Evidence of the Effectiveness of Household and Community WASH Interventions











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Executive Summary

Bangladesh is one of the most vulnerable countries in the world to the effects of climate change and variability and potentially will be one of the most adversely affected countries. The impact of climate change in Bangladesh is diverse in nature and affects through a number of complex mechanisms. The Bangladesh National Adaptation Plan of Action (NAPA) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP) projected that the climate change and short term weather variation will increase the climate extreme events such as flooding, drought, storms, sea level raise, cyclones etc. Such events will impact significantly different environmental determinants of health including the water supply and sanitation and hygiene by increasing the rate of non-functionality, inaccessibility, unavailability and bad quality of water. This will cause a greater intensity or spread of different types of water and vector borne infectious diseases with varying degree and magnitude considering the different geographic area of the country

The annual temperature of Bangladesh (between years 1948-2010) has been rising at a rate of 1.2°C per century and has become stronger in recent years with an increasing trend of 2.4°C and the rainfall pattern has became erratic and likely to be increased. This will lead to a favorable condition for disease causing bacteria and viruses depending upon primary climatic parameters and the the geography. The increased warmer and cooler weather condition in the respective seasons are also increasing the mortality and morbidity of heath related diseases as observed in the recent years. The Department of Environment of Bangladesh forecasted a significant impact on human health caused by the impact of climate change, short term weather variability and extremes which included diarrhoea, cholera, skin diseases, kalaazar, malaria, dengue and salinity related diseases. The prevalence of such diseases usually increases during the summer months and are closely interlinked with the quality of consumed water and sanitation facilities.

The method used for the "Evidence of the Effectiveness of Household and Community WASH Interventions" was mainly a ‘desktop review’ of the available documents in Bangladesh and via internet and organizational communication. An extensive literature review was also conducted using the keywords ‘water’, ‘sanitation’, ‘hygiene’, ‘WASH intervention trials’ ‘climate change adaptations’, ‘effectiveness of WASH interventions’ and ‘Bangladesh’, yielding 16 relevant articles. Different policy and strategy documents of health WASH and climate change were communicated and reviewed. It is important to note that there was a scarcity of literature on WASH interventions considering the climate change issues.

The overall findings of review indicated that none of the WASH interventions (hardware and software) have been properly evaluated for its effectiveness interms of functionality, accessibility, availability and quality in Bangladesh following rigorous scientific methods for its climate resilience. Some policy and strategy documents were modified and updated considering the impact of climate change, short term weather variability and climate extreme events. It was also found that no specific research has been conducted into the effectiveness of the WASH strategies in response to climate change, especially their ability to combat climate-related health problems such as the spread of disease, and/or withstand climate

related extreme events and disasters. The most visible evidence of variable effectiveness or ineffectiveness of WASH intervention interms of its functionality, accessibility, quantity and quality was that many of the projects and programmes modified their use of freshwater sources including the technologies due to the short term weather variability and climate extreme events. Some initiatives have been taken to reduce the risk such as promoting rainwater harvesting, raising apron of the water sources and the rising the plinth of the latrine etc.

A combined estimated health effects such as diarrhea have concentrated in most of the studies due to climate change in Bangladesh and showed that the Climate change likely to change the rates of diarrhoeal diseases in the long-term. The Department of Environment found that prevalence of diarrhoea, malnutrition and skin diseases have been increasing from 1995 to 2005. The IEDCR, along with DGHS and CCHPU of MOHFW also found that climate change is likely to increase the rates of diarrhoeal diseases and vector-borne diseases in the long term. A link was found between the climate change impact and non-communicable diseases, such as cardiovascular diseases caused by increased salinity in sources of drinking water. The climate extreme events like flood, drought, storm, etc. