may work more slowly than normal or have to repeat tasks), as well as the quality of work (they may make more or more serious mistakes).

In Bangladesh, the informal labor force has grown in recent years, and the majority of workers work in precarious and dangerous environments, with no access to sanitary services, potable water, or adequate waste disposal (Alam, 2012; Ali, 2013). If people's physical or mental health is suffering, it may have a negative effect on their productivity at work (Isham et al., 2020). A healthy worker can boost their efficiency, which can lead to increased labor productivity and a higher quality of living (Tompa, 2002). Bloom & Canning (2000) discovered that improving an individual's well-being contributes to increased workplace productivity.

Loss of productivity has often been quantified by days absent from work (absenteeism) (Beaton et al., 2009). Losses in productivity were also caused by absenteeism associated with caring for family members (Genowska et al., 2017). Therefore, one way in which ill-health may influence productivity is through greater "absenteeism"[112]. Alternatively, people may choose to attend work when ill, but experience reductions in their performance and productivity on the job due to their health condition. Ill health may therefore also influence productivity through greater "presenteeism"[113] (Isham et al., 2020). In Bangladesh, the expense of reduced production due to absence from work or presenteeism due to sickness has barely been studied. As a result, while this is an exploratory analysis on worker ill-health and productivity loss in Bangladesh, it is becoming a more pressing issue for governments and companies who depend on health workers to be efficient and successful in highly competitive markets. However, there are certain drawbacks to the current research that must be considered when evaluating the findings.

[112] Absenteeism: refers to a short period of absence from work because of ill-health (Strömberg et al. 2017)
[113] Presenteeism: a phenomenon in which people are present at work but operating at less than their full capacity (Isham et al., 2020)

10.2 Conceptual Framework of the Study

The impairment of worker productivity due to illness is included in the indirect costs of the research of the field of health economics (Koopmanschap et al., 2005; Meerding et al., 2005). The concept of the present study is adopted and modified from Beaton et al., *Worker productivity outcome measure* (2009) and presented in Figure 10.1 below-

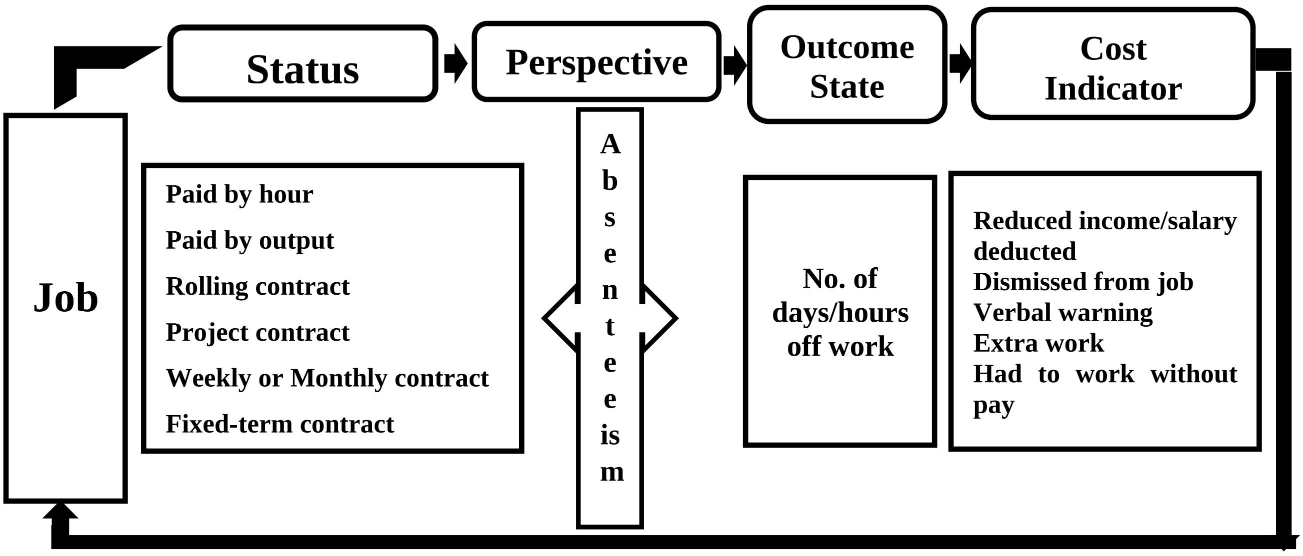

Figure 10.1: Conceptual framework of the study

10.3 Objectives of the Study

The present study aims to divulge the effects of water caused illness on productivity of the studied communities. Therefore, the specific objectives of the study are-

i. To find out various long-term illness among the studied communities;
ii. To find out various illness communities suffered in the past two weeks;
iii. To determine the number of days that populations have been away from work due to illness; and
iv. To assess the issues that occur as a result of illness-related absences from work.

10.4 Methodology of the Study

This part of the study is completely based on questionnaire survey data from 1826 households from different sectors of the labor market. In this study, productivity loss has been estimated by counting the number of days individuals are absent. Productivity loss related to absenteeism was measured using the question:

i. "In the past ONE year, how many days have you miss work or had to forgo income as a result of these illnesses?" Response choices for long-term illness were "1-2 days", "3-7 days", "1-2 weeks", "2-4 weeks", "More than 4 weeks", or "Don't know". and

ii. "In the past two weeks, how many days you absent from work or had to forgo income?" The absence response options were open-ended, meaning that respondents could answer every day between one day and fourteen days.

To address the research objectives formulated above, a review of available literature had been done to collect currently available evidence about the relation between worker illness and workplace productivity. SPSS 23 was also used to conduct general descriptive statistics (percentage, frequency, cross-tabulation) to illustrate the prevalence of health risk.

10.5 Findings

The study findings are discussed below under the following headings-

10.5.1 Long term illness that community suffered in the past one year

10.5.1.i Long-term illness that affects community ability to work or function properly

The communities were questioned over a long-term disease that had been plaguing them for the past few years where 34.6 percent (n=2470) were diagnosed with different forms of long-term illness, while 65.2 percent (n=4648) were free of any long-term illness (Appendix table H1). Body pain (40.9%) was the most common complaint in the study population, accompanied by fatigue/weakness (28.9%), blood pressure (26.4%), headache/migraine (20.3%), and multiple respiratory problems (12.8%) (Appendix table H2). Other illnesses, such as diabetes (9.4%), kidney-related disorders (4.4%), sexual health problems (2.1%), physical impairment (2.5%), numerous psychiatric problems, and retardation (1.5%) were also quite common in community members, together with various other illnesses (21.8%) (Appendix table H2). Other types of long-term illnesses include many of which fever, cardiological problems, cold/pneumonia, eye-related problems, gastric, skin disease, bone-related problems, etc. were most common (Appendix table H3).

In the case of female 99.1 percent (multiple responses) has long-term diseases, while in the case of male it was 71.9 percent (Appendix table H2). Except for respiratory-related conditions and physical impairment, females have a higher percentage of disease prevalence in this group (Figure 10.2, Appendix table H2). Also, Abdullahpur (33.6%), Konabari (31.9%), and Mausaid (26.8%) have the largest long-term disease distribution (Appendix table H4).

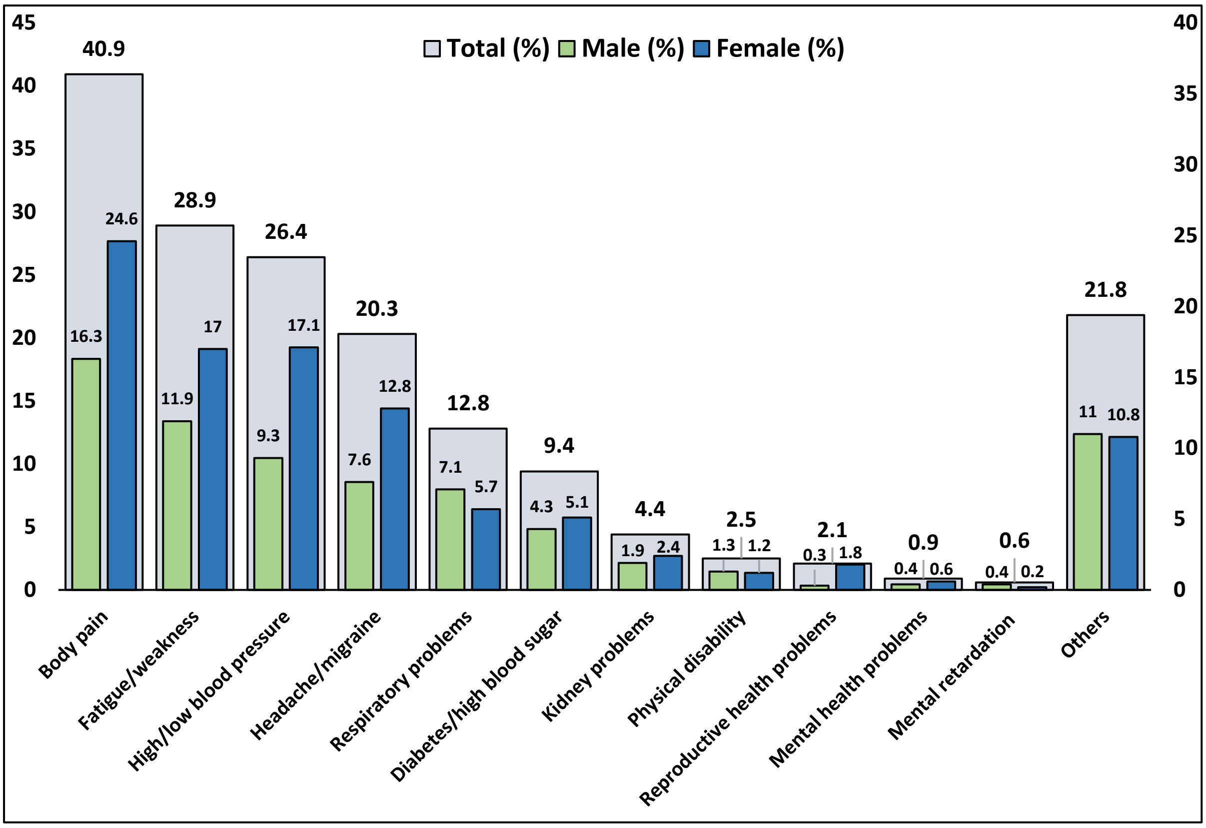

Figure 10.2: Percentage (%) of long-term illness existing among the studied community

Though the long-term illnesses presented in Figure 10.2, do not explicitly come under any water-related illness, therefore, respiratory illness has a close connection to water supplies, as do other illnesses such as body pain, fatigue/weakness, blood pressure, diabetes, fertility disorders, skin disease, and so on evaluated by Chi-square testing (Appendix table H5).

10.5.1.ii Miss of income or forgo their income because of long-term illness in the past one year

About 94 percent (n=6708) of the total 7134 people in the 1826 households surveyed, work in different formal and informal professions to support their families (Appendix table B9). A total of 34.6 percent (n=2470) were found to be suffering from various long-term illnesses (Appendix table H1) with 11.7 percent (n=834) claiming they had missed work due to sickness in the previous year (Appendix table H6).

Most of the respondents (3.2%, n=225) had been away from work for three to seven days. 2.6 percent (n=183) of respondents reported missing work for more than two to four weeks, 2.3 percent (n=164) reported missing work for one to two weeks, and 0.7 percent (n=52) reported missing work for one to two days (Figure 10.3; Appendix table H6). A long-term absence for more than four weeks absence was recorded for 2.9 percent of cases.

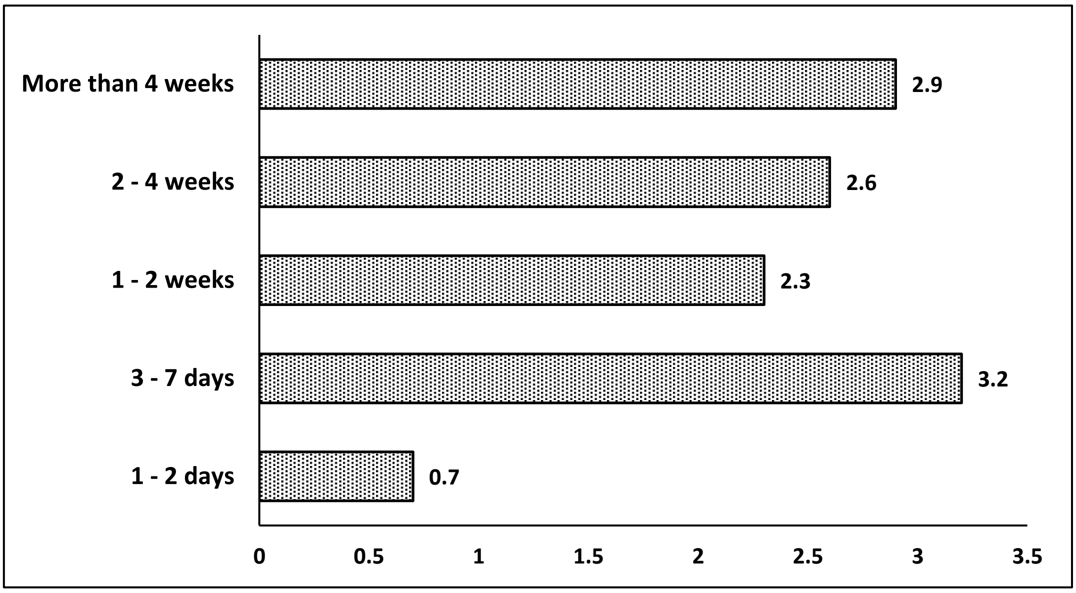

Figure 10.3: Days (%) to miss work due to long-term illness in the past one year

10.5.2 Loss of Productivity in the past two weeks

Aside from long term illness and contingent productivity loss community's income loss in the last two weeks were also analyzed and presented under the following headings –

10.5.2.i Reasons of absence from the work or forgo income in the past two weeks

The study findings show that among the total 7.2 percent (n=514) of respondents were absent from work in the past two weeks (Appendix table H7). Physical illness (5.0%) was reported as a leading cause of absence from work. Personal leave (1.5%), caring for other family members (0.1%), waterlogging, strikes (0.1%), and so on are some of the other factors (Table 10.1).

Table 10.1: Reasons of absence from work

Reasons for absent from the work	Frequency (n)	Percent (%)
Physical illness	360	5.0
Mental illness	1	0.01
To take care of other family members	10	0.1
Problems related to bio-physical/socio-political issues (waterlogging, strikes, etc.)	7	0.1
Personal leave	106	1.5
Others	36	0.5
Total	**520***	**7.21**

Source: HH Survey, 2017-18; *MR= Multiple Responses

Respondents also mention various other physical illnesses of their reasons for absence from the work (Appendix table H8). Among all the physical illness listed in Appendix table H8; fever (25%), cold/allergy/cough (9.4%), body pain (9.2%), weakness/sickness/tiredness

(9.2%), headache (5.8%), abdominal/stomach pain (5.6%), gastric (5%), back pain (3.1%), high/low blood pressure (3.1%) are the most frequent illnesses (Figure 10.4).

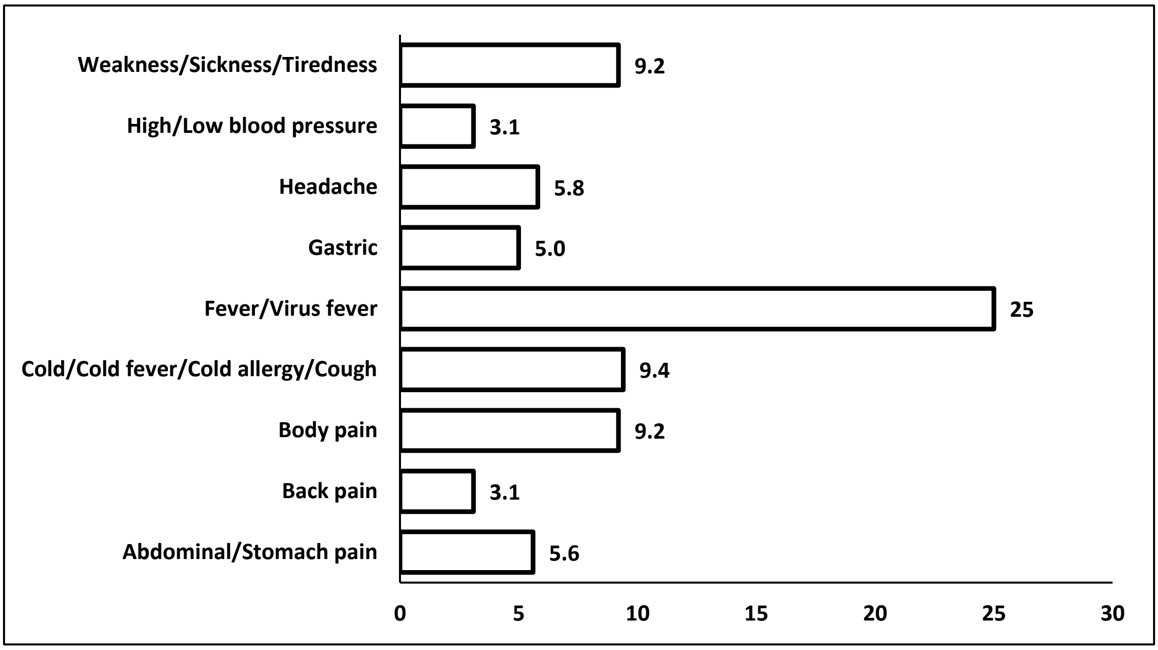

Figure 10.4: Most frequent physical illness (%) that causes respondents to leave work

10.5.2.ii Days of absence from the work or forgo income in the past two weeks

As mentioned earlier, 7.2 percent (n=514) of respondents had officially been away from work or foregone wages in the previous two weeks (Appendix table H7), most of them missed two or three days of work (3.5%) due to illness. 0.5 percent of respondents were absent for at least one day, and 0.4 percent were absent for fourteen days due to illness (Figure 10.5; Appendix table H7).

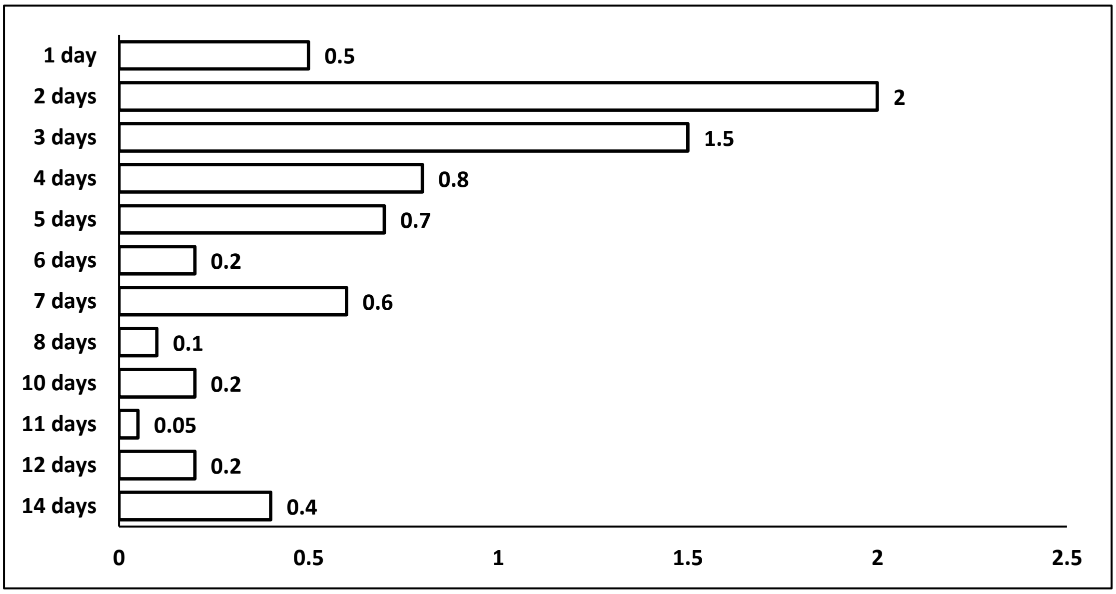

Figure 10.5: Days (%) of absent from work in the past two weeks

10.5.3 Effect or issues faced by the respondents in their workplace due to absence

Respondents were also questioned whether their absence from work had caused any issues or repercussions. Only 2.7 percent (Table 10.2) of the 11.7 percent (n=834) of total respondents who had missed work due to a long-term disease (Appendix table H6) and 7.2 percent (n=514) of overall respondents who had been sick in the preceding two weeks (Appendix table H7) and missed work or foregone income responded. In 0.6 percent (n=41) of case, for them there were no problems at work, and in 2 percent of cases, wage or pay deduction was recorded. Other problems include being dismissed from the job (0.8%) and getting verbal warnings (Table 10.2).

Table 10.2: Issues identified by the respondents due to their absence in the workplace

Issues in the job due to the absence	Frequency (n)	Percent (%)
No issue	41	0.6
Reduced income/salary deducted	141	2.0
Dismissed from job	8	0.1
Verbal warning	2	0.01
Total	**192**	**2.7**

Source: HH Survey, 2017-18

10.6 Discussion

People with poor physical health are more likely to be absent from work as well as perform poorly in the workplace. The study's results highlight the impaired productivity of all those who responded due to missed work or absenteeism. Bad productivity has been linked to a variety of physical health problems. According to the present study body pain (40.9%), fatigue or weakness (28.9%), blood pressure (26.4%), headache/migraine (20.3%), respiratory problems (12.8%), diabetes (9.4%), kidney-related disorders (4.4%), sexual health problems (2.1%), physical impairment (2.5%), numerous mental health problems, and retardation (1.5%) together with various other illnesses (21.8%) such as fever, cardiological problems, cold/pneumonia, eye-related problems, gastric, skin disease, bone-related problems, etc. (Appendix table H2) were the main reasons of absent or miss work for the past one year. The respondents' highest reported absences from work were for one week (3.2%) and more than four weeks (2.9%) (Figure 10.3). Fever (25%) was the most common reason for missing work in the previous two weeks, followed by cold/allergy/cough (9.4%), body pain (9.2%), weakness/sickness/tiredness (9.2%), headache (5.8%), abdominal/stomach pain (5.6%), gastric (5%), back pain (3.1%), high/low blood pressure (3.1%), etc. (Figure 10.4) with two (2%) to three (1.5%) days absence receiving the highest response (Figure 10.5). Extreme asthma (Chen et al., 2008), arthritis (Burton et al., 2005), chronic obstructive pulmonary disorder (Britton, 2003), and diabetes (Hex et al., 2012) have all been related to lower occupational efficiency, according to numerous studies. The most common side effects that hindered job efficiency, according to Kennedy et al. (2007), were tiredness and exhaustion. Depression, fear, obsessive-compulsive disorder, and post-traumatic stress disorder are manifestations of mental health issues (Kendrick & Pilling, 2012).

Though mental health is ignored in this report, its prevalence is documented among studied workers. According to Hafner et al., (2015), people who were marked as being at risk of having mental health disorders lost 13 percent more productivity than those who were not. Stress and mental health conditions were also one of the leading causes of long-term absence from jobs, according to Mind's (2014) study of 2,006 working adults in England and Wales in 2011. Not only the people with chronic health problems, as well as those who care for them, also experience productivity losses. Caregivers' physical fitness is often jeopardized by their caregiving responsibilities, resulting in decreased productivity at work. Grunfeld et al. (2004) also found that caregivers were more likely to incur lost productivity through absenteeism when their patient is in the terminal phase of their illness.

According to the findings, reduced income, or salary deduction, dismissal from a job, and verbal warning are all problems associated with being absent from jobs (Table 10.2). Several studies have looked at the impact of poor physical health on productivity. The results consistently indicate a negative association between these two variables (Meerding et al., 2005; Ford et al., 2011) which confirms our current findings. In this way, poor health can affect individual and social well-being by limiting earning ability and working hours (Sarkar et al., 2016) and a downward spiral into poverty (Huq et al., 2014). Poor health may also result in high out-of-pocket medical costs, which deplete existing and accrued household savings (Bloom & Canning, 2008; Huq et al., 2014). Failure to pay for healthcare due to a shortage of funds will push a family further into debt and misery, perpetuating the poverty cycle.

Our studies, taken together, aid in valuing the cost of illness-related absences by creating scenarios in which wage can be used as a fair substitute for missed productivity. This is crucial for economic analyses that aim to calculate the rise or decrease ineffectiveness of a healthcare technology or action, which can affect policy makers' funding decisions.

10.7 Conclusion

Most of the research into the relationship between health and productivity is based on examining the relationship between health questionnaire scores and productivity metrics. This means that we know that different health conditions have a positive or negative impact on performance, but it is not understood why or how. Future study might look at more specific ways by which people's health affects their productivity in terms of lost earnings and increased social stress.

Chapter 11: Summary and Conclusion

11.1 Summary of the Study Findings

This section reaffirmed the major findings of the study and presented below-

i. Among the selected eleven sites, 1826 HHs have been surveyed with the total population of the sampled standing at 7,134. The average household size is 4.0.
ii. The male and female percentages of the sample population are 50.1 and 49.9 percent, respectively.
iii. The most dominant age group of the respondent's household ranges from 16-25 (19.4%), 16-25 (22.9%), and 26-36 (20.1%) where no education' (28.5%) and education level is between 1 to 5 (25.8%) is most significant among the respondents. A major portion is unemployed though significant percentage are involved in the business, factory works, farming, and fishing.
iv. The available sources of water of the studied communities include- electric (motorized) tube well (73.8%), pipe connection into the yard (16.7%), pipe connection into the dwelling (4.5%), deep and shallow tube well (2.6%), public tap water (2.1%), open sources such as rainwater, river, lake, pond, etc. water (2.8%), etc.
v. Among 1826 households only 41.1 percent own water sources whereas most do not have their water sources (58.9%).
vi. On average the surveyed households spend 296±530.7 taka per month as water cost.
vii. The top five interactions by the studied communities with the Turag River include- water collection (99.5%), various non-essential tasks (65.1%), navigation/transport (61.9%), personal washing (52.1%), and cloth washing (40.1%).
viii. Women (46.6%) remain the highest in terms of interactions with rivers followed by men (36.4%), girls (10.3%), and boys (6.7%).
ix. Household-level water-related tasks are being performed mainly by the female (50%), female children (30.3%), male (16.7%), and male children (3.0%).
x. Time taken to do this task ranges from a maximum of 2.30 hours to a minimum of 10 minutes depending on the tasks they are performing.
xi. Among other water related tasks, fetching water is considered the main task for the females (97.1%) than their male counterparts (29.6%).

xii. Key challenges associated with fetching water includes- dispute with neighbors over water collection (8.4%), feeling uncomfortable (4.3%) in using someone else's sources, long queue (0.9), unsafe feeling (1.3%), etc.

xiii. Gastric/ulcers/stomach pain ranked highest (36.6%), skin disease (12.6%), dysentery (12.5%), chikungunya/dengue/malaria (11.1%), jaundice (9.2%), typhoid (6.0%), tuberculosis/pneumonia (5.4%) and cholera (0.8%) etc. are the major diseases among the respondents suffering from past one year.

xiv. The main materials used by the studied communities to wash hands after toileting includes- mud (2.1%), ash (1.2%), detergent (0.5%), hand wash (0.1%), etc.

xv. Only 3 percent of respondent’s households take various measures to make water safe before drinking.

xvi. People mainly go to medical college or specialized hospital (22.8%), private clinic (9.7%), self-treatment (5.4%), qualified doctor (5.0%), etc. to find treatment.

xvii. On average communities are found to expend a minimum of 135 and a maximum of 22000 takas for treatment.

xviii. Loss of productivity due to long term illness include body pain (40.9%), fatigue/weakness (28.9%), blood pressure (26.4%), headache/migraine (20.3%), respiratory problems (12.8%), diabetes (9.4%), kidney-related disorders (4.4%), sexual health problems (2.1%), physical impairment (2.5%), numerous mental health problems, and retardation (1.5%) together with various other illnesses (21.8%).

xix. Miss or absence of work due to these ling term illness was recorded as 1 to 2 days (0.7%), 3 to 7 days (3.2%), 1 to 2 weeks (2.3%), 2 to 4 weeks (2.6%) and more than four weeks (2.9%).

xx. They face a variety of problems because of their absence from jobs, including reduced income/salary deduction, job dismissal, verbal notice, and so on.

11.2 Conclusion

The current research focuses on how water sources and usages affect health risks (dysentery, dengue/malaria, jaundice, typhoid, tuberculosis/pneumonia, cholera, and skin disease), as well as the consequences of these illnesses. It also analyzed gender differential roles, responsibility, and challenges they face to perform their water-related daily household activities. Due to overpopulation, rapid industrial growth, and over-exploitation of water, the sources of urban water resources are threatened. Majority of the respondents have safe sources of water though for others affording water resources for their drinking, washing, bathing, and other domestic uses comes at greater cost and struggle. They, therefore, depends on unsafe polluted open sources of water such river, pond, canal, etc. Together with these unsafe open sources, the quality of water of various available sources has a great impact on community health which is associated with other impacts such as loss of income, a decrease in productivity, increase treatment cost, etc., and gendered disparities in water-related household activities. So, it concludes that sufficient water is not enough, but it must be quality water. In Bangladesh, both lack of investment and under maintained water supply systems resulting in scarcity of safe water. In many areas, water in supply systems in Dhaka are lost due to leakage, illegal abstractions, and vandalism. Water is heavily subsidized in some parts for individuals who are linked to the system, while those who are not, rely on unsafe sources or pricey private vendors. The number of water insecurity-related challenges encountered by poor people and other users' needs to be properly identified, recorded, and analyzed as part of improvement activities. However, while continuing to extend the system and addressing the needs of the poor, it is conceivable to enhance the performance of urban water delivery systems. The Government of Bangladesh is leading several initiatives to improve Dhaka's water security by involving partners from public and private sectors. Water policy needs to ensure the provision of urban poor with safe water access and for this significant progress in water security must be done. A special arrangement of water with a lower tariff should be considered for these underprivileged groups. For the coming decades, it is needed to manage the ways water is used and misused, a task that may need immediate action but will undoubtedly necessitate long-term strategic planning in Bangladesh.

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Appendix A: Survey Questionnaire

Appendix A1: Household Survey Questionnaire

QUESTIONS	CHOICES	INSTRUCTIONS FOR ENUMERATORS
Start date and time of the survey		
End date and time of the survey		
Section 1. Introduction and Identifiers		
1.1 Identification number of enumerators	**SELECT ONE** 1 2 3 4 5 6 7 8 9 10	
1.2 Consent and confidentiality agreement	I am working with the University of Dhaka as part of a research programme. I want to carry out a short survey, where I will be asking questions about you and your household members. The survey is expected to take approximately 30 minutes to complete. If you agree to participate, the information you provide will be used for research purposes only. Your responses to these questions will remain strictly confidential and your name will not appear in any data that is made publicly available. You may withdraw from the study at any time and if there are questions that you would prefer not to answer then we respect your right not to answer them. We would like to write down your contact information in case of some issues in the questionnaire are unclear and we need to follow up with you for more information or clarification. Do you consent to participate in and provide information for this study?	
1.3 Is the respondent happy to continue with the survey?	**SELECT ONE** Yes No	If no, thank the respondent for their time and move on to the next survey
1.4 Collect the GPS coordinates of this household	**PRESS GET COORDINATES** Stand directly in front of the household main entrance. Accuracy level should be at least 5m	Coordinates will be captured automatically once it gets below an accuracy threshold of 5m
1.5 Please select the site where this interview is occurring	Konabari Kashimpur Ichharkandi Palasana Gutia	

	Gusulia Bhakral Bhadam Rashadia Kathaldia Abdullahpur Mausaid	
1.6 How long have you been living in this area?	**SELECT ONE** Less than 1 year 1 - 2 years 2 - 5 years 5 - 10 years More than 10 years	Area refers to the broader study site selected above, not the particular house in which the respondent is staying at present
Section 2. Household demographics [2.1.1 – 2.1.10 to be repeated for each household member]		
How many people live in this household?	**INSERT INTEGER**	
Name of household member #1	**INSERT TEXT**	
2.1 Occupation and terms of contract		
2.1.1 What is NAME's relationship to the household head?	**SELECT ONE** Head Spouse Son or daughter Son-in-law or daughter-in-law Father or mother Father-in-law or mother-in-law Grandchild Brother or sister Adopted/foster child/stepchild Other relatives Not related Others	One of the members must be identified as the Head If 'Others' is selected, no need to specify further
2.1.2 Sex of NAME	**SELECT ONE** Male Female	
2.1.3 NAME's Age	**INSERT INTEGER**	Record approximate age if the exact age is not known
2.1.4 What is the highest-grade NAME completed? *Relevant if age>5*	**SELECT ONE** No education Pre-school/ kindergarten Class 1 Class 2 Class 3 Class 4 Class 5 (PSC) Class 6 Class 7	

	Class 8 (JSC) Class 9 Class 10 (SSC) Class 11 Class 12 (HSC) Bachelors/Diploma or Higher Don't know	
2.1.5 Does NAME have a personal mobile phone?	**SELECT ONE** Yes No	Relevant if age>13
2.1.6 NAME's Occupation	**SELECT ONE** Garment factory worker Skilled labour/professional (e.g., accountant, electrician, plumber, mechanic, tailor, etc) Factory (non-garment industry–cement, tannery, etc) Government (police, teacher, nurse) Agricultural labour Construction worker Fishing Rickshaw/van puller Domestic maid Boatman Business (shop owner, vendor, etc) Farmer (agriculture, aquaculture in own/ leased in land) Service (e.g., private job) Landlord/ Income from property rent Unemployed/ housewife Student Casual labour (construction, farm, other) Others (Specify)	Relevant if age>5
2.1.7 If (1) a garment factory worker: describe NAME's role in the garment factory?	**SELECT ONE** Dry production (sewing, cutting, packaging) Wet production (dyeing, washing) Management Others (Specify)	
Only applicable for individuals working in the garment industry, government, professional, or factory (categories 1-4 above)		
2.1.8 For how long you have been working in this job/factory?	**SELECT ONE** Less than 1 year 1 - 2 years 2 - 5 years 5 - 10 years More than 10 years	
2.1.9 What is the payment structure of NAME's contract?	**SELECT ONE** Paid by hour Paid by output (per piece) Rolling contract (by day)	

	Project contract (to fulfil order) Weekly or Monthly contract Fixed term (annual or longer) Don’t know Others (Specify)	
2.1.10 Based on the above, what type of contract does NAME have?	**SELECT ONE** Writing Verbal Other specify Don’t know	
2.2 Illnesses in the past ONE year		
2.2.1 In the past ONE year, did NAME suffer from any major illnesses?	**SELECT ONE** Yes No Don't know	If required, read out some of the choices as prompts
2.2.2 If so, what illness did NAME suffer from	**SELECT MULTIPLE** Dysentery (Diarrhoea with blood) Cholera Typhoid Jaundice Skin diseases Gastric ulcers/stomach pain Chikungunya/dengue/malaria Tuberculosis/pneumonia Others (Specify)	
2.2.3 Does NAME suffer from any other long-term illness/ disability that affect their ability to work or function properly?	**SELECT ONE** Yes No Don't know	
2.2.4 If so, what long-term illness/disability does NAME suffer from?	**SELECT ONE** Body pain Fatigue/weakness Headache/Migraine High/low blood pressure Diabetes/High blood sugar Kidney problems Respiratory problems Reproductive health problems Mental health problems Mental retardation (Autism/Down's syndrome etc.) Physical disability Others (Specify)	
2.2.5 In the past ONE year, did NAME have to miss work or forgo their income as a result of these illnesses?	**SELECT ONE** Yes No Don't know	

2.2.6 If so, how many days?	**SELECT ONE** 1 - 2 days 3 - 7 days 1 - 2 weeks 2 - 4 weeks More than 4 weeks Don't know	Record a rough estimate, if required
2.3 Loss of productivity in the past 2 weeks		
2.3.1 In the past 2 weeks, was NAME absent from work or had to forgo income?	**SELECT ONE** Yes No Don't know	
2.3.2 If so, how many days	**INSERT INTEGER**	
2.3.3 Why was NAME absent from work or had to forgo income	**SELECT ONE** Physical illness Mental illness To take care of other family members Problems related to bio-physical/socio-political issues (waterlogging, strikes??) Personal leave Others (Specify)	
2.3.4 What illness did NAME suffer from?	**INSERT INTEGER**	
2.3.5 Did you seek any advice, treatment or medicine for NAME's illness from any source	**SELECT ONE** Yes No Don't know	
2.3.6 Where did you seek advice or treatment?	**SELECT MULTIPLE** Upazilla Hospital District hospital Medical College/Specialized Hospital Private clinic Mother and Child Welfare Centre (MCWC) UHC (Union health centre) Union Health and Family Welfare Centre (UH & FWC) Satellite clinic/EPI outreach site Community clinic Family welfare/health centre NGO static clinic NGO satellite clinic NGO field worker Qualified doctor Unqualified doctor Pharmacy Homeopathy Ayurvedic Self-treatment Other (Specify)	

2.3.7 How much money have you spent in total in the last two weeks for NAME's treatment?	**INSERT INTEGER**	Record a rough estimate, or '999' if not known
2.3.8 Did NAME face any issues in their job due to absence?	**SELECT ONE** No issues Reduced income/salary deducted Dismissed from job Verbal warning Extra work/had to work without pay Others (Specify)	
2.4 Water and sanitation at the workplace		
2.4.1 Is there any provision for drinking water at NAME's workplace?	**SELECT ONE** Yes No Don't know	
2.4.2 If yes, *is the water safe to drink? *is it available when needed? *is it located nearby?	 Yes No Don't know Yes No Don't know Yes No Don't know	
2.4.3 Is there any toilet facility at NAME's workplace?	**SELECT ONE** Yes No Don't know	
2.4.4 If yes, *is it separated by gender? *does it have handwashing facilities? *is it accessible when needed?	 Yes No Don't know Yes No Don't know Yes No Don't know	
Section 3. Water and sanitation		
3.1 Drinking water - Source and Payments		
3.1.1 Name ALL the sources of DRINKING water used by your household in the past 1 year	**SELECT MULTIPLE** Public piped into dwelling Public piped into the yard Public tap/standpipe Deep tube well (with handpump only) Shallow tube well (with handpump only) Electric tube well (with motor only OR both motor and handpump) Rainwater Tanker truck Cart with small tank/containers Bottled water River/Canal Lake Pond Others (specify)	

3.1.2 Who owns this deep tube well? 3.1.2 Who owns this shallow tube well? 3.1.2 Who owns this electric tube well?	**SELECT ONE** Own immediate family Extended family (cousin, brother, etc.) Another unrelated family (neighbor) Group of families (collective) Community/government (Public) School/Mosque/Other institutes Others	Relevant if Deep/Shallow tube well is selected in 3.1.1
3.1.3 Of the sources mentioned above, which one is your MAIN drinking water source?	**INSERT INTEGER**	Choice filter based on options selected in 3.1.1
» » These questions are applicable for the MAIN source only		
3.1.4 Do you share this water source with other households?	**SELECT ONE** Yes No	
3.1.5 How many households share this water source?	**SELECT ONE** Less than 5 Between 5 and 10 More than 10	
3.1.6 How much time does it take to go to the source, get water, and come back?	**SELECT ONE** Less than 5 minutes 5-10 minutes 10-15 minutes 15 - 30 minutes More than 30 minutes Don't know	
3.1.7 Who usually goes to this water source to fetch the water for your household?	**SELECT MULTIPLE** Adult male(s) Adult female(s) Male children Female children	For this question, children are defined as any individual less than 12 years of age
3.1.8 Has this person(s) ever faced any challenges while fetching water?	**SELECT MULTIPLE** Quarrels/conflicts with neighbours Felt uncomfortable in using someone else's source Felt unsafe Eve teasing Physical/sexual harassment Physical burden associated with carrying heavy water containers Other (Specify)	If required, read out the choices as prompts
3.1.9 Do you or someone in your house pay for this water?	**SELECT ONE** Yes No	This includes payment for water only; not infrastructure repair or

		maintenance costs
3.1.10 To whom are payments for water made?	**SELECT ONE** At the Water Utility office/bank/to the tariff collector Included in house rent/to landlord At the place where water is fetched from/ delivered to Other (Specify)	
3.1.11 How often do you pay?	**SELECT ONE** Monthly (Fixed amount) Variable amount (One-off payment/for transport) Per container	
3.1.12.a. How much do you pay monthly? 3.1.12.b How much do you pay seasonally/lump sum? 3.1.12.c How much do you pay per container? 3.1.12.d How much do you pay per cubic meter?	**INSERT INTEGER (a-d)**	Record in Taka
» » These questions are applicable for the SECONDARY source		
3.1.13 Of the sources mentioned above, which one is your SECONDARY drinking water source?	**SELECT ONE** Public piped into dwelling Public piped into the yard Public tap/ standpipe Deep tube well (with handpump only) Shallow tube well (with handpump only) Electric tube well (with motor only OR both motor and handpump) Rainwater Tanker truck Cart with small tank/containers Bottled water River/Canal Lake Pond Others (specify)	
3.1.14 Why did you use this source instead of your main source?	**SELECT ONE** Infrastructure not working New infrastructure installed Unreliable supply Not enough water Alternative source has better quality Alternative source is cheaper Alternative source has better taste/smell/colour Easier access Other (Specify)	

3.1.15 For how long you had to use this secondary source?	**SELECT ONE** Less than 5 days Between 5 and 30 days Between 1-2 months More than 2 months Don't know	
3.1.16 Do you or someone in your house pay for this water?	**SELECT ONE** Yes No	This includes payment for water only; not infrastructure repair or maintenance costs
3.1.17 To whom are payments for water made?	**SELECT ONE** At the Water Utility office/bank/to the tariff collector Included in house rent/to landlord At the place where water is fetched from/ delivered to Other (Specify)	
3.1.18 How often do you pay?	**SELECT ONE** Monthly (Fixed amount) Seasonally/lump sum (Fixed amount paid for certain times of the year) Per container Per cubic meter (Volumetric payment applies for metered connections only)	
3.1.19.a How much do you pay monthly? 3.1.19.b How much do you pay seasonally/lump sum? 3.1.19.c How much do you pay per container? 3.1.19.d How much do you pay per cubic meter?	**INSERT INTEGER (a-d)**	Record in Taka
3.1.20 Did you face any additional challenges as a result of switching from your MAIN source to this SECONDARY source?	**SELECT MULTIPLE** No challenges Women spent more time/effort in collecting water Girls (<12yrs) spent more time/effort in collecting water Women felt unsafe collecting water Girls (<12yrs) felt unsafe collecting water Felt uncomfortable in using someone else's source Higher costs Poor water quality Other (Specify)	
3.2 Drinking water - Intervention and maintenance		

3.2.1 In the past 5 years, has there been any development intervention that has improved your drinking water situation?	**SELECT ONE** Yes No Don't know	This refers to community level interventions by the government, private sector, institutions, or CBOs, NOT by households for their private use.
3.2.2 What type of intervention has been implemented? *Relevant if 'yes' is selected in 3.2.1*	**SELECT MULTIPLE** Installation of deep/shallow tube well Piped water system (new/expansion) Water vending (new/expansion) Rainwater harvesting system Public Pond excavation Installation of Pond Sand Filter (PSF) Managed aquifer recharge Other (Specify)	
3.2.3 In the past 5 years, did your household install any new water related infrastructure?	**SELECT ONE** Yes No Don't know/No response	This refers to the installation of new tube well or new motor/pipes, NOT repair or maintenance work
3.2.4 What did you install? *Relevant if 'yes' is selected in 3.2.3*	**SELECT MULTIPLE** New shallow tube well (handpump/motorized) New deep tube well (handpump/motorized) Electric/diesel motor to the existing tube well Pipes/Storage tank to existing tube well Storage tank for rainwater harvesting Other (Specify)	
3.2.5 How much money did your household spend/contribute to this installation?	**INSERT INTEGER**	Record in Taka
3.2.6 In the past 12 months, did you/anyone else conduct any maintenance or repairs to the water source?	**SELECT ONE** Yes No Don't know/No response	This involves replacing washers, buckets, pipes, or handles of tube wells; electric parts of pump motor
3.2.7 How much money did your household	**INSERT INTEGER**	Record in Taka. Write '999' if the

spend/contribute to this maintenance/repair work? *Relevant if 'yes' is selected in 3.2.6*		amount is not known.
3.3 Drinking water - Quality and storage		
3.3.1 Do you think that the water you drink is safe?	**SELECT ONE** Yes No Don't know/No response	
3.3.2 If not, why? *Relevant if 'no' is selected in 3.3.1*	**SELECT MULTIPLE** Water has Arsenic Water has Iron Water is saline Water has germs Water doesn't taste/smell/look good Other (Specify)	
3.3.3 Do you do anything to the water to make it safer to drink?	**SELECT ONE** Yes No	
3.3.4 What do you usually do to make the water safer to drink? *Relevant if 'yes' is selected in 3.3.3*	**SELECT MULTIPLE** Boil Add bleach/chlorine Add alum Add halotab Strain through a cloth Water filter (Bio sand/composite/ceramic filter) Solar disinfection Let it stand and settle Other (specify)	
3.3.5 Does your household store water on the premises? This refers to storing large quantities of water for at least a few hours due to difficulties in fetching water as and when needed	**SELECT ONE** Yes No	
3.3.6 Please show me where you store water. Take picture of the storage container(s) Encourage them to show you their biggest container(s).		
3.3.7 How long is the water stored for?	**SELECT ONE** 6 hours or less 6 - 12 hours 12 - 24 hours 1 - 2 days More than 2 days	
3.3.8 Where do you store the water?	**SELECT MULTIPLE** Pitcher (kolshi) Jug	

	Bucket Container/Jerrycan Bottle	
3.3.9 Is the storage container covered with a lid?	**SELECT ONE** Yes No	Observation only
3.3.10 Do you clean the container(s) before water collection?	**SELECT ONE** Always Sometimes Never	
3.3.11 Where do you wash the storage container?	**SELECT ONE** At the water source At pond Others (Specify)	
3.3.12 What materials do you use to wash the container?	**SELECT MULTIPLE** Only water Ash Soap Others (Specify)	
3.4 Water for domestic uses		
3.4.1 What is your household's main source of water for cooking and food preparation?		
Cooking and food preparation Washing clothes and dishes Bathing	**SELECT MULTIPLE** Public piped into dwelling Public piped into the yard Public tap/standpipe Deep tube well (with handpump only) Shallow tube well (with handpump only) Electric tube well (with motor only OR both motor and handpump) Rainwater Tanker truck Cart with small tank/containers Bottled water River/Canal Lake Pond Others (specify)	Dry and Wet Season
3.5 Sanitation and hygiene		
3.5.1 What kind of toilet facility do ADULTS of your household use?	**SELECT ONE** Flush to septic tank Pour flush to pit latrine Ventilated improved pit latrine Pit latrine with slab Pit latrine without slab/open pit Hanging toilet/waste discharged directly into waterbodies No facility/bush/field	
3.5.2 Where do you dispose of your child's waste?	**SELECT ONE** Not applicable (no child under 5)	Relevant if a child (under 5) uses a

	In the toilet On dry open ground/bush Into waterbodies (pond/river) Other (specify)	potty/re-usable cloth
3.5.3 Do you share this toilet facility with other households?	**SELECT ONE** Yes No	
3.5.4 How many households share this toilet facility?	**SELECT ONE** Less than 5 Between 5 and 10 More than 10	
3.5.5 Please show me your toilet. Take photo of toilet, if permitted		
3.5.6 What do members of your household wash your hands with before eating a meal or after going to the toilet?	**SELECT ONE** Only water Soap Detergent Ash Mud Sand Other (Specify)	If soap is mentioned, please ask the respondent to show it
Section 4. Poverty		
4.1 Assets		
4.1.1 What is your current occupancy status?	**SELECT ONE** Owner Tenant Free accommodation (public land/embankment) Other (Specify)	
4.1.2 Does your household have any of the following assets?		
Television	**SELECT ONE for each** Yes No	
Radio/CD player		
Computer/ laptop		
Bicycle		
Motorcycle		
Autobike/tempo/CNG		
Car/truck/microbus		
Rickshaw/van/animal cart		
Almirah/wardrobe/showcase		
Electric fan		
Refrigerator		
Power tiller/tractor		
Electric/diesel pump		
IPS/Generator		
4.2 Land and livestock		
4.2.1 Does your household own any agricultural land?	**SELECT ONE** Yes No Don't know	This refers to land from which the household generates any sort

		of income at present
4.2.2 How much agricultural land do you own?	**INSERT INTEGER**	Record in decimals. If respondent mentions other units like bigha/kani/acre, convert to decimals
4.2.3 Does your household own any homestead land?	**SELECT ONE** Yes No Don't know	
4.2.4 How much homestead land do you own?	**INSERT INTEGER**	Record in decimals. If respondent mentions other units like bigha/kani/acre, convert to decimals
4.2.5 Does your household own any livestock?	**SELECT ONE** Yes No	
4.2.6 No. of Cow/buffalo	**INSERT INTEGER**	
4.2.7 No. of Goat/sheep	**INSERT INTEGER**	
4.2.8 Drinking water for livestock	**SELECT MULTIPLE** Public piped into dwelling Public piped into the yard Public tap/standpipe Deep tube well (with handpump only) Shallow tube well (with handpump only) Electric tube well (with motor only OR both motor and handpump) Rainwater Tanker truck Cart with small tank/containers Bottled water River/Canal Lake Pond Others (Specify)	
4.3 Power sources and housing material		
4.3.1 What is the power source for lighting and electronics?	**SELECT MULTIPLE** Grid supply electricity Generator Solar panel Kerosene	

	Other (Specify)	
4.3.2 What type of fuel does your household mainly use for cooking?	**SELECT MULTIPLE** Electricity Natural gas (Supply/cylinder) Kerosene Animal dung Wood/fuel sticks Straw/shrubs/grass Other (Specify)	
4.3.3 Do you have a separate room which is used as a kitchen?	**SELECT ONE** Yes No	
4.3.4 With how many households do you share your kitchen?	**SELECT ONE** Not shared with any other household Shared with 1-2 other households Shared with more than 2 households	
4.3.5 Main material of the floor of house	**SELECT ONE** Earth/mud Wood/bamboo Brick or Cement Tiles/Mosaic Other (Specify)	
4.3.6 Main material of the roof of house	**SELECT ONE** Leaves/straw/plastic Wood/bamboo Tin/corrugated iron Brick/cement Other (Specify)	
4.3.7 Main material of the exterior walls of house	**SELECT ONE** Leaves/straw/cardboard/plastic Earth/mud Wood/bamboo Tin/corrugated iron Brick/cement Others (Specify)	
4.3.8 How many rooms do members of this household usually use for sleeping? Do not include open verandas	**INSERT INTEGER**	
4.3.9 Take a picture of the house so that the roof, wall, and floor materials are clearly visible.		
4.3.10 How would you describe the current welfare situation of your household?	**SELECT ONE** Doing well Doing just OK Struggling Unable to meet household needs Don't know/No response	
4.3.11 How would you describe the welfare situation of your household about a year ago?	**SELECT ONE** Better than present situation Same as present situation Worse than present situation	

	Don't know/No response	
4.4 Can you please provide a rough estimate of your households' monthly expenditure in relation to the following categories? Write '999' if not known		
House rent	**SELECT ONE for each** Yes No Don't know	
Education		
cooking		
Utilities (Water, Electricity, Gas) Write '888' if cost is included in house rent		
Treatment (Doctor's fees, medicines, etc.)		
Clothing and footwear		
Remittance (Send money back home		
Miscellaneous (Entertainment, mobile credit, etc.)		
Section 5. Priority concerns		
5.1 Socio-economic concerns		
5.1.1 Now I am going to go through a list of CONCERNS that some families in this area have expressed. Suppose that the government could help your area with just THREE of these issues, which would YOUR FAMILY choose? *Rank in order of importance*		
Concern #1	**SELECT ONE for each** Healthcare Erosion and flood protection Canal dredging Transportation and roads Sanitation Drinking water services Clean environment Security and crime Employment Education Electricity Gas supply Financial services Agricultural support No concerns/Don't know Others (Specify)	If the respondent cannot name any concerns, mention a few from the list as examples. However, do not mention anything related to water. ONA programming: Option selected for 'Concern #1' cannot be selected for 'Concern#2' and so on. If 'No concerns' is selected for 'Concern #1', for example, questions for 'Concern #2' and 'Concern #3' will not appear.
Concern #2		
Concern #3		

5.2 Concerns regarding water		
5.2.1 Do you have any concerns regarding the WATER you drink and use for domestic purposes?	**SELECT ONE** Yes No	
5.2.2 What are your three main concern (Rank in order of importance (Do not Prompt))		
Concern #1	**SELECT ONE for each** Water is unsafe to drink Water is too costly Water source is too far Water for domestic use is dirty Water supply is unpredictable Not enough No concerns/Don't know Other (Specify)	ONA programming: Only the options selected in 4.1.1 will appear for this one MAIN source is defined as the one which is used 'usually' or for the majority of the year
Concern #2		
Concern #3		
5.3 Concerns regarding the natural environment		
5.3.1 Do you have any concerns regarding your NATURAL ENVIRONMENT?	**SELECT ONE** Yes No	
5.3.2 What are your three main concerns?		
Concern #1	**SELECT ONE for each** Rivers/canals are dirty or polluted No/ inadequate rubbish collection or cleaning People commonly defecate in public spaces Riverine flooding in wet season Waterlogging after heavy rain Decline of fisheries population Forests and vegetation are decreasing No concerns/Don't know Other Rivers/canals are dirty or polluted No/inadequate rubbish collection or cleaning People commonly defecate in public spaces	ONA programming: Option selected for 'Concern #1' cannot be selected for 'Concern#2' and so on. If 'No concerns' is selected for 'Concern #2', questions for 'Concern #3' will not appear.
Concern #2		
Concern #3		
Section 6. Enumerator Closing Questions		
6.1 Did the respondent understand the majority of the questions?	**SELECT ONE** Understood all the questions well Understood most of the questions, but not all Understood some of the questions (roughly half) Did not understand many questions (less than half) Understood very few questions	

6.2 How would you rate the accuracy of the respondent's answers?	**SELECT ONE** Accurate Satisfactory Average Poor	
6.3 Contact phone number 1	**INSERT TEXT**	Enter '999' if the phone number is not given
6.4 Name of person for contact number 1		
6.5 Contact phone number 2	**INSERT TEXT**	Enter '999' if the phone number is not given
6.6 Name of person for contact number 2		

Appendix A2: Introduction of Interviewer

<u>Introduction to the Interviewee</u>

I am ____ and I am here to collect data for REACH: Improving Water security for the Poor Project. The Project focuses on water poverty nexus with the aim of improving water security for people of different categories, especially of poor, living in riverbank and adjacent areas. The discussion will take around one and half hour or so depending on your interest and participation. Any information that you provide will be kept strictly confidential and will not be shown to other people. The information that you provide during the discussion will be presented together with answers from other participants so that you cannot be identified. The discussion is voluntary, and you are free to choose not to answer any or all of the questions, or to leave the discussion at any time. The present research will mostly deal with the use, exposure, risks and vulnerabilities of different categories of urban poor in the way they interact with the surrounded water of the river Turag. The study will mainly focus on understanding risk of interacting river water and to develop a sustainable pathway to mitigate risk. This Risk-based research will be directed to support improved policy and practice on how urban river water security risks can be addressed at scale for the benefit of the poor.

Appendix A3: Interview guideline (FGD)

FOCUS GROUP DISCUSSION

Group: Urban male/ Urban female/ Mixed group
Number of participants: X
Venue: X's office or home, name of village or town
Date: DD Month 2016 (Day of week)
Time: HH:MM to HH:MM
Facilitator: Name, gender, designation, organisation
Note-taker: Name, designation, organisation
Remarks: Any issues that might have affected the FGD, including, but not limited to, absence of any participant, non-responsiveness of certain participants, external factors causing disruption or distraction, issues related to recording or note taking.

START OF FGD [Total number and file names of Audio tapes]

I:
P:
P:
I:

END OF FGD

List of participants

SL. No.	Name/ Identifier	Age	Education	Occupation	Family members	Category of participants	Remarks, if any

Appendix A4: Consent form and participant information: Focus Group Discussion

Participant information and consent form – FGD

Name of interviewer:
Date:

Oral Information and Consent form

[To be read out by interviewer for verbal consent]

Welcome to all of you and thank you for attending.

My name is [name] and I am the team leader for this group discussion. I work for the University of Dhaka/Oxford as part of a research project titled 'REACH: Improving Water Security for the Poor'.

We are running these workshops to discuss issues of water-related challenges that you/your family face in your day to day lives and how these issues affect your quality of life/ well-being. This discussion will take about 1-2 hours. While we deeply appreciate your time and effort, you will not receive any direct benefit as a result of taking part in this open discussion. As this is a research study, you will not receive any direct help as a result of taking part. Your participation is completely voluntary, and you may withdraw at any time.

I will be audio recording this discussion, so that we can later remember what you say. The audio records will be kept confidential and will only be accessed by our researchers. Your name and identification information will not be used in any of our documents/ reports. We will share the overall outcomes of this research with relevant members of the Government/DPHE and UNICEF, so that they can take appropriate steps to address some of these water-related challenges in the near future.

This discussion is completely voluntary, and we can stop any time you like. You must be over 18 to take part in this interview, can you confirm that you are over 18.

Yes ………….. No…………

If you have any complaints about the discussion, then please contact:

Prof. Mahbuba Nasreen
Director & Professor,
Institute of Disaster Management and Vulnerability Studies (IDMVS)
University of Dhaka
Dhaka-1000, Bangladesh
Phone (work): +88-02-9661900-73 (Ext :4727, 4728)
E-mail: mahbubadu@yahoo.com

Having listened to this summary, do you agree to take part?

Yes ………….. No…………

We will be making audio and video recordings in this focus group discussion. These will be used so that we can remember what you say afterwards, and will only be used by the researchers and will not be shared with anyone else

Do you still agree to take part?

Yes…………… No………….

We are also taking pictures today for our research. These will not be linked to any other information you may give us today. Do you give us permission to use pictures of you in the reporting of our research?

Yes………. No……….

Appendix A5: Enumerator agreement

Behaviour Contract for REACH enumerators and facilitators

Between

REACH: Improving water security for the poor, University of Oxford

And

Researchers and Enumerators, Health and Demographic Surveillance Survey, Mekelle

There are three key principals for our research:

1. **Respect for all participants**: we appreciate and value the contribution of people in Wukro to the REACH project. As one of our key principles, we specify that all members of the research team, including field workers/data collectors, are responsible for ensuring that any person involved in the research is treated with respect at all times. This means respecting the opinions and contributions of all participants.
2. **Respect for fieldworkers**: we appreciate the contribution that you also make to the project, and we respect your well-being and safety in the field. This includes making sure that you have a safe work environment and are not put at any risk through your involvement in the research.
3. **Non-judgement**: your role is not to judge the opinions, decisions, or actions of people involved in the research. Your role is to document their perspectives through systematic, scientifically sound methods.

As part of the REACH team, and the University of Oxford, you are expected to meet the same standards for undertaking research as the rest of the research team.

All our research must be kept confidential. Participants' contributions must be kept confidential and not discussed with anyone apart from fellow enumerators, facilitators or translators, or the University of Oxford team. Any further discussion of the content of any research must be in the appropriate context, such as clarification for translation, and through secure channels.

1. All of our research is voluntary and REACH enormously value the contributions made by participants to our research. It is important that participants take part of their own free will and do not feel pressured by field workers/data collectors or other participants/family members/friends into taking part in the research.
2. Please respect the decision of the participants if they refuse to participate. It is their choice to be involved in the research. Keep a record of the reason an individual or

household no longer wishes to be involved and thank them for their time and contribution to the study.

3. Free and willing participation: As above, people take part in this research voluntarily. We do not take participation for granted. Please always respect the rights of participants and do not take it for granted. Participants need to be given respect, and have their opinions and answers respected too.
4. Consent: Your role is to clearly communicate to participants the purpose of the research, why they have been asked to participate, what their participation involves, any benefits of risks expected to result from participation, and expected use of the things that they tell you.

I confirm that I have read, understand, and agree to the above policy and practices.

Name of enumerator/field officer	
Signature	
Date	
Name of supervisor	
Signature	
Date	

*Based on Young Lives' "Ethics of Research with Children" page 22-24 http://www.younglives.org.uk/sites/www.younglives.org.uk/files/YL-WP53-Morrow-EthicsOfResearchWithChildren.pdf

Appendix A6: FGD Checklist

a. General Information

Serial No.	Name	Sex	Age	Occupation	Secondary Occupation
1.					
2.					
3.					
4.					
5.					
6.					

b. Research specific Information

1) Turag River Water Use
i. Sources of water • (drinking, cooking, household, irrigation) ii. Purposes of river water use iii. Seasonal variation of river water use a. Use of river water in wet season and purpose b. Use river water in dry season and purposes c. Time of change in water use behaviour between the wet and the dry season d. Main Reasons for change in water use behaviour between the wet and the dry season iv. Specific reasons for specifically using the river water v. Time of the day for water use and collection vi. People that use the river most (in the community) • From local community or another community vii. Access to water supplies and Providers • Government/NGOs/Others viii. Amount paid for this service • (Record in taka)
2) Perception on Health Risks
ix. Nature of health problems the community suffering from x. Effects of river water on your health • Ways river water affects you & your family's health xi. Among the Turag river water users (discussed in Part 1) • Greatest health risks (name of diseases) xii. Explain the sources or causes of river pollution xiii. Gender variation of the diseases xiv. Measures or treatment taken for these diseases • Nearest medical /treatment facilities
3) Gender Issues
xv. Most river water is used by • Women/Men xvi. Purposes of water use by sex (water use variation by sex) • Men/Women/Girls/Boys xvii. Water related household activities • Cooking, Washing clothes/vegetables/Utensils • Collecting and storing water. • Bathing xviii. Family member's responsible to manage water for household use xix. Time of the day to do these tasks xx. Time spent to do these tasks xxi. Challenges faced while go for collecting water • Security, Harassment xxii. Physical problem due to carrying out heavy load of water for household water

Appendix A7: List of participants of FGDs

Sl. No.	Name	Sex	Age	Occupation
Abdullahpur (Male Group)				
1	Abdus Salam	Male	57	Former President of Ward Number 57 Youth League
2	Abdul Kuddus	Male	45	Calciferous factory worker
3	Raja Miya	Male	35	Business (Fish)
4	Noor Mohammad	Male	40	Livestock rearing
5	Mohammad Jibon	Male	38	Business (Fish)
6	Bashir	Male	32	Van Driver
7	Mohammad Moshtak	Male	70	Wright
Abdullahpur (Female Group)				
8	Forida	Female	60	Housewife
9	Rupzan Bibi	Female	58	Cake seller
10	Rina	Female	40	Boatman
11	khushi	Female	65	Housewife
12	Nasima	Female	40	Housewife
13	Bubli	Female	35	Housewife
14	salma	Female	30	Housewife
Mausaid (Mixed Group)				
15	Shamol Dominic Cruz	Male	44	Lab Assistant Notre Dame College
16	Daniel Correa	Male	54	Worker at AZ Enterprise
17	Shanti	Female	60	Housewife
18	Shetu Correa	Female	38	Housewife
19	Suniti Sarkar	Female	53	Housewife
20	Ripa	Female	30	Housewife
Bhadam (Mixed Group)				
21	Alamgir	Male	19	Factory worker
22	Md Shohidul Islam	Male	29	Factory accounts officer
23	Md Asif Islam	Male	22	Factory worker
24	Yasin	Male	21	Factory worker
25	Chompa Akter	Female	40	Factory worker
26	Malekha	Female	33	Factory worker
27	Shahana	Female	24	Factory worker
28	Hemonti	Female	28	Factory worker
Konabari (Female Group)				
29	Momtaj Begum	Female	52	Garment's worker
30	Jhorna	Female	30	Business
31	Rohima	Female	35	Housewife
32	Selina	Female	23	Housewife
33	Aklima	Female	19	Housewife
34	Firoza	Female	45	Housewife
35	Maya	Female	30	Housewife
Kashimpur (Male group)				
36	Abu Khalek	Male	40	Car driving+Brick Kiln
37	Md Altaf Ali	Male	58	Retired businessman
38	Md Razzaque Miah	Male	55	Brick kiln

39	Mansur Ali	Male	50	
40	Liakat	Male	70	
41	Siddik	Male	65	Shopkeeper
42	Shahjahan	Male	60	

Appendix A8: KII Checklist

a. General Information

Name:	**Age:**
Sex:	**Occupation:**
Position/Designation:	**Monthly Income:**
Address:	**Phone No.:**

b. Specific Information

i. <u>Local Government (01)</u>

1. As you experienced in the community, how do the local people use water from the river? What do they use the water for?
2. If they do not use the river, why not?
3. Have you observed any change in water use based on seasonal variation?
4. In your experience, how has water use been changing over the years?
5. What do you think the reason is for the occurring change in water use?
6. What other supplies of water do they have access to?
7. How do you access these supplies i.e., do you pay for the service or is it provided by the government?
8. What makes the people use river water?
9. Is there a specific group of people who use the water? Like, poorer people, a specific gender, etc? If so, how are they related?
10. Do you think there are any relationships between water use and the overall health of the community?
11. Have you heard of anyone getting sick from using river water? If you have, please elaborate. Is this a common phenomenon in the community?
12. Who has more responsibility in managing everyday water (men or women)?
13. What are their main purposes for water use?
14. Have you noticed any changes over time? If so, in what ways?
15. What can be done to improve community health regarding water use?

16. How would you describe the role of the river in the community's livelihood/profession? Vital, just another source, or of growing/diminishing importance?

ii. Local leader (01)

1. As you experienced in the community, how do the local people use water from the river? What do they use the water for?
2. If they do not use the river, why not?
3. Have you observed any change in water use based on seasonal variation?
4. In your experience, how has water use been changing over the years?
5. What do you think the reason is for the occurring change in water use?
6. What other supplies of water do the community have access to?
7. How do they access these supplies i.e., do you pay for the service or is it provided by the government?
8. What makes the people use river water?
9. Is there a specific group of people who use the water? Like, poorer people, a specific gender, etc? If so, how are they related?
10. Do you think there are any relationships between water use and the overall health of the community?
11. Have you heard of anyone getting sick from using river water? If you have, please elaborate. Is this a common phenomenon in the community?
12. Who has more responsibility in managing everyday water (men or women)? And what purposes:

    Cooking: Women/Men/Girls/Boys

    Washing clothes: Women/Men/Girls/Boys

    Washing vegetables: Women/Men/Girls/Boys

    Washing utensils: Women/Men/Girls/Boys

    Collecting and storing water: Women/Men/Girls/Boys

    Bathing children: Women/Men/Girls/Boys

13. Have you noticed any changes over time? If so, in what ways?
14. What can be done to improve community health regarding water use?
15. How would you describe the role of the river in the community's livelihood/profession? Vital, just another source, or of growing/diminishing importance?

iii. <u>Community users' group (03)</u>

1. As you experienced in the community, how do the local people use water from the river? What do they use the water for?
2. If they do not use the river, why not?
3. Have you observed any change in water use based on seasonal variation?
4. In your experience, how has water use been changing over the years?
5. What do you think the reason is for the occurring change in water use?
6. What other supplies of water do you have access to?
7. How do you access these supplies i.e., do you pay for the service or is it provided by the government?
8. What makes the people use river water?
9. Is there a specific group of people who use the water? Like, poorer people, a specific gender, etc.? If so, how are they related?
10. Do you think there are any relationships between water use and the overall health of the community?
11. Have you heard of anyone getting sick from using river water? If you have, please elaborate. Is this a common phenomenon in the community?
12. Who has more responsibility in managing everyday water (men or women)? And what purposes:

    Cooking: Women/Men/Girls/Boys

    Washing clothes: Women/Men/Girls/Boys

    Washing vegetables: Women/Men/Girls/Boys

    Washing utensils: Women/Men/Girls/Boys

    Collecting and storing water: Women/Men/Girls/Boys

    Bathing children: Women/Men/Girls/Boys

iv. <u>Local Youth Leader (01)</u>

1. As you experienced in the community, how do the local people use water from the river? What do they use the water for?
2. If they do not use the river, why not?
3. Have you observed any change in water use based on seasonal variation?
4. In your experience, how has water use been changing over the years?
5. What do you think the reason is for the occurring change in water use?
6. What other supplies of water do you have access to?

7. How do you access these supplies i.e., do you pay for the service or is it provided by the government?
8. What makes the people use river water?
9. Is there a specific group of people who use the water? Like, poorer people, a specific gender, etc.? If so, how are they related?
10. Do you think there are any relationships between water use and the overall health of the community?
11. Have you heard of anyone getting sick from using river water? If you have, please elaborate. Is this a common phenomenon in the community?
12. Who interacts with water, or water-based tasks more, males or females?
13. Do you notice males or females falling ill more often? What causes this illness?
14. Do you think there are any impacts on people who use river water due to the factory releasing water? If so, how do you think they are impacted?

v. <u>Industrial Officials (02)</u>

1. As you experienced in the community, how do the local people use water from the river? What do they use the water for?
2. If they do not use the river, why not?
3. Have you observed any change in water use based on seasonal variation?
4. In your experience, how has water use been changing over the years?
5. What do you think the reason is for the occurring change in water use?
6. Do you think there are any relationships between water use and the overall health of the community?
7. How does your factory use water?
8. Can you tell us about where it comes from, and what happens to it? How is the water disposed of?
9. What can be done to improve community health regarding water use?
10. Tell us about the wastewater from the factory. What is it like when the water has done its job (e.g., does it smell, is it hot, is it off coloured, etc.)?
11. Does anyone have contact with the wastewater, and if so, are there any safety precautions?
12. Do you know of anyone who fell ill after coming in contact with the water?
13. How do you release water back to the river?
14. Do you have some sort of treatment facility? What sort of effect does this have on the water?

15. Do you think there are any impacts on people who use river water due to the factory releasing water? If so, how do you think they are impacted?

vi. Health Officials (02)

1. Please tell me a little more about yourself. Qualification, years of experience in medicine, and in your post?
2. What are your interactions with the community on a daily basis?
3. From your experience or from what you know, what are the major cases of morbidity or mortality in the area? Are there any documented records we could see?
4. Is there a specific age/gender that is more likely to suffer from a certain ailment? Is this chronic or short-termed?
5. Are there any specific water-related cases that the clinic has identified?
    a. *Water-borne* - in the strict sense in which the pathogen is ingested in drinking water
    b. *Water-washed* - that is, favoured by inadequate hygiene conditions and practices and susceptible to control by improvements in hygiene
    c. *Water-based* - referring to transmission by means of an aquatic invertebrate host
    d. *Water-related insect vector routes* - involving an insect vector that breeds in or near to water
6. Is there any seasonal variation in disease occurrence?
7. Has there been a specific event that has been associated with the rise of a specific illness/condition?
8. Are there any additional comments on other environmental sources of pollution that may be of concern from a clinical perspective?

vii. NGO officials (02)

1. As you experienced in the community, how do the local people use water from the river? What do they use the water for?
2. Have you observed any change in water use based on seasonal variation?
3. In your experience, how has water use been changing over the years?
4. Why do you think the reason for occurring change in water use?
5. What type of intervention does your organization operate in the community to water use?
6. Do you think there is any relationship between water use and the overall health of the community?
7. Have you heard of anyone getting sick from using river water? If you have, please elaborate the type. Is this a common phenomenon in the community?

8. What can be done to improve the community health regarding water use? is your organization doing currently on health to address this?
9. From your personal experience, who are the people that use the river? Are they from the local community or another community?
10. Which organization other than you (if any) has been working on water use in this community, or has worked in the past?
11. Has your organization ever worked on water related issues? (if yes, please explain the activities)

Appendix A9: List and details of the key informant's interviewee

Sl. No	Sites	Criteria	Details
1.	Abdullahpur	Health Official	Md Abdul Hie, Male, Deputy Director, East-West Medical Hospital
2.	Abdullahpur	Local Government Representative	Md Gias Uddin Molla (59), Male, Ward Councilor, Gazipur City Corporation
3.	Abdullahpur	Local leader	Mirash Mondol (48), Male, Jubo Leauge President, 57 no. ward
4.	Mausaid	Garment's worker	Delowar Hossain Sarkar (42), Male, Assistant Feeder, Dyeing Factory
5.	Mausaid	NGO Official	Robert Correa (41), Male, Mausaid Christian Multipurpose Co-operative Society Limited, Assistant Accountant
6.	Bhakral	Industry Worker	Aminur Islam (32), Male, Caretaker, Ayurvedic Medicine Factory
7.	Bhakral	Community User	Hashi (35), Female, Garment's worker
8.	Konabari	NGO Official	Indra Mohon (40), Male, Field Facilitator
9.	Konabari	Community User	Mumtaj khatun (49), Female, Housewife,
10.	Konabari	Community Youth Leader	Md. Daud Hossain (31), Male, Teacher, BRAC Primary School
11.	Kashimpur	Health Official	Md. Masud Rana (37), Male, Emergency Medical Officer (E.M.O) at Shaheed Ahsan Ullah Master General Hospital, Tongi, Gazipur
12.	Kashimpur	Community User	Meherjan (50), Female, Housewife

Appendix B: Socio-Demographic Characteristics of Survey Community

Appendix table B1: Age-Sex distribution

Age Group (Year)	Male		Female		Total (N)	Percentage (%)
	n	%	n	%		
0-5	259	7.3	273	7.7	532	7.5
6-15	702	19.7	679	19.1	1381	19.4
16-25	737	20.6	897	25.2	1634	22.9
26-35	703	19.7	729	20.5	1432	20.1
36-45	518	14.5	449	12.6	967	13.6
46-55	350	9.8	305	8.6	655	9.2
56-65	227	6.4	144	4.0	371	5.2
66>	77	2.2	85	2.4	162	2.3
Total	**3573**	**100**	**3561**	**100**	**7134**	**100**

Appendix table B2: Sex-Grade cross-tabulation

Grade	Male		Female		Total (N)	Percentage (%)
	n	%	n	%		
No education	928	27.6	1109	33.2	2037	28.5
Pre-school/Signature only	89	2.6	92	2.75	181	2.5
Class 1-5 (PSC)	923	27.4	909	27.18	1832	25.8
Class 6-8 (JSC)	533	15.8	594	17.76	1127	15.8
Class 9-10 (SSC)	477	14.2	401	11.99	878	12.3
Class 11-12 (HSC)	239	7.1	155	4.64	394	5.5
Bachelors/Diploma or Higher	160	4.7	78	2.3	238	3.3
Don't know	16	0.48	6	0.18	22	0.3
Total	**3365**	**100**	**3344**	**100**	**6709**	**94.0**
Missing system					**425**	**6.0**

Appendix table B3: Area-wise education level

Area	Education Level															
	No Education		Pre-school/ Signature only		Class 1-5 (PSC)		Class 6-8 (JSC)		Class 9-10 (SSC)		Class 11-12 (HSC)		Bachelor/Diploma or Higher		Don't know	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Konabari	283	**13.9**	41	**22.7**	292	**15.9**	157	**13.9**	139	**15.8**	65	16.5	15	6.3	3	13.6
Kashimpur	246	12.1	17	9.4	175	9.6	127	11.3	106	12.1	53	13.5	23	9.7	0	0.0
Ichharkandi	179	8.8	6	3.3	131	7.2	103	9.1	69	7.9	32	8.1	30	12.6	0	0.0
Palasana	136	6.7	18	9.9	67	**3.7**	69	6.1	56	6.4	20	5.1	21	8.8	0	0.0
Gutia	125	6.1	15	8.3	112	6.1	64	5.7	60	6.8	9	2.3	16	6.7	2	9.1
Gusulia	66	**3.2**	6	3.3	74	4.0	47	4.2	36	4.1	15	3.8	10	4.2	6	27.3
Bhakral	108	5.3	7	3.9	109	6.0	55	4.9	31	3.5	24	6.1	10	4.2	0	0.0
Bhadam	131	6.4	10	5.5	171	9.3	106	9.4	81	9.2	32	8.1	14	5.9	3	13.6
Kathaldia	215	10.6	13	7.2	279	**15.2**	174	**15.4**	98	11.2	32	8.1	19	8.0	8	36.4
Rashadia	121	6.0	4	**2.2**	84	4.6	21	1.9	14	**1.6**	7	**1.8**	4	**1.7**	0	0.0
Abdullahpur	342	**16.8**	34	**18.8**	219	12.0	104	9.2	54	6.2	15	3.8	7	2.9	0	0.0
Mausaid	85	4.2	10	5.5	119	6.5	100	8.9	134	**15.3**	90	**22.8**	69	**29.0**	0	0.0
Sub total	2037	100	181	100	1832	100	1127	100	878	100	394	100	238	100	22	100
Total																**6709**
Missing System																**425**

Appendix table B4: Occupation level of respondent's household members

Occupation	Male		Female		Total (N)	Percentage (%)
	n	%	n	%		
Garment Factory worker	421	12.5	347	10.4	768	10.8
Other Factory worker	137	4.1	64	1.9	201	2.8
Government Service (Police, teacher, clerk)	18	0.5	5	0.2	23	0.3
Non-Government service	85	2.5	22	0.7	107	1.5
Skilled labour (Plumber, mechanic, tailor etc)	171	5.1	24	0.72	195	2.7
Rickshaw/van puller	75	2.2	0	0.0	75	1.1
Domestic maid	1	0.0	71	2.1	72	1.0
Construction labour	65	1.9	13	0.4	78	1.1
Agricultural labour	72	2.14	5	0.2	77	1.1
Other Casual labour	185	5.5	26	0.8	211	3.0
Fishermen	84	2.5	1	0.03	85	1.2
Boatman	2	0.1	0	0.0	2	0.0
Business (shop owner, vendor etc)	497	14.8	41	1.2	538	7.5
Farmer (agriculture in own/leased in land)	190	5.7	7	0.2	197	2.8
Landlord/income from property rent	18	0.5	11	0.3	29	0.4
Unemployment/housewife	252	7.5	1820	54.4	2072	**29.0**
Student	865	25.7	830	24.8	1695	**23.8**
Others (specify)	226	6.7	57	1.7	283	4.0
Total	**3364**	**100**	**3344**	**100**	**6708**	**94.0**
Missing System					**426**	**6.0**

Appendix table B5: List of occupation (Others)

Occupation_Other	Count	Occupation_Other	Count
Auto/Car garage	4	Hawker	1
Barber	1	Hospital marketing manager	1
Beggar	13	Hotel	1
Land Broker	1	House maid	2
Business	3	Import export company	1
Butcher	1	Imam (Religious Leader)/Kabiraj/Khadem	5
Connects dish line	1	Intern	1
Canteen boy	3	Jewellery shop	2
Carpenter	2	Journalist	1
Chef (*Baburchi*)	9	Medical assistant	1
Cosmetic shop	1	Mechanic	2
Cleaner	5	Hostel Manager	1
Driver/Helper/Conductor (Truck/Bus/Auto)	71	Manager of public toilet	1
Develop company	1	Medical cleaner	5
Day labour	3	Medical garage	1
Disabled+ Children+ Housewife	8	Medical maintenance	1
Electrician	4	Medical pharmacy	1
Embroidery work	1	Milk seller	1
Farmer	1	Measure public weight	1
Fashion designer	1	Night guard	2
Foreign Worker	5	Peon	1
Foreman	1	Paint worker	1
Fruit seller	1	Private job	2
Hard board factory	1	Potter	12
Printing office in university	1	Teacher	15
Quality controller	1	Textile	1
Restaurant	1	Timekeeper in burger company	1
Rice mill	1	Tokai	1
Road supervisor	1	Tailoring	4
Retired from service	4	Union Parishad worker	1
Student	1	Worker in a poultry farm	1
Security guard	17	Working at Bata company	1
Nurse/Sister/Ward Attendants	5	Working at school/market	2
Sports personality	2	Work at customer care	1
Site worker	2	Working in a medicine company	1
Supplier	1	Working at shop	13
Self Employed	3	Work at medicine company	1
Salesman	3	Working in agricultural land	1
Satellite television	2	Working in market	1
Tea shop owner	2	Working at the mobile shop	1
		Grand Total	**283**

Appendix table B6: Sex distribution of HH Head

N		Frequency (n)	Percent (%)
Valid	Male	1669	91.4
	Female	157	8.6
	Total	1826	100

Statistics		
Age of Household Head		
N	Valid	1826
	Missing	0
Mean		1.09
Median		1.00
Mode		1
Std. Deviation		.280
Variance		.079
Range		1
Percentiles	25	1.00
	50	1.00
	75	1.00

Appendix table B7: Age-Sex distribution of HH Head

Statistics		
Age of Household Head		
N	Valid	1826
	Missing	0
Mean		42.52
Median		40.00
Mode		40
Std. Deviation		12.588
Variance		158.450
Range		74
Percentiles	25	33.00
	50	40.00
	75	50.00

Age Group	Sex distribution							
	Male		Round (%)	Female		Round (%)	Total	Percentage
	n	%		n	%		N	%
16-25 yr	136	7.4	8.1	11	0.6	7.0	147	8.1
26-35 yr	476	26.1	28.5	38	2.1	24.2	514	28.1
36-45 yr	477	26.1	28.6	46	2.5	29.3	523	28.6
46-55 yr	322	17.6	19.3	31	1.7	19.7	353	19.3
56-65 yr	207	11.3	12.4	23	1.3	14.6	230	12.6
66> yr	51	2.8	3.1	8	0.4	5.1	59	3.2
Total	**1669**	**91.4**	**100**	**157**	**8.6**	**100**	**1826**	**100**

Appendix table B8: HH Head Grade-Sex Crosstabulation

Statistics		
Grade of Household Head		
N	Valid	1826
	Missing	0
Mean		10.17
Median		5.00
Mode		0
Std. Deviation		73.552
Variance		5409.938
Minimum		0
Maximum		999
Sum		18574
Percentiles	25	.00
	50	5.00
	75	9.00

Grade of HH Head	**HH Head Sex**						**Total (N)**	**Percentage (%)**
	Male		**Round %**	**Female**		**Round %**		
	n	**%**		**n**	**%**			
No education	686	37.6	41.1	107	5.9	68.2	793	43.4
Signature only	3	0.2	0.2	1	0.1	0.6	4	0.2
Class 1-5 (PSC)	366	20.0	21.9	34	1.9	21.7	400	21.9
Class 6-8 (JSC)	220	12.0	13.2	6	0.3	3.8	226	12.4
Class 9-10 (SSC)	233	12.8	14.0	4	0.2	2.5	237	13.0
Class 11-12 (HSC)	90	4.9	5.4	3	0.2	1.9	93	5.1
Bachelors/Diploma or Higher	61	3.3	3.7	2	0.1	1.3	63	3.5
Don't know	10	0.5	0.6	0	0.0	0.0	10	0.5
Total	**1669**	**91.4**	**100**	**157**	**8.6**	**100**	**1826**	**100**

Appendix table B9: Occupation status of the household head

Statistics		
Occupation of Household Head		
N	Valid	1825
	Missing	1
Mean		12.71
Median		11.00
Mode		13
Std. Deviation		13.626
Variance		185.667
Minimum		1
Maximum		55
Sum		23187
Percentiles	25	5.00
	50	11.00
	75	14.00

Household head occupation	**Male**		**Female**		**Total (N)**	**Percent (%)**
	n	%	n	%		
Garment Factory worker	256	14.0	24	1.3	280	15.3
Other Factory worker	91	5.0	9	0.5	100	5.5
Government service (Police, teacher, clerk, etc.)	14	0.8	1	0.1	15	0.9
Non-government service	49	2.7	3	0.2	52	2.9
Skilled labour (Plumber, mechanic, tailor etc)	115	6.3	1	0.1	116	6.4
Rickshaw/ van puller	54	3.0	0	0.0	54	3
Domestic maid	0	0.0	16	0.9	16	0.9
Construction labour	49	2.7	3	0.2	52	2.9
Agricultural labour	62	3.4	3	0.2	65	3.6
Other casual labour	120	6.6	5	0.3	125	6.9
Fisherman	74	4.1	0	0.0	74	4.1
Boatman	1	0.1	0	0.0	1	0.1
Business (shop owner, vendor, etc.)	364	19.9	9	0.5	373	20.4
Farmer (agriculture, aquaculture in own or leased in land)	173	9.5	3	0.2	176	9.7
Landlord/income from property rent	16	0.9	5	0.3	21	1.2
Unemployed/housewife	89	4.9	63	3.5	152	8.4
Student	3	0.2	0	0.0	3	0.2
Others	138	7.6	12	0.7	150	8.3
Sub-total	**1668**	**91.4**	**157**	**8.6**	**1825**	**100**
Missing system					1	0.1
Grand total					**1826**	**100.0**

Appendix Table B10: Education level and Occupation cross-tabulation of Household Head

Occupation	No education		Signature only		Class 1-5 (PSC)		Class 6-8 (JSC)		Class 9-10 (SSC)		Class 11-12 (HSC)		Bachelors/ Diploma or Higher		Don't know		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	N	%
Garment Factory worker	**61**	3.3	0	0.0	**66**	3.6	**57**	3.1	**51**	2.8	**27**	1.5	15	0.8	3	0.2	280	15.3
Other Factory worker	34	1.9	0	0.0	17	0.9	17	0.9	18	1.0	10	0.5	4	0.2	0	0.0	100	5.5
Government service (Police, teacher, clerk, etc.)	1	0.1	0	0.0	3	0.2	1	0.1	3	0.2	2	0.1	5	0.3	0	0.0	15	0.8
Non-government service	8	0.4	0	0.0	5	0.3	8	0.4	12	0.7	8	0.4	10	0.5	1	0.1	52	2.8
Skilled labour (Plumber, mechanic, tailor, etc.)	46	2.5	1	0.1	31	1.7	18	1.0	17	0.9	2	0.1	0	0.0	1	0.1	116	6.4
Rickshaw/van puller	39	2.1	0	0.0	7	0.4	5	0.3	3	0.2	0	0.0	0	0.0	0	0.0	54	3.0
Domestic maid	11	0.6	1	0.1	4	0.2	0	0.0		0.0	0	0.0	0	0.0	0	0.0	16	0.9
Construction labour	33	1.8	0	0.0	13	0.7	3	0.2	3	0.2	0	0.0	0	0.0	0	0.0	52	2.8
Agricultural labour	43	2.4	0	0.0	13	0.7	5	0.3	4	0.2	0	0.0	0	0.0	0	0.0	65	3.6
Other casual labour	**66**	3.6	1	0.1	40	2.2	9	0.5	5	0.3	2	0.1	0	0.0	2	0.1	125	6.8
Fisherman	**60**	3.3	0	0.0	7	0.4	6	0.3	1	0.1	0	0.0	0	0.0	0	0.0	74	4.1
Boatman	1	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1
Business (shop owner, vendor, etc.)	**122**	6.7	0	0.0	**92**	5.0	**56**	3.1	**59**	3.2	**29**	1.6	13	0.7	2	0.1	373	20.4
Farmer (agriculture, aquaculture in own or leased in land)	**96**	5.3	0	0.0	39	2.1	11	0.6	24	1.3	5	0.3	1	0.1	0	0.0	176	9.6
Landlord/income from property rent	10	0.5	0	0.0	5	0.3	3	0.2	2	0.1	1	0.1	0	0.0	0	0.0	21	1.2
Unemployed/housewife	**93**	5.1	1	0.1	30	1.6	10	0.5	11	0.6	3	0.2	4	0.2	0	0.0	152	8.3
Student	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0	2	0.1	0	0.0	3	0.2
Others	**69**	3.8	0	0.0	27	1.5	17	0.9	23	1.3	4	0.2	9	0.5	1	0.1	150	8.2
Total	**793**	**43.5**	**4**	**0.2**	**399**	**21.9**	**226**	**12.4**	**237**	**13.0**	**93**	**5.1**	**63**	**3.5**	**10**	**0.5**	**1825**	**100**

Appendix table B11: Age-wise occupation distribution of household head

Occupation	Age range													
	16-25 yrs		26-35 yrs		36-45 yrs		46-55 yrs		56-65 yrs		65+ yrs		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	N	%
Garment Factory worker	59	3.2	**123**	6.7	**75**	4.1	20	1.1	3	0.2	0	0.0	280	**15.3**
Other Factory worker	20	1.1	**35**	1.9	**23**	1.3	18	1.0	4	0.2	0	0.0	100	**5.5**
Government Service (Police, teacher, clerk)	1	0.1	**5**	0.3	**4**	0.2	4	0.2	1	0.1	0	0.0	15	**0.8**
Non-Government service	2	0.1	**14**	0.8	11	0.6	**13**	0.7	10	0.5	2	0.1	52	**2.8**
Skilled labour (Plumber/mechanic/tailor etc)	10	0.5	**40**	2.2	**41**	2.2	14	0.8	10	0.5	1	0.1	116	**6.4**
Rickshaw/van puller	2	0.1	**19**	1.0	**20**	1.1	10	0.5	3	0.2	0	0.0	54	**3.0**
Domestic maid	3	0.2	**4**	0.2	**4**	0.2	3	0.2	2	0.1	0	0.0	16	**0.9**
Construction labour	4	0.2	**15**	0.8	**16**	0.9	11	0.6	3	0.2	3	0.2	52	**2.8**
Agricultural labour	0	0.0	15	0.8	**16**	0.9	**18**	1.0	14	0.8	2	0.1	65	**3.6**
Other Casual labour	10	0.5	**43**	2.4	**51**	2.8	15	0.8	5	0.3	1	0.1	125	**6.8**
Fishermen	1	0.1	**18**	1.0	**22**	1.2	**18**	1.0	13	0.7	2	0.1	74	**4.1**
Boatman	0	0.0	0	0.0	0	0.0	0	0.0	1	0.1	0	0.0	1	**0.1**
Business (shop owner, vendor etc)	12	0.7	**100**	5.5	**120**	6.6	**91**	5.0	43	2.4	7	0.4	373	**20.4**
Farmer (agriculture in own/leased in land)	0	0.0	17	0.9	**48**	2.6	**61**	3.3	**42**	2.3	8	0.4	176	**9.6**
Landlord/income from property rent	0	0.0	4	0.2	4	0.2	4	0.2	**6**	0.3	3	0.2	21	**1.2**
Unemployment/housewife	7	0.4	19	1.0	25	1.4	25	1.4	**51**	2.8	25	1.4	152	**8.3**
Student	1	0.1	2	0.1	0	0.0	0	0.0	0	0.0	0	0.0	3	**0.2**
Others (specify)	15	0.8	**40**	2.2	**43**	2.4	28	1.5	19	1.0	5	0.3	150	**8.2**
Total	**147**	**8.1**	**513**	**28.1**	**523**	**28.7**	**353**	**19.3**	**230**	**12.6**	**59**	**3.2**	**1825**	**100**

Appendix table B12: Monthly Expenditure of surveyed household

Expenditure Groups	Range in taka	Frequency	Percentage	Mean±SD
		n	%	
House rent	0 (no rent)	681	37.3	-----
	1-1000	55	3.2	829.4±252.9
	1001-2000	179	10	1696.2±296.2
	2001-3000	170	9.6	2643.4±300.9
	3001-4000	114	6.4	3635.3±309.1
	4001-7000	48	2.7	5208.3±748.6
	7001-10000	5	0.4	8600±894.4
	>10001	2	0.2	23500±16263.5
	Don't know (999)	358	19.6	-----
	Subtotal	**1612**	**88.4**	**2710.34±1940.36**
	Missing system	**214**	**11.7**	**-----**
Education	0 (no cost)	450	24.6	-----
	1-500	134	7.3	403.7±127.2
	501-1000	184	10.1	914.7±139.8
	1001-1500	124	6.8	1450±112.3
	1501-2000	132	7.2	1986±66.3
	2001-3000	130	7.1	2870±220.5
	3001-7000	247	13.5	5016.2±1015
	7001-10000	64	3.5	9070.3±954.8
	10001-15000	26	1.4	13711.5±1550.3
	15001-20000	16	0.9	19250±1341.6
	20001-50000	9	0.5	33444.4±10513.2
	Don't know (999)	183	10.0	-----
	Subtotal	**1699**	**92.9**	**3585.8±4543.2**
	Missing system	**127**	**7.0**	**-----**
Cooking/Food	1-1000	19	1.0	747.8±347.8
	1001-2000	20	1.1	1800±293.8
	2001-3000	75	4.1	2926.7±194.1
	3001-5000	285	15.6	4625.6±487
	5001-7000	351	19.2	6319.1±477.4
	7001-10000	578	31.7	9200.7±904.7
	10001-15000	362	19.8	13341.2±1512.7
	15001-20000	89	4.9	18809±1657.5
	20001-25000	18	1.0	24444.4±1293.5
	>25000	16	0.9	31812.5±3166.9
	Don't know (999)	5	0.3	-----
	Subtotal	**1818**	**99.6**	**9143.1±4867.9**
	Missing system	**8**	**0.4**	**-----**

Appendix table B12: Cont…………..

Expenditure Groups	Range in taka	Frequency n	Percentage %	Mean±SD
Utilities (Water, Electricity, Gas)	0 (no cost)	26	1.4	------
	1-250	94	5.0	176.6±52.3
	251-500	319	17.5	425±77.8
	501-750	186	10.2	643.4±56.8
	751-1000	636	34.8	900±62
	1001-1250	112	6.0	1179±44.6
	1251-1500	108	5.9	1475.9±56.2
	1501-2000	133	7.3	1870.5±149.6
	2001-2500	52	2.8	2379.8±152.2
	2501-5000	93	5.0	3615±760.6
	5001-10000	22	1.2	7090.9±1240.5
	10001-15000	7	0.4	1311.4±144.6
	>15001	4	0.3	16750±957.4
	Don't know (999)	16	0.9	------
	Subtotal	**1808**	**99.0**	**1140.7±1049.5**
	Missing system	**18**	**1.0**	**-----**
Treatment (Doctors fees, medicines, etc.)	0 (no cost)	15	0.8	-----
	1-100	158	8.7	75.1±8.7
	101-300	362	19.8	237.8±52.3
	301-500	352	19.3	477.6±43.6
	501-750	77	4.2	637.7±52.7
	751-1000	276	15.1	987.6±47.5
	1001-2500	263	14.4	1742.4±349.1
	2501-5000	154	8.4	3769.5±867.2
	5001-10000	46	2.5	7794±1522.6
	>10001	20	1.1	15350±3013.6
	Don't know (999)	50	2.7	-----
	Subtotal	**1773**	**97**	**1341.9±2197.9**
	Missing system	**53**	**2.9**	**------**
Clothing and footwear	0 (no cost)	2	0.1	-----
	1-250	94	5.1	145.7±63.8
	251-500	386	21.1	447.9±76.7
	501-750	82	4.5	632.3±48.7
	751-1000	407	22.3	983±54
	1001-1500	240	13.1	1444.6±116
	1501-2000	251	13.7	1992.4±47.1
	2001-5000	214	11.7	3311.7±778.5
	5001-10000	22	1.2	7657.5±1779.9
	>10001	7	0.4	16714.3±3450.3
	Don't know (999)	22	1.2	-----
	Subtotal	**1727**	**94.4**	**1455.96±1582.1**
	Missing system	**99**	**5.4**	**-----**

Appendix table B12: Cont…………..

Expenditure Groups	Range in taka	Frequency n	Percentage %	Mean±SD
Remittance (send money back home)	0 (no cost)	874	47.9	------
	1-2500	124	6.8	1461.8±675.7
	2501-5000	112	2.1	4071.4±869.5
	5001-7500	19	1.0	6395.9±540.1
	7501-10000	24	1.3	9249.96±944.05
	>10001	8	0.4	14000±2927.7
	Don't know (999)	405	22.2	------
	Subtotal	**1566**	**81.7**	**3807.6±3006.5**
	Missing system	**260**	**14.2**	**------**
Miscellaneous (Entertainment, mobile credit, etc.)	0 (no cost)	20	1.1	------
	1-250	396	21.7	162±59.6
	251-500	571	31.3	425±82.3
	501-1000	402	22.0	797±177.8
	1001-2000	255	14.0	1633.3±323.9
	2001-3000	43	2.4	2719.8±305.3
	3001-5000	13	0.7	4284.6±519.4
	5001-10000	6	0.3	6367.2±1022.3
	>10001	3	0.2	24333.3±17925.8
	Don't know (999)	83	4.5	------
	Subtotal	**1792**	**98.2**	**786±1394.3**
	Missing system	**34**	**1.9**	**-----**
	Mean±SD of Grand Total			**2942.6±4121.1**

Appendix table B13: Details about household having at least one member working in garments sector

Statistics					
Member's role in the garment factory		Dry Production	Wet Production	Management	Other
N	Valid	768	768	768	768
	Missing	6366	6366	6366	6366
Mean		1.39	1.86	1.93	1.82
Median		1.00	2.00	2.00	2.00
Mode		1	2	2	2
Std. Deviation		.489	.352	.254	.385
Variance		.239	.124	.064	.148
Percentiles	25	1.00	2.00	2.00	2.00
	50	1.00	2.00	2.00	2.00
	75	2.00	2.00	2.00	2.00

Appendix table B13: Cont……….

Characteristics	Frequency (n)	Percentage (%)
Role in Garments Factory		
Dry production (sewing, cutting, packaging)	466	6.5
Wet Production (dyeing, washing)	111	1.6
Management	53	0.7
Others	138	1.9
Total	**768**	**10.8**
Missing system	**6366**	**89.2**
Duration/years of working in this factory		
Less than 1 year	261	3.7
1-2 years	225	3.2
3-4 years	202	2.8
5-10 years	272	3.8
More than 10 years	139	1.9
Total	**1099**	**15.4**
Missing system	**6035**	**84.6**
Is there any job contract		
Yes	351	4.9
No	689	9.7
Don’t know	59	0.8
Total	**1099**	**15.4**
Missing system	**6035**	**84.6**
Payment Structure		
Rolling contract (by day)	830	11.6
Fixed-term contact (annual or longer)	18	0.3
Permanent contract	79	1.1
No contract	36	0.5
Don’t know	134	1.9
Others	02	0.02
Total	**1099**	**15.4**
Missing system	**6035**	**84.6**

Appendix table B14: Garment’s worker role others

Others_Role in garments	n	%	Others_Role in garments	n	%
Operator (machine/boiler)	30	0.4	Cook/canteen worker	7	0.1
Iron man	15	0.2	Fashion and finishing	7	0.1
Helper/labour	22	0.3	Mechanic	6	0.1
Cloth and Sweater knitting/ mending	13	0.2	Supervisor/peon/security guard	5	0.1
Textile/printing/sampling	10	0.1	Cleaner	5	0.1
Quality checking and maintenance	9	0.1	Civil (construction)	1	0.0
Spring/technical site	7	0.1	Patent master	1	0.0
			Total	**138**	**1.9**

Appendix table B15: Occupancy status of survey community

Occupancy status					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Owner	942	51.6	51.6	51.6
	Tenant	578	31.7	31.7	83.2
	Free accommodation (public land/embankment)	286	15.7	15.7	98.9
	Other (specify)	20	1.1	1.1	100.0
	Total	**1826**	**100.0**	**100.0**	

Appendix table B16: Occupancy status others specify

Others Occupancy	**Frequency (n)**	**Percent (%)**
Brother House	2	0.1
Built house but pays money for land to chairman/local leader	3	0.2
Free accommodation from the factory	2	0.1
Government	1	0.0
Grandfather land	1	0.0
Household manager/caretaker	2	0.1
Stay in others land	3	0.2
Relative’s land	5	0.4
Under Case in Court	1	0.0
Total	**20**	**1.1**

Appendix table B17: Housing materials (%) of respondent households

Housing materials		**Frequency**	**Percentage**
		n	**%**
Floor	Earth/mud	648	35.5
	Wood/bamboo	65	3.6
	Brick or Cement	1099	60.2
	Tiles/mosaic	9	0.5
	Others	5	0.3
Example of others: Boathouse, tin, jute, plastic			
Roof	Leaves/straw/plastic	12	0.7
	Wood/bamboo	4	0.2
	Tin/corrugated iron	1807	99.0
	other (specify)	3	0.2
Example of others: Boathouse, half tin half straw			
Exterior walls	Leaves/straw/plastic	64	3.5
	Earth/mud	12	0.7
	Wood/bamboo	1738	95.2
	Others (specify)	12	0.7
Example of others: Boathouse, half tin half straw			

Appendix table B18: Household power sources for lighting and electronics (%)

Power sources	Frequency	Percentage
	n	%
Grid supply electricity	1710	93.6
Candle	78	4.3
Kerosene/Harican/Kupi	67	3.7
Sideline/supply from another family	64	3.5
Charge light	53	2.9
Solar panel	14	0.8
No electricity	11	0.6
Generator	2	0.1
Torch light	2	0.1
IPS/Biogas	2	0.1
Total	**2003*MR**	**109.7**

***MR= Multiple Responses**

Appendix table B19: Sources of fuel at the household level (%)

Sources of fuel	Frequency	Percentage
	n	**%**
Electricity	6	0.3
Natural gas (Supply/Cylinder)	811	44.4
Kerosene	13	0.7
Animal dung	101	5.5
Wood/fuel sticks	1381	75.6
Straw/shrubs/grass	635	34.8
Others	10	0.5
Total	**2957*MR**	**161.8**
Example others: Biogas, cloths, jute, stove, companies' canteen		

***Multiple Response**

Appendix table B20: Toilet facilities for household adults

Households' toilet facility	Frequency (n)	Percent (%)
Flush to septic tank	622	34.1
Pour flush to pit latrine	269	14.7
Ventilated improved pit latrine	125	6.8
Pit latrine with slab	486	26.6
Pit latrine without slab/open pit	56	3.1
Hanging toilet/hanging latrine	254	13.9
No facility/bush/field	14	0.8
Total	**1826**	**100**

Appendix table B21: Child wastes disposal (%)

Place of disposal	Frequency n	Percent %
Not applicable (no children under 5)	1336	73.2
In the toilet	331	18.1
On dry open ground/ bush	81	4.4
Into waterbodies (pond/ river)	73	4.0
Other (specify)	5	0.3
Total	**1826**	**100**
Example others: Drain, Dustbin, Open dirty place, Under the mud		

Appendix table B22: Sharing of the toilet (%) at the household level

Toilet Sharing	Frequency (n)	Percent (%)
Sharing toilet with others		
Yes	992	54.3
No	834	45.7
Total	**1826**	**100.0**
Shared with how many?		
Less than 5	486	26.6
Between 5 and 10	235	12.9
More than 10	271	14.8
Total	992	54.3
Missing System	834	45.7
Total	**1826**	**100.0**

Appendix C: Available Sources, Usage's pattern, and Related issues

Appendix table C1: Number of water sources used by the respondent households

Number of sources	Frequency (n)	Percent (%)
1	1772	97.0
2	46	2.5
3	6	0.3
4	2	0.1
Total	**1826**	**100.0**

Appendix table C2: Available sources of drinking water (%)

Sources of drinking water	Available sources		Alternative sources	
	n	%	n	%
Public piped into dwelling	83	4.5	2	0.1
Public piped into the yard	305	16.7	1	0.1
Public tap	38	2.1	---	---
Deep tube well (with hand pump only)	37	2.0	1	0.1
Shallow tube well (with hand pump only)	11	0.6	---	---
Electric tube well (with motor only/both motor and hand pump)	1348	73.8	8	0.4
Tanker truck	3	0.2	---	---
Cart with small tank/containers	1	0.1	1	0.1
Bottled water	1	0.1	---	---
Rainwater	6	0.3	1	0.1
River/Canal	20	1.1	17	0.9
Lake	2	0.1	2	0.1
Pond	23	1.3	21	1.2
Others	12	0.7	---	---
Grand total	**1890***	**103.6**	**54**	**3.1**
Example of other sources: Other households water source, Compressor pump, Madrasa's submersible, Brickfield				

***MR: Multiple Response**

Appendix table C3: Site-wise distribution of available sources of drinking water

Area	Piped_ dwelling	Piped_ yard	Public_ tap	Tubewell_ deep	Tubewell_ shallow	Tubewell_ motor	Rain water	Vended_ truck	Vended_ cart	Bottled_ water	Rive_ canal	Lake	Pond	Other
Frequency (n) distribution of available drinking water sources														
Konabari	1	9	8	16	3	211	0	0	0	0	0	0	0	3
Kashimpur	32	44	1	6	5	115	0	0	1	0	1	0	0	0
Ichharkandi	0	0	0	5	0	158	0	0	0	0	13	2	10	1
Palasana	0	0	0	0	0	109	4	0	0	0	4	0	13	1
Gutia	1	1	0	1	0	101	0	0	0	0	0	0	0	3
Gusulia	0	34	1	0	0	30	1	0	0	0	0	0	0	0
Bhakral	4	3	0	1	0	77	0	0	0	0	0	0	0	0
Bhadam	0	1	0	0	0	196	0	0	0	0	0	0	0	2
Kathaldia	35	97	0	0	0	90	0	0	0	0	0	0	0	0
Rashadia	3	63	0	0	0	3	0	0	0	0	0	0	0	0
Abdullahpur	6	53	28	4	3	123	1	3	0	1	2	0	0	2
Mausaid	1	0	0	4	0	135	0	0	0	0	0	0	0	0
Total	**83**	**305**	**38**	**37**	**11**	**1348**	**6**	**3**	**1**	**1**	**20**	**2**	**23**	**12**
Percentage (%) distribution of available drinking water sources														
Konabari	0.1	0.5	0.4	0.9	0.2	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Kashimpur	1.8	2.4	0.1	0.3	0.3	6.3	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0
Ichharkandi	0.0	0.0	0.0	0.3	0.0	8.7	0.0	0.0	0.0	0.0	0.7	0.1	0.6	0.1
Palasana	0.0	0.0	0.0	0.0	0.0	6.0	0.2	0.0	0.0	0.0	0.2	0.0	0.7	0.1
Gutia	0.1	0.1	0.0	0.1	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Gusulia	0.0	1.9	0.1	0.0	0.0	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bhakral	0.2	0.2	0.0	0.1	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bhadam	0.0	0.1	0.0	0.0	0.0	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Kathaldia	1.9	5.3	0.0	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rashadia	0.2	3.5	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Abdullahpur	0.3	2.9	1.5	0.2	0.2	6.7	0.1	0.2	0.0	0.1	0.1	0.0	0.0	0.1
Mausaid	0.1	0.0	0.0	0.2	0.0	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**4.6**	**16.7**	**2.1**	**2.0**	**0.6**	**73.8**	**0.3**	**0.2**	**0.1**	**0.1**	**1.1**	**0.1**	**1.3**	**0.7**

Appendix table C4: Drinking water source for nonfixed water collection group

Water source	Nonfixed main source		Secondary source	
	n	**%**	**n**	**%**
Public piped into dwelling	---	---	2	0.1
Public piped into yard	3	0.2	1	0.1
Public tap	1	0.1	---	---
Deep tube well (with hand pump only)	4	0.2	1	0.1
Shallow tube well (with hand pump only)	2	0.1	---	---
Electric tube well (with motor only/both motor and hand pump)	40	2.2	8	0.4
Tanker truck	2	0.1	---	---
Cart with small tank/containers	---	---	1	0.1
Rainwater	---	---	1	0.1
River/Canal	---	---	17	0.9
Lake	---	---	2	0.1
Pond	2	0.1	21	1.2
Total	**54**	**3.0**	**54**	**3.0**

Appendix table C5: Reasons for using secondary sources instead of the main source

Reasons for using a secondary source	Frequency(n)	Percent (%)
Infrastructure not working	2	0.1
New infrastructure installed	1	0.1
Unreliable supply	6	0.3
Not enough water	1	0.1
Alternative source has better quality	2	0.1
Alternative source is cheaper	1	0.1
Alternative source has better taste/smell/color	1	0.1
Easier access	39	2.1
Others	1	0.1
Total	54	3.0
Missing System	1772	97.0
Total	**1826**	**100.0**

Appendix table C6: Duration of using these secondary water sources

Duration	Frequency (n)	Percent (n)
Less than 5 days	2	0.1
Between 5 and 30 days	2	0.1
Between 1-2 months	3	0.2
More than 2 months	41	2.2
Don't know	6	0.3
Total	54	3.0
Missing System	1772	97.0
Total	**1826**	**100.0**

Appendix table C7: Challenges faced because of switching from main sources to secondary sources of water

Challenges	Frequency (n)	Percentage (%)
No challenges	29	1.6
Women spent more time/effort in collecting water	9	0.5
Women felt unsafe collecting water	2	0.1
Felt uncomfortable in using someone else's source	4	0.2
Higher costs	4	0.2
Poor water quality	6	0.3
Total	**54**	**3.0**

Appendix table C8: Sharing of water sources with other households

Households with the shared water source		Frequency	Percent
		n	%
Do you share a water source with other households?	*Yes*	1279	70
	No	547	30
If yes, with how many households?	Less than 5	526	28.8
	Between 5 and 10	315	17.3
	More than 10	438	24.0
Total		**1279**	**70.0**

Appendix table C9: Sources of water for domestic use based on season

Sources of water	**Changes in water use with season**																	
	Cooking				**Mean of Total**		**Washing Clothes and Dishes**				**Mean of Total**		**Bathing**				**Mean of Total**	
	Wet		**Dry**				**Wet**		**Dry**				**Wet**		**Dry**			
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Public piped into dwelling	68	3.7	68	3.7	**68**	**3.7**	67	3.7	64	3.5	**66**	**3.6**	68	3.7	64	3.5	**66**	**3.6**
Public piped into yard	316	17.3	312	17.1	**314**	**17.2**	303	16.6	297	16.3	**300**	**16.5**	299	16.4	292	16.0	**296**	**16.2**
Public tap	40	2.2	40	2.2	**40**	**2.2**	35	1.9	37	2.0	**36**	**2.0**	38	2.1	37	2.0	**38**	**2.1**
Deep tube well (with handpump only)	32	1.8	32	1.8	**32**	**1.8**	32	1.8	32	1.8	**32**	**1.8**	30	1.6	29	1.6	**30**	**1.6**
Shallow tube well (with handpump only)	14	0.8	10	0.5	**12**	**0.7**	11	0.6	10	0.5	**11**	**0.6**	11	0.6	13	0.7	**12**	**0.7**
Electric tube well (with motor only/both motor and handpump)	1348	73.8	1343	73.5	**1346**	**73.7**	1291	70.7	1265	69.3	**1278**	**70.0**	1275	69.8	1247	68.3	**1261**	**69.1**
Rainwater	2	0.1	15	0.8	**9**	**0.5**	5	0.3	32	1.8	**19**	**1.1**	1	0.1	25	1.4	**13**	**0.8**
Tanker truck	3	0.2	3	0.2	**3**	**0.2**	3	0.2	3	0.2	**3**	**0.2**	3	0.2	3	0.2	**3**	**0.2**
Cart with small tank/containers	1	0.1	1	0.1	**1**	**0.1**	1	0.1	1	0.1	**1**	**0.1**	1	0.1	2	0.1	**2**	**0.1**
Bottled water	1	0.1	0	0.0	**1**	**0.1**	1	0.1	1	0.1	**1**	**0.1**	0	0.0	1	0.1	**1**	**0.1**
River/Canal	8	0.4	27	1.5	**18**	**1.0**	113	6.2	342	18.7	**228**	**12.5**	134	7.3	400	21.9	**267**	**14.6**
Lake	2	0.1	2	0.1	**2**	**0.1**	10	0.5	11	0.6	**11**	**0.6**	8	0.4	10	0.5	**9**	**0.5**
Pond	4	0.2	5	0.3	**5**	**0.3**	98	5.4	100	5.5	**99**	**5.5**	108	5.9	110	6.0	**109**	**6.0**
Others	4	0.2	5	0.3	**5**	**0.3**	6	0.3	6	0.3	**6**	**0.3**	6	0.3	6	0.3	**6**	**0.3**
Grand total	**1843**	**101**	**1863**	**102**	**1853**	**101.6**	**1976**	**108.4**	**2201**	**120.7**	**2089**	**114.6**	**1982**	**108.5**	**2239**	**122.6**	**2111**	**115.6**

Appendix table C10: Payment structure of water sources of surveyed households

Payment structure of water sources	Main sources		Alternative/secondary sources	
	Frequency	Percentage	Frequency	Percentage
	n	%	n	%
Does the house pay for this water?				
Yes	690	37.8	5	0.3
No	1136	62.2	49	2.7
Total	1826	100.0	54	3.0
To whom are payments for water made?				
At the Water Utility office/bank/to the tariff collector	176	9.6	1	0.1
Included in house rent/to landlord	223	12.2	1	0.1
At the place where water is fetched from/ delivered to	277	15.2	3	0.2
Others	14	0.8	----	----
Sub total	**690**	**37.8**	**5**	**0.3**
Missing system	1136	62.2	1821	99.7
Total	1826	100.0	1826	100.0
How often the payment is made?				
Monthly (Fixed amount)	683	37.4	4	0.2
Per container	7	0.4	1	0.1
Sub total	**690**	**37.8**	**5**	**0.3**
Missing system	1136	62.2	1821	99.7
Total	1826	100.0	1826	100.0

Appendix table C11: Specification of others to whom are payments for water made

Others Specify_To whom are payments for water made		
Payment made to-	**Frequency (n)**	**Percentage (%)**
Commissioner	3	0.2
Mosque committee	5	0.3
Neighbor family	1	0.1
Petrol pump	1	0.1
Political leader	1	0.1
Relative	2	0.1
Tube well owner	1	0.1
Sub total	***14***	***0.8***
Missing system	1812	99.2
Total	1826	100.0

Appendix table C12: Amounts of taka spent for main sources of water

Amounts of payment	Range in taka	Frequency n	Percentage %	Mean±SD
Main Water Sources	0-50	50	2.8	41.8±9.4
	51-100	223	12.2	86.1±13.1
	101-150	30	1.6	140.3±13.8
	151-200	97	5.3	197.9±7.5
	250-500	105	5.8	371.9±82.9
	600-1000	25	1.3	786.6±152.6
	1100-1700	11	0.7	1381.8±204
	2001-4000	15	1.1	3053.4±667.4
	Don't know (999)	127	7.0	----
Sub total		***683***	***37.8***	***296±530.7***
Missing system		*1143*	*62.6*	----
Total		*1826*	*100.0*	----
Secondary Water Sources	50	1	0.1	----
	150	1	0.1	
	170	1	0.1	
	700	1	0.1	
Sub total		**4**	**0.2**	----
Missing system		1822	99.8	----
Total		1826	100.0	----

Appendix table C13: Development intervention that has improved your drinking water situation by the Govt, Private sector, Institutions or CBO's

Development intervention	Frequency n	Percent %
Is there any development intervention that has improved your drinking water by the Govt, Private sector, Institutions or CBO's?		
Yes	196	10.7
No	1503	82.3
Don't Know	125	6.8
Total	**1824**	**99.9**
If yes, what types of intervention have been implemented?		
Installation of hand pump	14	0.8
Installation of piped water system	168	9.2
Vending water expansion	6	0.3
Others	11	0.6
Total	***196***	***10.7***
Did your households install any new water related infrastructure for their private use?		
Yes	402	22.0
No	1264	69.2
Don't Know	155	8.5
Total	**1821**	**99.7**
If yes, what types of installation?		
New shallow tube well (handpump/motorized)	95	5.2
New deep tube well (handpump/motorized)	251	13.7
Electric/diesel motor to existing tube well	21	1.2
Storage tank to existing tube well	35	1.9
Others	35	1.9
Total	**437*MR**	**23.9**

Appendix table C14: Maintenance or repairs cost of the water infrastructure

Maintenance or repairs to the water source	Frequency	Percent	Mean±SD
	n	%	
In the past 12 months, did you/anyone else conduct any maintenance or repairs to the water source?			
Yes	261	14.3	-----
No	1035	56.7	-----
Don't Know	82	4.5	-----
Sub total	1378	75.5	-----
Missing System	448	24.5	-----
Total	1826	100	-----
How much money did your household spend/contribute to this maintenance/repair work?			
20-500	28	1.5	297.1±168.1
501-1000	16	0.8	843.8±171.1
1001-2000	30	1.7	1733.3±304.4
2001-3000	28	1.6	2817.9±258.3
3001-5000	25	1.3	4608±551.5
5001-10000	28	1.5	8267.9±1658.2
10001-20000	22	1.2	15595.5±4463.7
20001-30000	9	0.6	26000±3162.3
30001-50000	5	0.3	41000±5477.2
Don’t know (999)	70	3.8	-----
Total	***261***	***14.3***	***6709.5±8801.4***

Appendix table C15: Community concerns regarding water

Concerns regarding water	Frequency (n)	Percentage (%)
Water is unsafe to drink	116	6.4
Water is too costly	118	6.5
Water sources is too far	145	7.9
Water for domestic use is dirty	126	6.9
Water supply is unpredictable	246	13.5
Not enough	153	8.4
No concern	336	18.4
Others	105	5.8
Total	***1345***	***73.8***

Appendix table C16: Community concerns regarding water Others_Specify

Other Concern	n	%	Other Concern	n	%	Other Concern	n	%
Depends on others as don't have or able to install own tube well/no access	10	0.5	High labor/carrying problem	2	0.1	Polluted river water (with chemicals/cow dung/hanging toilet/industrial waste in river)	5	0.3
High maintenance cost	11	0.6	Long queue	4	0.2	Not available all the time/less available in summer or peak period	6	0.3
Supply not reliable	11	0.6	No and unequal govt supply water	2	0.1	Less and costly freshwater source/high water cost	3	0.2
Water source is not enough	21	1.2	Take enough time to get water from motor tube well/too slow	3	0.2	Prestige issue	3	0.2
Frequent motor damage/Water is unavailable if motor is damaged	3	0.2	Unavailable if there is no electricity	1	0.1	More repair time	2	0.1
Bad odor of river water	5	0.3	Have to collect within a limited time	1	0.1	Water quality is bad in rainy season/mosquito	3	0.2
Water layer getting down	7	0.4	Water contains too much iron/sand mixed	2	0.1	***Total***	***105***	***5.8***

***n=Frequency; %=percentage**

Appendix D: Qualitative (FGD and KII) Data Findings

Appendix table D1: Turag River Water Use and Related Issues

Questions	*Up-stream*		*Mid-stream*		*Down-stream*	
	Konabari	**Kashimpur**	**Bhadam**	**Bhakral**	**Abdullahpur**	**Mausaid**
Sources of Water	• Submersible pump with 5000 litre tanks (installed by NGO) • Submersible pump with 1000 litre tank (installed by Government) • Turag River • Brickfield (owned by Brickfield owners)	• Submersible pumps • Deep tube wells	• Submersible pumps to bring up ground water • Nearby mosque, office	• Submersible (Personal / Individual) • Turag River	• Submersible (installed by Government) • Turag River	Submersible pump (Personal/Individual)
Purpose of river water use	• Bathing • Washing clothes • Washing utensils • Used for drinking & cooking during the rainy season	• Irrigating the paddy fields • Navigation and transportation	• Not used	• Bathing • Washing clothes • Washing utensils	• Bathing • Washing clothes • Washing utensils • Crossing the river for fish selling • Dumping waste in the water • Using toilet elevated over the river	• Crossing the river • Dumping waste in the water
Seasonal variation of river water use	Dry: 1. Bathing 2. Washing clothes 3. Washing utensils Wet: 1. Washing clothes 2. Bathing 3. Drinking 4. Cooking • During the monsoon season water flow of the river increases, as a result, all the black water gets washed away brings back added water.	Dry: Some farmers use it to irrigate paddy fields Wet: Bathing, washing clothes, recreation.	**Dry:** Not used **Wet:** Recreation	Dry: 1. Bathing 2. Washing clothes 3. Washing utensils Wet: 1. Bathing 2. Washing clothes 3. Washing utensils They do not use river water for drinking and	Dry: 1. Bathing 2. Washing clothes 3. Washing utensils Wet: 1. Bathing 2. Washing clothes 3. Washing utensils They do not use river water for drinking and cooking in the wet seasons too though the quality of	Dry: 1. Occasional swimming Wet: 1. Washing clothes 2. Bathing 3. Brushing teeth • Better water quality in

<table>
<tr><td></td><td></td><td></td><td></td><td>cooking in the wet seasons too.</td><td>water in the monsoon is better than in other seasons.</td><td>monsoon than the dry season</td></tr>
<tr><td>Reason for river water use</td><td>Near where they live
Availability & accessibility of water
No cost</td><td>River water cheap
Available
Groundwater is expensive</td><td>Recreation</td><td>Availability & accessibility of water
No cost</td><td>Water quality becomes better due to an increase in the water flow of the river
River right next to their household
Availability & accessibility of water
No cost</td><td>Recreational purposes
No cost and limit to use the river water
Availability</td></tr>
<tr><td>Time of the day for water collection</td><td>Morning
Noon
Evening (after Maghrib)</td><td>Morning
Noon
Afternoon
Evening</td><td>Morning
Noon
Afternoon
Evening</td><td>Morning
Afternoon
Evening</td><td>Morning
Noon
Afternoon to Night</td><td>Morning
Noon
Afternoon
Night</td></tr>
<tr><td>People that use the river most</td><td>Everybody for one purpose or another use river water
Outsiders do not use their riverbank to use water</td><td>Farmers
Transport workers</td><td>Youth</td><td>General people who live beside the riverbank</td><td>Merchants of Sandar Parr (West Abdullahpur)
Traders of fish business in Abdullahpur</td><td>Boatmen
Merchants</td></tr>
<tr><td>Access to water supplies and Providers</td><td><table><tr><td>Water Supply</td><td>Provider</td></tr><tr><td>Submersible pump with 5000 litres</td><td>Care Bangladesh, VERC, C&A Foundation</td></tr><tr><td>Submersible liter 1000 litre</td><td>Gazipur City Corporation</td></tr></table></td><td>Supply:
Submersible
Deep tube well
Provider:
Self</td><td>Supply:
Submersible
Deep tube well
Provider:
Landlord</td><td><table><tr><td>Water Supply</td><td>Provider</td></tr><tr><td>Submersible / Motor pump</td><td>Personal / Individual</td></tr></table></td><td><table><tr><td>Water Supply</td><td>Provider</td></tr><tr><td>Submersible / Motor pump</td><td>Gazipur City Corporation</td></tr></table></td><td><table><tr><td>Water Supply</td><td>Provider</td></tr><tr><td>Submersible / Motor pump</td><td>Personal / Individual</td></tr></table></td></tr>
</table>

Amount paid for water services	NGO = 50 taka monthly Government = 30 takas monthly	• To set submersible: 1lac taka • Monthly cost included with electricity	Included in rent 3800 takas	Monthly = 500 takas for submersible pump water (including electricity bill)	Amount paid (per household) = 100 takas per month	Monthly Included in the Electricity bill

Appendix table D2: Perception on Health Risks

Questions	***Up-stream***		***Mid-stream***		***Down-stream***	
	Konabari	**Kashimpur**	**Bhadam**	**Bhakral**	**Abdullahpur**	**Mausaid**
Nature of health problems	• Skin diseases • Stomachache • Respiratory problems	• Many mosquitoes that breed in the river • The river water is toxic, can't use- causes skin problems and diarrhea, etc.	• General diseases, nothing specific	• Skin diseases • Stomach problem	• Respiratory problems • Stomach problems • Skin diseases	• Stomach problems • Skin diseases
Greatest health risks	• Psora (skin diseases) • Dysentery/ Diarrhea • Kidney problems • Asthma • Typhoid • Cholera	• Upset stomach (Diarrhea) • Skin problems	•River unfit for use	• Fever • Dysentery/ Diarrhea • Jaundice • Psora (skin diseases	• Dysentery/ Diarrhea • Asthma • Typhoid • Cholera • Jaundice • Psora (skin diseases) • Gastric	• Dysentery/ Diarrhea • Jaundice • Psora(skin diseases)
Explain the sources or causes of river pollution	• Garment factories dyeing • Industries waste • Not dredging enough • Dumping garbage on the river	• Garment factories dyeing • Industries waste		• Garment factories dyeing • Industries waste (chemical release)	• Chemicals from the industries in Tongi • Dyeing from garments factories • Hospital waste released in the river	• Chemicals released from the industries • Dyeing from garments factories
Gender variation of the diseases	Women are more affected as they work most water related activities	• Usually, women and children are more vulnerable		• Women and child are mostly affected	• Women & children suffer from diseases the most	Women do most of the work but there is no gender

						variation of diseases
Nearest medical / treatment facilities	• Nearby Pharmacies in Kadda (ward number: 13, Gazipur City Corporation) to consult mainly with Pharmacists, not Doctors • Doctors in central Konabari (ward number: 8, Gazipur City Corporation) • ICDDR, B (Mohakhali) • Tongi Hospital in Tongi	• Konabari • Mohakhali • Tongi Hospital • East-West Medical	• Taltola Medical	• Pharmacies near Bhadam • ICDDR,B medical, Mohakhali	• Tongi Medical, Tongi • Shaheed Monsur Ali Medical, Uttara • Aichi Medical, Abdullahpur • ICDDR,B medical, Mohakhali • East-West Medical, Dhour	• Medicals in Uttara • ICDDR,B medical, Mohakhali

Appendix table D3: Gender Issues

Questions	***Up-stream***		***Mid-stream***		***Down-stream***	
	Konabari	**Kashimpur**	**Bhadam**	**Bhakral**	**Abdullahpur**	**Mausaid**
Water related household activities	Activities Cooking: Women Washing clothes: Women, Men, Girls, Boys Washing Utensils: Women, Girls, Collecting and storing water: Women, Men, Girls, Boys Bathing Children: Women	Activities Cooking;: Women, Girls, Washing clothes;: Women, Girls, Washing vegetables;: Women, Girls, Washing Utensils;: Women, Girls, Collecting and storing water;: Women, Girls, Bathing Children: Women, Girls,	Activities Cooking;: Women, Girls, Men Washing clothes;: Women, Girls, Men Washing vegetables;: Women, Girls, Men Washing Utensils;: Women, Girls, Men Collecting and storing water;: Women, Girls, Men Bathing Children: Women, Girls, Men	Activities Cooking;: Women Washing clothes;: Women, girls Washing vegetables;: Women, girls Washing Utensils;: Women, girls Collecting and storing water;: Women, girls Bathing Children: Women	Activities Cooking;: Women Washing clothes;: Women, men Washing vegetables;: Women Washing Utensils;: Women, Girls Collecting and storing water;: Women, men Bathing Children: Women	Activities Cooking;: Women Washing clothes;: Women, Men Washing Utensils;: Women Collecting and storing water;: Women

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<td>Time of the day to do these tasks</td>
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<tr><th>Activities</th><th>Time</th></tr>
<tr><td>Cooking</td><td>Morning, Noon, Night</td></tr>
<tr><td>Washing clothes</td><td>Morning, Noon</td></tr>
<tr><td>Washing utensils</td><td>Morning, Noon, Night</td></tr>
<tr><td>Collecting and storing water</td><td>Morning, Noon, Evening</td></tr>
<tr><td>Bathing</td><td>Noon</td></tr>
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<tr><td>Washing utensils</td><td>Morning, Noon</td></tr>
<tr><td>Collecting and storing water</td><td>Morning, Afternoon, Evening</td></tr>
<tr><td>Bathing</td><td>Morning, Noon</td></tr>
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<tr><td>Washing utensils</td><td>Morning, Noon</td></tr>
<tr><td>Collecting and storing water</td><td>Morning, Afternoon, Evening</td></tr>
<tr><td>Bathing</td><td>Morning, Noon</td></tr>
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<tr><td>Washing utensils</td><td>Morning, Noon, Night</td></tr>
<tr><td>Collecting and storing water</td><td>Morning, Noon, Night</td></tr>
<tr><td>Bathing</td><td>Morning, Noon</td></tr>
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<tr>
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<tr><td>Washing clothes</td><td>10 minutes</td></tr>
<tr><td>Washing utensils</td><td>20 minutes</td></tr>
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<tr><td>Bathing</td><td>10 minutes</td></tr>
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<tr><td>Washing clothes</td><td>30 minutes</td></tr>
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<tr><td>Cooking</td><td>1.30 - 2 hours</td></tr>
<tr><td>Washing clothes</td><td>20-30 minutes</td></tr>
<tr><td>Washing utensils</td><td>20 -35 minutes</td></tr>
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<tr><td>Cooking</td><td>1.30 hours</td></tr>
<tr><td>Washing clothes</td><td>20 minutes</td></tr>
<tr><td>Washing utensils</td><td>20 minutes</td></tr>
<tr><td>Collecting and storing water</td><td>10 minutes</td></tr>
<tr><td>Bathing</td><td>15 minutes</td></tr>
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<tr>
<td>Challenges (Security, Harassment, Physical problem)</td>
<td>• Long queue
• Dispute with people in the line who should go first
• Physical problem for old people to carry heavy loads of water</td>
<td>• Electricity is not always available, so in times like that we all need to rely on the deep tube wells
• It may be that one person is in a hurry and wants to go first, another person may object, and so on.</td>
<td>• It may be that one person is in a hurry and wants to go first, another person may object, and so on.
• Problem of pregnant women</td>
<td>• Long queue
• No government supports
• Quarrel between the people who are standing in the queue</td>
<td>• There is not so much problem with collecting water
• The river itself is dying
• Lack of fish
• Undrinkable water quality</td>
<td>• There are not many problems with collecting and storing water as most of them have a submersible
• Undrinkable water quality</td>
</tr>
</table>

Appendix E: The Turag River: Uses, Water Quality and Welfare Change over Time

Appendix table E1: Observed weather condition of the study sites

Observed site	Weather condition on observed day								Total (N=32)
	Sunny (n=14; %=43.8)		Gloomy (n=0; %=0)		Cloudy (n=08; %=25)		Rainy (n=10; %=31.3)		
	n	%	n	%	n	%	n	%	
Konabari	6	37.5	0	0	4	25	6	37.5	16
Abdullahpur	8	50	0	0	4	25	4	25	16

Source: Water Use Behaviour Survey, 2018

Appendix table E2: River condition at observed sites

Observation sites	Condition of River Water				
	Very Bad= 1	Bad=2	Moderate=3	Good=4	Very Good=5
Konabari			Ö		
			Ö		
Abdullahpur	Ö				
	Ö				
Abdullahpur	Ö				
	Ö				
Konabari			Ö		
			Ö		
Abdullahpur	Ö				
	Ö				
Konabari			Ö		
				Ö	
Konabari				Ö	
				Ö	
Abdullahpur	Ö				
	Ö				
Abdullahpur	Ö				
	Ö				
Konabari				Ö	
				Ö	
Abdullahpur	Ö				
	Ö				
Konabari					Ö
					Ö
Konabari					Ö
					Ö
Abdullahpur	Ö				
	Ö				
Abdullahpur	Ö				
	Ö				
Konabari					Ö
					Ö

Source: Water use behavior survey, 2018

Appendix table E3: Sex wise age group of observed communities

Age group	Women		Men	
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Child	110	18	72	16
Adult	470	77	312	67
Elderly	30	5	78	17
Total	**610**	**56.9**	**462**	**43.1**

Appendix table E4: Gender information of observed sites

Options		Konabari		Abdullahpur		Total	
		Frequency (F)	**Percentage (%)**	**Frequency (F)**	**Percentage (%)**	**Frequency (F)**	**Percentage (%)**
Gender group	Women	230	45.3	270	47.9	500	46.6
	Men	191	37.6	199	35.3	390	36.4
	Girls	57	11.2	53	9.4	110	10.3
	Boys	30	5.9	42	7.4	72	6.7
Total		**508**	**47.4**	**564**	**52.6**	**1072**	**100**
Age group	Child	87	47.8	95	52.2	182	17.0
	Adult	367	46.9	415	53.1	782	73.0
	Elderly	54	50	54	50	108	10.1
Assemblage	Individual	102	51.5	96	48.5	198	58.9
	Group	60	43.5	78	56.5	138	41.1

Source: Water use behavior survey, 2018

Appendix table E5: Purposes of water use at survey areas

Purposes of water use		Konabari Frequency (F)	Konabari Percentage (%)	Abdullahpur Frequency (F)	Abdullahpur Percentage (%)	Total (N)	Percentage (%)
Consumption	Drinking	0	0.0	0	0.0	0	0.0
	Cooking	0	0.0	1	100	1	0.5
	Water collection	91	46.2	106	53.8	197	99.5
Washing	Vegetable washing	2	66.7	1	33.3	3	1.2
	Dish washing	20	27.4	53	72.6	73	29.0
	Clothes washing	69	68.3	32	31.7	101	40.1
	Property washing	28	37.3	47	62.7	75	29.8
Hygiene	Bathing	64	87.7	9	12.3	73	34.0
	Ablution	2	66.7	1	33.3	3	1.4
	Personal washing	52	46.4	60	53.6	112	52.1
	Open defection	15	55.6	12	44.4	27	12.6
Amenities	Boating	7	41.2	10	58.8	17	8.7
	Angling	1	100	0	0	1	0.5
	Swimming/recreation	36	72	14	28	50	25.6
	Non-essential task	49	38.6	76	59.8	127	65.1
Productivity	Navigation/Transport	56	43.1	74	56.9	130	61.9
	Fishing	4	100.0	0	0	4	1.9
	Commerce	9	33.3	18	66.7	27	12.9
	Irrigation	0	0	0	0	0	0.0
	Watering plants	0	0	1	100	1	0.5
	Watering and bathing of livestock	0	0	0	0	0	0.0
	Case (Fish) Culture	0	0	0	0	0	0.0
	Duck rearing	27	56.3	21	43.8	48	22.9

Source: Water use behavior survey, 2018

Appendix table E6: Gender disparities in Turag River water use

Gender ratio of river use		Total (N) = 1072					
		Male, n= 462; %=43.1			Female, n= 610; %=56.9		
		Child (72)	Adult (312)	Elderly (78)	Child (110)	Adult (470)	Elderly (30)
Category	**Types of activity**	**16%**	**67%**	**17%**	**18%**	**77%**	**5%**
Consumption	Drinking	0%	0%	0%	0%	0%	0%
	Cooking	0%	0%	0%	0%	1%	0%
	Water collection	5%	22%	5%	6%	27%	2%
Washing	Vegetable washing	0%	0%	0%	0%	3%	0%
	Dish washing	0%	13%	0%	0%	56%	0%
	Cloth washing	7%	29%	12%	8%	43%	5%
	Property washing	2%	26%	8%	7%	37%	8%
Hygiene	Bathing	2%	7%	1%	3%	20%	5%
	Ablution	0%	0%	0%	0%	0%	3%
	Personal washing	0%	34%	17%	0%	58%	12%
	Open defection	8%	0%	0%	2%	0%	0%
Amenities	Boating	2%	7%	0%	3%	12%	0%
	Angling	0%	0%	0%	0%	1%	0%
	Swimming/recreation	5%	17%	0%	3%	27%	0%
	Non-essential task	17%	36%	9%	10%	53%	5%
Productivity	Navigation/Transport	1%	55%	0%	0%	26%	0%
	Fishing	0%	2%	0%	0%	0%	0%
	Commerce	0%	22%	0%	0%	0%	0%
	Irrigation	0%	0%	0%	0%	0%	0%
	Watering plants	0%	1%	0%	0%	0%	0%
	Watering and bathing livestock	0%	0%	0%	0%	0%	0%
	Case (Fish) Culture	0%	0%	0%	0%	0%	0%
	Duck rearing	0%	0%	5%	0%	22%	0%

Source: Water use behavior survey, 2018

Appendix F: Urban Water Use: A Gendered Analysis

Appendix table F1: Gendered responsibility and time of the day to do of various household activities

Activities	Responsible person				Time of the day people do these tasks				
	Female	Male	Female children	Male children	Morning	Noon	After noon	Evening	Night
Cooking	6	1	2		4	4			4
Washing vegetables	4	1	3						
Washing utensils	6	1	5		4	4			2
Washing clothes	6	4	4	1	2	4			
Collecting and storing water	6	3	4	1	4	2	2	3	1
Bathing children	5	1	2		3	4			
Frequency (n)	**33**	**11**	**20**	**2**	**17**	**18**	**2**	**3**	**7**
Percentage (%)	**50**	**16.7**	**30.3**	**3.0**	**36.2**	**38.3**	**4.3**	**6.4**	**14.9**

***Source: FGDs & KIIs, 2018; Time slots for the morning (6:00-10:00 am), noon (10:00 am-1:00 pm just before Dhuhr azan), afternoon (1:00 pm-4:00 pm, just before Asr azan), evening (4:00-6:00 pm/just after sunset, in between Asr and Magrib time) and night (7:00-10:00 pm) is set as per the respondent's community**

Appendix table F2: Gender performance who use river water for domestic activities

Gender group	Count	
	n	%
Adult Male	8	0.4
Adult female	39	2.1
Male Children	5	0.3
Female children	8	0.4
Total	60	3.3

Source: Survey data, 2017-18; N=1826

Statistics		Adult male	Adult female	Male children	Female children
N	Valid	39	39	39	39
	Missing	1787	1787	1787	1787
Mean		1.79	1.00	1.87	1.79
Median		2.00	1.00	2.00	2.00
Mode		2	1	2	2
Std. Dev.		.409	.000	.339	.409
Variance		.167	.000	.115	.167
Range		1	0	1	1
Minimum		1	1	1	1
Maximum		2	1	2	2
Sum		70	39	73	70
Percentiles	25	2.00	1.00	2.00	2.00
	50	2.00	1.00	2.00	2.00
	75	2.00	1.00	2.00	2.00

Appendix table F3: Responsible person to fetch water for household

Group responsible for fetching water	Frequency (n)	Percentage (%)
Adult male	541	29.6
Adult female	1773	97.1
Male children	92	5.0
Female children	189	10.4
Total	2595*MR	142.1

Source: Survey data, 2017-18; N=1826

Statistics					
Who usually goes to this water source to fetch the water for your household?		Adult male	Adult female	Male children	Female children
N	Valid	1826	1826	1826	1826
	Missing	0	0	0	0
Mean		1.70	1.03	1.95	1.90
Median		2.00	1.00	2.00	2.00
Mode		2	1	2	2
Std. Deviation		.457	.168	.219	.305
Variance		.209	.028	.048	.093
Range		1	1	1	1
Minimum		1	1	1	1
Maximum		2	2	2	2
Sum		3111	1879	3560	3463
Percentiles	25	1.00	1.00	2.00	2.00
	50	2.00	1.00	2.00	2.00
	75	2.00	1.00	2.00	2.00

Appendix table F4: Time taken to fetch water

Time to fetch water	Frequency (n)	Percentage (%)
Less than 5 minutes	1275	69.8
5-10 minutes	338	18.5
10-15 minutes	141	7.7
15-30 minutes	61	3.3
More than 30 minutes	11	0.6
Total	**1826**	**100**

Source: Survey data, 2017-18

Appendix table F5: Time of fetching water by gender group

Time spent by gender group	Adult male		Adult female		Male children		Female children	
	n	%	n	%	n	%	n	%
Less than 5 minutes	428	23.4	1247	68.3	67	3.7	137	7.5
5-10 minutes	67	3.7	318	17.4	14	0.8	33	1.8
10-15 minutes	23	1.3	139	7.6	5	0.3	10	0.5
15-30 minutes	22	1.2	58	3.2	5	0.3	9	0.5
More than 30 minutes	1	0.1	11	0.6	1	0.1	0	0.0
Total	**541**	**29.6**	**1773**	**97.1**	**92**	**5.0**	**189**	**10.4**

Source: Survey data, 2017-18

Appendix table F6: Challenges faced of fetching water by sex

Challenges by sex	Adult Male		Adult Female		Male Children		Female Children		Total	
	n	%	n	%	n	%	n	%	n	%
No Problems	465	17.9	1468	56.6	74	2.9	163	6.3	2170	83.6
Quarrels	24	0.9	151	5.8	5	0.2	13	0.5	193	7.4
Uncomfortable feeling	22	0.8	77	3.0	5	0.2	4	0.2	108	4.2
Feel unsafe	2	0.1	23	0.9	1	0.0	0	0.0	26	1.0
Eve teasing	0	0.0	1	0.0	1	0.0	0	0.0	2	0.1
Physical or sexual harassment	0	0.0	1	0.0	0	0.0	0	0.0	1	0.0
Physical Burden	49	1.9	178	6.9	15	0.6	18	0.7	260	10.0
Others	8	0.3	27	1.0	1	0.0	0	0.0	36	1.4
Total	570	22.0	1926	74.2	102	3.9	198	7.6	2796*	107.7

Source: Survey data, 2017-18; n=2595, *MR= Multiple Response

Appendix G: Urban Water Use and Health Risk

Appendix table G1: Percentage of community members suffering from major illness in the past one year

Disease in past one year	Frequency (n)	Percentage (%)
Yes	1968	27.5
No	5155	72.1
Don't Know	11	0.2
Total	7134	99.7

Statistics		
N	Valid	7134
	Missing	0
Mean		3.26
Median		2.00
Mode		2
Std. Deviation		39.135
Variance		1531.574
Range		998
Minimum		1
Maximum		999
Sum		23267
Percentiles	25	1.00
	50	2.00
	75	2.00

Appendix table G2: Disease occurrence and gender disparities in past one year

Diseases past one year	Male		Female		Total (N)	Percentage (%)	P-value	Comment
	n	%	n	%				
Dysentery (Diarrhoea with blood)	127	6.5	119	6.0	246	12.5	0.275	Not significant
Cholera	9	0.5	6	0.3	15	0.8	0.366	Not significant
Typhoid	57	2.9	61	3.1	118	6.0	0.988	Not significant
Jaundice	84	4.3	97	4.9	181	9.2	0.579	Not significant
Skin diseases	129	6.6	118	6.0	247	12.6	0.195	Not significant
Gastric ulcers/stomach pain	327	16.6	394	20.0	721	36.6	0.044	Not significant
Chikungunya/dengue/malaria	111	5.6	108	5.5	219	11.1	0.468	Not significant
Tuberculosis/pneumonia	49	2.5	57	2.9	106	5.4	0.649	Not significant
Others	276	14.0	316	16.1	592	30.1	0.308	Not significant
Total	1169	59.5	1276	64.8	2445*MR	124.2	---	---

Source: HH Survey, 2017-18; *P<0.005

Appendix table G3: List of other illness community members suffering from past one year

Illness	n	Illness	n	Illness	n
Accident (bus/motorcycle/fell from tree, roof)	15	Dental problem	7	Lung Disease	2
Allergy	5	Diabetes	14	Mental/psychological disorder	4
Anaemia/ blood related problem/Thalassaemia	7	Ear/eye/nasal related problem	35	Others (Dog biting/gangrene/IBS/Infection)	23
Appendicitis	9	Fever (viral/rheumatic)	77	Paralysis/neurological problem	10
Back pain/ bone problem/decay/fraction/ low density	31	Fracture/injury in arm/leg/neck/face	11	Pain (arm/neck/leg/waist/chest)	24
Body pain	48	Fistula/piles/polypus	8	Physical disability	5
Blood pressure (high/low)	21	Gastric/ulcer	2	Stomach problem/pain	3
Breathing/respiratory problem	17	Gynaecological/menstrual/abortion problem/ reproductive health/ovary/pregnancy related problem/ uterus operation	26	Stroke	17
Burn	3	Headache	9	Surgery/operation	6
Bile operation/stone	2	Heart related/cardiological problem (attack/blockage/operation)	40	Tumour	17
Chest pain	6	Hernia	4	Urinal Infection	12
Chicken pox	5	Kidney related problems/stone	25	Weakness	5
Cold/allergy/tonsil/cough	27	Liver related problems/Hepatitis/Tuberculosis	10	**Total**	**592**

***n=Frequency**

Appendix table G4: Area wise diseases distribution of studied community suffering from last one year

Area	Types of diseases																		Total	
	Dysentery		Cholera		Typhoid		Jaundice		Skin diseases		Gastric/ulcer/stomach pain		Chikungunya/dengue/malaria		Tuberculosis /pneumonia		Others			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Konabari	40	2.0	0	0.0	22	1.1	34	1.7	55	2.8	134	6.8	47	2.4	20	1.0	48	2.4	**400**	**16.4**
Kashimpur	1	0.1	0	0.0	6	0.3	14	0.7	20	1.0	120	6.1	0	0.0	1	0.1	144	7.3	**306**	**12.5**
Ichharkandi	3	0.2	2	0.1	1	0.1	1	0.1	7	0.4	7	0.4	1	0.1	10	0.5	44	2.2	**76**	**3.1**
Palasana	3	0.2	5	0.3	5	0.3	0	0.0	2	0.1	8	0.4	2	0.1	10	0.5	30	1.5	**65**	**2.7**
Gutia	11	0.6	1	0.1	1	0.1	9	0.5	2	0.1	15	0.8	3	0.2	0	0.0	36	1.8	**78**	**3.2**
Gusulia	2	0.1	1	0.1	5	0.3	1	0.1	3	0.2	11	0.6	6	0.3	4	0.2	27	1.4	**60**	**2.5**
Bhakral	14	0.7	0	0.0	7	0.4	5	0.3	22	1.1	24	1.2	6	0.3	5	0.3	49	4.6	**132**	**5.4**
Bhadam	14	0.7	0	0.0	6	0.3	13	0.7	11	0.6	91	4.6	6	0.3	1	0.1	29	1.5	**171**	**7.0**
Kathaldia	7	0.4	3	0.2	19	1.0	12	0.6	3	0.2	40	2.0	13	0.7	12	0.6	26	1.3	**135**	**5.5**
Rashadia	18	0.9	0	0.0	6	0.3	15	0.8	25	1.3	41	2.1	8	0.4	5	0.3	27	1.4	**145**	**5.9**
Abdullahpur	87	4.4	2	0.1	18	0.9	44	2.2	47	2.4	144	7.3	71	3.6	30	1.5	90	4.6	**533**	**21.8**
Mausaid	46	2.3	1	0.1	22	1.1	33	1.7	50	2.5	86	4.4	56	2.8	8	0.4	42	2.1	**344**	**14.1**
Total	**246**	**12.5**	**15**	**0.8**	**118**	**6.0**	**181**	**9.2**	**247**	**12.6**	**721**	**36.6**	**219**	**11.1**	**106**	**5.4**	**592**	**30.1**	2445*	124.2

Source: HH Survey, 2017-18; *MR=Multiple Response

Appendix table G5: Age-wise diseases distribution of studied community

Age Group (Year)	Diseases																			
	Dysentery		Cholera		Typhoid		Jaundice		Skin diseases		Gastric/ulcer/ stomach pain		Chikungunya/ dengue/malaria		Tuberculosis/ pneumonia		Others		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
0-5	36	1.8	1	0.1	7	0.4	4	0.2	13	0.7	3	0.2	7	0.4	20	1.0	24	1.2	115	5.8
6-15	43	2.2	3	0.2	29	1.5	18	0.9	37	1.9	27	1.4	38	1.9	21	1.1	58	2.9	274	13.9
16-25	53	2.7	2	0.1	30	1.5	48	2.4	56	2.8	130	6.6	45	2.3	12	0.6	102	5.2	478	24.3
26-35	37	1.9	3	0.2	23	1.2	47	2.4	49	2.5	214	10.9	45	2.3	16	0.8	110	5.6	544	27.6
36-45	29	1.5	2	0.1	13	0.7	32	1.6	40	2.0	168	8.5	37	1.9	12	0.6	108	5.5	441	22.4
46-55	18	0.9	2	0.1	12	0.6	16	0.8	24	1.2	95	4.8	20	1.0	12	0.6	104	5.3	303	15.4
56-65	16	0.8	2	0.1	2	0.1	10	0.5	15	0.8	58	2.9	15	0.8	7	0.4	62	3.2	187	9.5
66>	14	0.7	0	0.0	2	0.1	6	0.3	13	0.7	26	1.3	12	0.6	6	0.3	24	1.2	103	5.2
Total	246	12.5	15	0.8	118	6.0	181	9.2	247	12.6	721	36.6	219	11.1	106	5.4	592	30.1	2445*	124.2

Source: HH Survey, 2017-18; *MR=Multiple Response

Appendix table G6: Malnutrition count and statistic of the surveyed population

Malnutrition	Frequency (n)	Percentage (%)
Yes	1298	18.2
No	5738	80.4
Don't know	97	1.4
Total	7133	100.0
Missing system	1	0.0

Statistics		
N	Valid	7133
	Missing	1
Mean		15.38
Median		2.00
Mode		2
Std. Deviation		115.501
Variance		13340.43
Range		998
Minimum		1
Maximum		999
Sum		109677
Percentiles	25	2.00
	50	2.00
	75	2.00

Appendix table G7: Age-wise malnutrition distribution of surveyed population

	Frequency (n)	**Percentage** (%)
Sex group		
Male	632	48.7
Female	666	51.3
Age Group (Year)		
0-5	119	9.0
6-15	238	18.2
16-25	260	20.0
26-35	209	16.1
36-45	167	12.9
46-55	133	10.3
56-65	111	8.7
66>	61	5.0
Total	**1298**	**100**

Appendix table G8: Percentage of respondents think the water they drink is safe and reasons if they think it is not safe

Characteristics	**Frequency (n)**	**Percentage (%)**
Do you think that the water you drink is safe?		
Yes	1695	92.8
No	77	4.2
Don't Know	54	3.0
If no, why		
Water has Iron	53	2.9
Water has Germs	24	1.3
Water doesn’t taste/smell/look good	18	1.0
Others	1	0.1

Appendix table G9: Community perception on dirty sources of water for domestic use and a factor for disease occurrence

Domestic use	Dirty sources for causing disease	Wet season		Mean±SD	Dry season		Mean±SD
		n	%		n	%	
Cooking							
Supply/Ground source	Piped into dwelling	2	0.1	0.7±1.2	2	0.1	0.7±1.2
	Piped into yard	21	1.6	7.0±4.4	19	1.4	6.3±3.8
	Public tap	10	0.7	3.3±2.5	10	0.7	3.3±2.5
	Motor tube well	91	6.8	30.3±11.0	91	6.8	30.3±11.0
	Sub total	***124***	***9.2***	***41.3±17.0***	***122***	***9.1***	***40.7±16.4***
Open source	River/canal	2	0.1	0.7±1.2	4	0.3	1.3±1.2
	Rainwater	---	---	---	4	0.3	1.3±2.3
	Sub total	***2***	***0.1***	***0.7±1.2***	***8***	***0.6***	***2.7±1.2***
Total		126*	9.4	42±20.2	130*	9.7	43.3±21.9
Cloth and dish washing							
Supply/Ground source	Piped into dwelling	1	0.1	0.3±0.6	1	0.1	0.3±0.6
	Piped into yard	17	1.3	5.7±3.2	16	1.2	5.3±3.1
	Public tap	8	0.6	2.7±1.5	9	0.7	3.0±2.0
	Motor tube well	81	6.0	27.0±10.0	76	5.7	25.3±9.1
	Vended bottle	1	0.1	0.3±0.6	1	0.1	0.3±0.6
	Sub total	***108***	***8.0***	***36.0±14.4***	***103***	***7.7***	***34.3±13.6***
Open source	Rainwater	---	---	---	7	0.5	2.3±2.1
	River/canal	36	2.7	12.0±7.0	62	4.6	20.7±11.0
	Lake	3	0.2	1.0±1.0	3	0.2	1.0±0.0
	Pond	15	1.1	5.0±2.0	15	1.1	5.0±2.6
	Sub total	***54***	***4.0***	***18.0±9.5***	***87***	***6.4***	***29.0±14.7***
Total		162*	12.0	54±25.9	190*	14.1	63.3±31.0
Bathing							
Supply/Ground source	Piped into dwelling	2	0.1	0.7±0.6	1	0.1	0.3±0.6
	Piped into yard	15	1.1	5.0±2.6	15	1.1	5.0±3.0
	Public tap	10	0.7	3.3±2.5	8	0.6	2.7±1.5
	Shallow tube well	---	---	---	1	0.1	0.3±0.6
	Motor tube well	80	5.9	26.7±10.0	77	5.7	25.7±10.6
	Vended bottle	---	---	---	1	0.1	0.3±0.6
	Sub total	***107***	***8.0***	***35.7±14.3***	***103***	***7.7***	***34.3±14.0***
Open source	Rainwater	---	---	---	6	0.4	2.0±1.0
	River/canal	43	3.2	14.3±7.4	66	4.9	22.0±12.5
	Lake	2	0.1	0.7±1.2	3	0.2	1.0±1.0
	Pond	17	1.3	5.7±2.5	18	1.3	6.0±2.6
	Sub total	***62***	***4.6***	***20.7±10.2***	***93***	***6.9***	***31.0±16.1***
Total		169*	12.6	56.3±26.8	196*	14.6	65.3±34.0

Source: HH Survey, 2017-18; *MR=Multiple Response

Appendix table G10: Water source and short-term diseases chi-square test

Diseases past one year	**Pearson Chi-square (χ^2) test (p-value)**											
	Piped_dwelling	**Piped_yard**	**Public_tap**	**Tubewell_deep**	**Tubewell_shallow**	**Tubewell_motor**	**Vended_truck**	**Vended_bottled**	**Rain water**	**River/canal**	**Pond**	**Others**
Dysentery	0.016	0.828	0.294	0.489	0.118	0.445	0.397	0.512	0.354	0.129	0.098	0.142
Cholera	0.609	0.060	0.494	0.244	0.717	0.163	0.844	0.879	0.830	0.725	0.001*	0.733
Typhoid	0.124	0.557	0.765	0.382	0.296	0.689	0.187	0.662	0.005*	0.271	0.403	0.913
Jaundice	0.517	0.499	0.117	0.009	0.188	0.708	0.017	0.581	0.435	0.646	0.163	0.146
Skin diseases	0.164	0.481	0.151	0.496	0.405	0.594	0.615	0.511	0.353	0.995	0.097	0.141
Gastric ulcers/stomach pain	0.002*	0.032	0.513	0.192	0.103	0.734	0.439	0.280	0.866	0.002*	0.018	0.421
Chikungunya/dengue/malaria	0.001*	0.001*	0.149	0.960	0.001*	0.003*	0.428	0.540	0.385	0.533	0.121	0.273
Tuberculosis/Pneumonia	0.094	0.971	0.630	0.670	0.323	0.742	0.147	0.679	0.558	0.001*	0.319	0.825
Others	0.001*	0.010	0.718	0.558	0.039	0.828	0.142	0.902	0.862	0.321	0.002*	0.783

***Chi-square test that shows significant relation, P<0.05 at a confidence level of 95%**

Appendix table G11: Water source and short-term diseases spearman correlation test

Disease types	**Spearman Correlation** (r_s)											
	Piped_dwelling	Piped_yard	Public_tap	Tubewell_deep	Tubewll_shallow	Tubewell_motor	Vended_truck	Vended_bottled	Rainwater	River/canal	Pond	Others
Dysentery	0.016*	0.828	0.294	0.489	0.118	0.445	0.389	0.513	0.354	0.129	0.098	0.142
Cholera	0.609	0.060	0.495	0.244	0.717	0.163	0.845	0.879	0.830	0.725	0.001*	0.733
Typhoid	0.124	0.558	0.765	0.382	0.296	0.690	0.187	0.662	0.005*	0.271	0.404	0.913
Jaundice	0.517	0.500	0.117	0.009*	0.188	0.708	0.017*	0.581	0.435	0.646	0.163	0.146
Skin diseases	0.164	0.482	0.152	0.497	0.405	0.595	0.615	0.512	0.353	0.995	0.097	0.141
Gastric ulcers/stomach pain	0.002*	0.032*	0.513	0.193	0.103	0.734	0.440	0.280	0.867	0.002*	0.018*	0.421
Chikungunya/dengue/malaria	0.001*	0.001*	0.149	0.960	0.001*	0.003*	0.428	0.540	0.386	0.534	0.121	0.273
Tuberculosis/ pneumonia	0.094	0.971	0.630	0.671	0.323	0.742	0.147	0.679	0.559	0.001*	0.319	0.826
Others	0.001*	0.010*	0.718	0.558	0.039*	0.828	0.142	0.902	0.862	0.321	0.002*	0.783

***Correlation is significant at the 0.05 level (2-tailed)**

Appendix table G12: Handwashing materials used before eating and after going to the toilet by the studied communities.

Washing material	Frequency (n)	Percentage (%)
Only water	341	18.7
Soap	1415	77.5
Detergent	9	0.5
Ash	22	1.2
Mud	38	2.1
Hand wash	1	0.1
Total	1826	100.0

Statistics		
N	Valid	1826
	Missing	0
Mean		1.93
Std. Error of Mean		.033
Median		2.00
Mode		2
Std. Deviation		1.401
Variance		1.962
Range		54
Sum		3531
Percentiles	25	2.00
	50	2.00
	75	2.00

Appendix table G13: Household paid for water

Costing of water	Frequency (n)	Percentage (%)
Valid	556	30.4
Don’t know	127	7.0
Missing System	1143	62.6
Total (N)	1826	100.0

Source: HH Survey, 2017-18

Appendix table G14: Household level water storage practices by the studied communities

Water storage practices	Frequency (n)	Percentage (%)
Does household store water on the premises		
Yes	1075	58.9
No	751	41.1
If yes, how long the water stored for		
6 hours or less	446	24.4
6-12 hours	281	15.4
1 day	240	13.1
2 days	86	4.7
More than 2 days	22	1.2
Total	1075	58.9
Where does the water store?		
Pitcher (Kolshi)	770	42.2
Jug	472	25.8
Bucket	222	12.2
Jerrycan	178	9.7
Bottle	147	8.1
Total	1789*MR	98.0
Is the storage container covered with a lid		
Yes	888	48.6
No	187	10.2

Source: **HH Survey, 2017-18**

Appendix table G15: Washing practices of water storage container

Washing of storage container	Frequency (n)	Percentage (%)
Does household clean containers before water collection		
Always	636	34.8
Sometimes	431	23.6
Never	8	0.4
Total	1075	58.9
Sites of washing		
At the water source	1040	57.0
At home	19	1.0
Others (specify)	8	0.4
Total	1067	58.4
Material used to wash the containers		
Only water	658	36.0
Ash	327	17.9
Soap	706	38.7
Others	34	1.9
Total	1725*MR	94.5

Appendix table G16: Treatment measures taken by the households

Treatment measures taken by the households	Frequency (n)	Percentage (%)
Yes	53	2.9
No	1773	97.1
Total	**1826**	**100.0**

Statistics		
N	Valid	1826
	Missing	0
Mean		1.97
Std. Error of Mean		0.004
Median		2.00
Mode		2
Std. Deviation		0.168
Variance		0.028
Range		1
Sum		3599
Percentiles	25	2.00
	50	2.00
	75	2.00

Appendix table G17: Types of water treatment taken by the respondent households

Treatment types	Frequency (n)	Percent (%)
Boil	32	1.8
Add alum	1	0.05
Strain through a cloth	4	0.2
Water filter (bio sand/composite/ceramic filter)	14	0.8
Solar disinfection	1	0.05
Let it stand and settle	2	0.1
Other (Water purifying tablet)	2	0.1
Total	**56***	**3.1**

Source: HH Survey, 2017-18; *MR=Multiple Response

Appendix table G18: Household level treatment seeking behavior

Seek any advice or treatment from any source?		Frequency (n)	Percentage (%)
Valid	Yes	298	4.2
	No	58	0.8
	Total (n)	**356**	**5.0**
Missing System		6778	95.0
Total (N)		7134	100.0

Statistics		
N	Valid	356
	Missing	6778
Mean		1.16
Median		1.00
Mode		1
Std. Deviation		.370
Variance		.137
Range		1
Minimum		1
Maximum		2
Sum		414
Percentiles	25	1.00
	50	1.00
	75	1.00

Appendix table G19: Place where community seek treatment

Treatment source	**Frequency (n)**	**Percentage (%)**
Upazilla hospital	11	0.2
District hospital	11	0.2
Medical College/Specialized hospital	68	1.0
Private clinic	29	0.4
Mother and Child Welfare Centre (MCWC)	1	0.0
UHC (Union health Centre)	1	0.0
Community clinic	2	0.0
Qualified doctor	15	0.2
Unqualified doctor	3	0.1
Pharmacy	162	2.3
Homeopathy	6	0.1
Ayurvedic	4	0.1
Self-treatment	16	0.2
Others	9	0.1
Total	**338*MR (n=298)**	**4.9**
Example of others: Garment companies assigned medical/doctors, kobiraj (religious doctor), Dhaka medical		

Source: HH Survey, 2017-18; *MR=Multiple Response

Appendix table G20: Disease-wise treatment seeking behavior of past one-year ill persons

Means of Treatment	Types of Disease																			
	Dysentery		Cholera		Typhoid		Jaundice		Skin diseases		Gastric/ulcer/ stomach pain		Chikungunya/ dengue/ malaria		Tuberculosis/ pneumonia		Others		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Upazila Hospital			1	0.4	1	0.4	2	0.7									2	0.7	6	2.1
District hospital	3	1.1			2	0.7	1	0.4	1	0.4	6	2.1	2	0.7			3	1.1	18	6.3
Medical college/specialized hospital	7	2.5					9	3.2	4	1.4	20	7.0	7	2.5	5	1.8	16	5.6	68	23.9
Private clinic							1	0.4	1	0.4	6	2.1			1	0.4	6	2.1	15	5.3
Union Health Centre (UHC)									1	0.4									1	0.4
Community clinic							1	0.4											1	0.4
Qualified doctor			1	0.4							4	1.4							5	1.8
Unqualified doctor					1	0.4													1	0.4
Pharmacy	23	8.1	1	0.4	5	1.8	14	4.9	7	2.5	64	22.5	13	4.6	4	1.4	19	6.7	150	52.6
Homeopathy							2	0.7	1	0.4									3	1.1
Ayurvedic							2	0.7									1	0.4	3	1.1
Self-treatment	1	0.4					1	0.4	2	0.7	4	1.4							8	2.8
Others									1	0.4	2	0.7			1	0.4	2	0.7	6	2.1
Total	34	11.9	3	1.1	9	3.2	33	11.6	18	6.3	106	37.2	22	7.7	11	3.9	49	17.2	285	100

Source: HH Survey, 2017-18

Appendix table G21: Treatment expenditure of respondent household by sex

Expenditure range (BDT)	Treatment expenditure by sex				Health expenditure at household level		Sum of expenditure	Mean±SD
	Male		Female					
	n	%	n	%	n	%		
20-200	42	14.1	12	4.0	54	0.7	7306	135.3±59.8
201-500	50	16.8	18	6.0	68	1.0	27380	402.6±103.6
501-1000	58	19.5	30	10.1	88	1.2	84278	957.7±107.8
1001-2500	27	9.1	14	4.7	41	0.6	68000	1659±352.8
2501-5000	18	6.0	7	2.3	25	0.4	102100	4084±842.5
5001-10000	8	2.7	1	0.3	9	0.1	68000	7556±1667
15000-50000	11	3.7	2	0.7	13	0.1	286000	22000±9806
Total	**214**	**71.8**	**84**	**28.2**	**298**	**4.2**	**643064**	**2157.9±4937.6**

Source: HH Survey, 2017-18

Appendix table G22: Treatment expenditure by site

Area	Area-wise treatment cost in BDT (Tk.)															
	20-200		201-500		501-1000		1001-2500		2501-5000		5001-10000		15000-50000		Total (N)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Konabari	13	4.4	11	3.7	18	6.0	3	1.0	2	0.7	1	0.3	1	0.3	49	16.4
Kashimpur	0	0.0	2	0.7	0	0.0	3	1.0	0	0.0	0	0.0	0	0.0	5	1.7
Ichharkandi	2	0.7	1	0.3	2	0.7	1	0.3	3	1.0	0	0.0	0	0.0	9	3.0
Palasana	3	1.0	2	0.7	2	0.7	3	1.0	2	0.7	0	0.0	0	0.0	12	4.0
Gutia	1	0.3	1	0.3	1	0.3	4	1.3	4	1.3	2	0.7	1	0.3	14	4.7
Gusulia	3	1.0	0	0.0	1	0.3	2	0.7	1	0.3	0	0.0	1	0.3	8	2.7
Bhakral	0	0.0	5	1.7	13	4.4	3	1.0	2	0.7	1	0.3	5	1.7	29	9.7
Bhadam	3	1.0	11	3.7	13	4.4	5	1.7	3	1.0	0	0.0	1	0.3	36	12.1
Kathaldia	12	4.0	4	1.3	10	3.4	4	1.3	2	0.7	0	0.0	0	0.0	32	10.7
Rashadia	1	0.3	10	3.4	11	3.7	3	1.0	1	0.3	0	0.0	1	0.3	27	9.1
Abdullahpur	11	3.7	16	5.4	16	5.4	7	2.3	5	1.7	3	1.0	0	0.0	58	19.5
Mausaid	5	1.7	5	1.7	1	0.3	3	1.0	0	0.0	2	0.7	3	1.0	19	6.4
Total	54	18.1	68	22.8	88	29.5	41	13.8	25	8.4	9	3.0	13	4.4	298	100

Source: HH Survey, 2017-18

Appendix H: Loss of Productivity due to Illness

Appendix table H1: Long-term illness recorded for surveyed communities

	Frequency	Percent
Yes	2470	34.6
No	4648	65.2
Do not Know	16	0.2
Total	7134	100

Statistics		
N	Valid	7134
	Missing	0
Mean		3.89
Median		2.00
Mode		2
Std. Deviation		47.185
Variance		2226.431
Range		998
Sum		27750
Percentiles	25	1.00
	50	2.00
	75	2.00

Appendix table H2: Long term illness in percentage with gendered variation

Long term diseases	**Male**		**Female**		**Total**	**Percentage**	**P-value**	**Comments**
	n	%	n	%	N	%		
Body pain	402	16.3	608	24.6	1010	40.9	0.000	Significant
Fatigue/weakness	295	11.9	419	17.0	714	28.9	0.020	Significant
Headache/migraine	187	7.6	315	12.8	502	20.3	0.000	Significant
High/low blood pressure	230	9.3	422	17.1	652	26.4	0.000	Significant
Diabetes/high blood sugar	105	4.3	127	5.1	232	9.4	0.929	Non-significant
Kidney problems	48	1.9	60	2.4	108	4.4	0.909	Non-significant
Respiratory problems	176	7.1	140	5.7	316	12.8	0.000	Significant
Reproductive health problems	7	0.3	44	1.8	51	2.1	0.000	Significant
Mental health problems	9	0.4	14	0.6	23	0.9	0.571	Non-significant
Mental retardation (Autism/down syndrome etc.)	11	0.4	5	0.2	16	0.6	0.055	Significant
Physical disability	33	1.3	29	1.2	62	2.5	0.186	Non-significant
Others	272	11.0	266	10.8	538	21.8	0.003	Significant
Total	**1775**	**71.9**	**2449**	**99.1**	**4224***	**171**		

⁎MR= Multiple Response, P<0.05

Appendix table H3: List of other long-term illness community members suffering from

Long term illness	Count	Long term illness	Count	Long term illness	Count
Accident	2	Ear Problem/Hearing problem	12	Pain in neck/knee/chest/waist/ hand	16
Allergy	18	Eye related problem/Glaucoma/Blind	43	Paralysis	7
Appendicitis	4	Fever (viral/rheumatic/allergic)	77	Physical disability	1
Asthma	14	Gastric	29	Piles/polypus	9
Backpain/Body pain/spinal cord problem	9	Hernia	1	Reproductive Health/Menstrual Problem	8
Blood problem	2	Cardiological problem/heart attack/blockage/operation	65	Skin diseases	23
Blood pressure (low/high)	3	Injury (face/hand/leg/head)	2	Lung/respiratory illness /suffocation/tuberculos is/pneumonia	5
Bone related problem/ Thalassaemia (decay, fraction, operation)	18	Kidney problem/stone	2	Stomach pain/stone	7
Brain stroke	10	Infection	2	Thyroid	2
Burning	1	Leg problem/pain	11	Tumor	9
Cancer (Breast/Ovary/stomach)	7	Lever problem/stone	4	Ulcer	7
Cold/tonsil/cough/pneumonia	56	Nasal Problem	9	Urinal Infection	3
Dental problem	3	Neurological problem	2	Uterus operation	3
Diabetic	14	Others	14	**Total (n)**	**538**
Dysentery	1	Operation (leg/throat)	3	**Percentage (%)**	**21.8**

Appendix table H4: Area-wise distribution of long-term illness

Area	Area wise-long term illness																										Total	
	Body pain		Fatigue/weakness		Headache/migraine		High/low blood pressure		Diabetes/high blood sugar		Kidney problems		Respiratory problems		Reproductive health problems		Mental health problems		Mental retardation		Physical disability		Others					
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%			n	%
Konabari	184	7.4	137	5.5	87	3.5	100	4.0	34	1.4	30	1.2	95	3.8	13	0.5	2	0.1	2	0.1	18	0.7	85	3.4			787	31.9
Kashimpur	66	2.7	34	1.4	38	1.5	19	0.8	12	0.5	4	0.2	3	0.1	0	0.0	0	0.0	1	0.0	4	0.2	28	1.1			209	8.5
Ichharkandi	80	3.2	48	1.9	14	0.6	30	1.2	22	0.9	4	0.2	16	0.6	3	0.1	0	0.0	0	0.0	3	0.1	23	0.9			243	9.8
Palasana	32	1.3	17	0.7	7	0.3	17	0.7	10	0.4	3	0.1	13	0.5	4	0.2	2	0.1	2	0.1	0	0.0	12	0.5			119	4.8
Gutia	46	1.9	9	0.4	5	0.2	26	1.1	12	0.5	8	0.3	21	0.9	5	0.2	1	0.0	1	0.0	2	0.1	48	1.9			184	7.4
Gusulia	12	0.5	9	0.4	1	0.0	28	1.1	12	0.5	4	0.2	14	0.6	1	0.0	0	0.0	0	0.0	2	0.1	14	0.6			97	3.9
Bhakral	71	2.9	47	1.9	31	1.3	29	1.2	9	0.4	4	0.2	9	0.4	0	0.0	4	0.2	1	0.0	6	0.2	38	1.5			249	10.1
Bhadam	103	4.2	44	1.8	42	1.7	62	2.5	17	0.7	3	0.1	24	1.0	4	0.2	5	0.2	0	0.0	5	0.2	39	1.6			348	14.1
Kathaldia	33	1.3	27	1.1	5	0.2	94	3.8	30	1.2	11	0.4	17	0.7	2	0.1	4	0.2	0	0.0	4	0.2	39	1.6			266	10.8
Rashadia	67	2.7	54	2.2	30	1.2	21	0.9	8	0.3	2	0.1	5	0.2	2	0.1	2	0.1	0	0.0	5	0.2	34	1.4			230	9.3
Abdullahpur	194	7.9	197	8.0	145	5.9	112	4.5	29	1.2	14	0.6	34	1.4	5	0.2	2	0.1	3	0.1	6	0.2	88	3.6			**829**	**33.6**
Mausaid	122	4.9	91	3.7	97	3.9	114	4.6	37	1.5	21	0.9	65	2.6	12	0.5	2	0.1	5	0.2	7	0.3	90	3.6			663	26.8
Total	**1010**	**40.9**	714	28.9	502	20.3	652	26.4	232	9.4	108	4.4	316	12.8	51	2.1	23	0.9	16	0.6	62	2.5	538	21.8			4224*	171

***Total response 2470; *MR count=4224**

Appendix table H5: Association of long-term illness with water sources

Long-term illness	Chi-square test (p-value)										
	Piped_dwelling	Piped_yard	Public_tap	Tubewell_deep	Tubewell_shallow	Tubewell_motor	Rain_water	Vended_bottle	River/canal	Pond	Others
Body pain	0.179	0.328	0.458	0.962	0.786	0.122	0.786	0.404	0.094	0.947	0.026
Fatigue/waekness	0.264	0.049	0.886	0.853	0.077	0.074	0.077	0.579	0.944	0.625	0.562
Headache/migraine	0.658	0.488	0.860	0.863	0.430	0.897	0.430	0.649	0.361	0.147	0.226
High/low blood pressure	0.048	0.527	0.724	0.310	0.615	0.084	0.364	0.601	0.862	0.911	0.164
Diabetes/high blood sugar	0.791	0.255	0.242	0.518	0.618	0.100	0.618	0.774	0.189	0.007	0.444
Kidney problem	0.261	0.197	0.387	0.633	0.712	0.256	0.712	0.831	0.669	0.497	0.571
Respiratory problem	0.026	0.119	0.193	0.472	0.578	0.033	0.150	0.002	0.521	0.238	0.002
Reproductive health problems	0.662	0.409	0.015	0.838	0.874	0.990	0.874	0.927	0.855	0.771	0.808
Mental health problems	0.151	0.311	0.065	0.801	0.846	0.624	0.846	0.911	0.822	0.721	0.765
Mental retardation	0.662	0.546	0.711	0.838	0.874	0.990	0.874	0.927	0.855	0.771	0.808
Physical disability	0.401	0.687	0.555	0.744	0.801	0.725	0.801	0.885	0.771	0.643	0.699
Others	0.659	0.607	0.189	0.730	0.293	0.452	0.293	0.545	0.293	0.225	0.068

Appendix table H6: Miss of work or forgo their income because of long-term illness in the past one year

Miss or forgo income	Frequency (n)	Percentage (%)
Misses work due to illness?		
Yes	834	11.7
No	733	10.3
Don't Know	6	.1
Total	1573	22.0
If so, how many days?		
1 - 2 days	52	0.7
3 - 7 days	225	3.2
1 - 2 weeks	164	2.3
2 - 4 weeks	183	2.6
More than 4 weeks	209	2.9
Don't know	1	0.0
Total	**834**	**11.7**

Appendix table H7: Absent from work in the past two weeks

	Frequency (n)	Percent (%)
If community absent from work in the past two weeks?		
Yes	514	7.2
No	3035	42.5
Don't Know	17	.2
Total	**3566**	**50.0**
Days of absence in the last two weeks		
1 Day	39	0.5
2 Days	141	2.0
3 Days	105	1.5
4 Days	55	0.8
5 Days	51	0.7
6 Days	16	0.2
7 Days	43	0.6
8 Days	5	0.1
10 Days	13	0.2
11 Days	1	0.0
12 Days	17	0.2
14 Days	28	0.4
Total	**514**	**7.2**

Appendix table H8: List of physical illness that has caused absences from work in the past two weeks

Physical illness	Frequency (n)	Percentage (%)
Abdominal/Stomach pain	20	5.6
Allergy	2	0.6
Appendicitis operation	2	0.6
Asthma	9	2.5
Accidental problem/Injury	4	1.1
Back pain	11	3.1
Body pain	33	9.2
Bone decay	1	0.3
Leg infection/pain/injury	9	2.5
Cold/Cold fever/Cold allergy/Cough	34	9.4
Chest Pain	8	2.2
Chikungunya	1	0.3
Cholera	1	0.3
Dental problem	1	0.3
Diabetes	4	1.1
Diarrhoea	4	1.1
Dysentery	5	1.4
Eye/eyesight problem	4	1.1
Excretory Problem	1	0.3
Fainted	1	0.3
Fatigue	3	0.8
Fever/virus fever	90	25.0
Gastric	18	5.0
Pain in knee	1	0.3
Headache	21	5.8
Heart disease/Problem	6	1.7
High/low blood pressure	11	3.1
IBS disease	1	0.3
Jaundice	6	1.7
Kidney problem	5	1.4
Leg infection/pain	9	2.5
Mental Health Problem	1	0.3
Paralysis/Physical disability	4	1.1
Polypus	2	0.6
Pregnancy	1	0.3
Respiratory problem	8	2.2
Skin disease	5	1.4
Surgery	1	0.3
Tonsil	4	1.1
TB	1	0.3
Ulcer	3	0.8
Vomiting	3	0.8
Virus	2	0.6
Virus Fever	1	0.3
Waist pain	6	1.7
Weakness/Sickness/Tiredness	33	9.2
Total	**401*MR**	**111.4**

Appendix I: Photographs (FGDs & KIIs)

Appendix Photograph I1: Conducting FGD in Abudullahpur (male participants)

Appendix Photograph I2: FGD in Mausaid (mixed participants)

Appendix Photograph I3: FGD in Bhadam (mixed participants)

Appendix Photograph I4: FGD in Konabari (female group)

Appendix Photograph I5: FGD in Kashempur (elderly male group)

Appendix Photograph I6: Conducting KII in Abdullahpur (local leader)

Appendix Photograph I7: Conducting KII in Mausaid (user group)

Appendix Photograph I8: Conducting KII in Kashempur (experienced one)

Appendix Photograph I8: KII in Konabari (Local Govt's official)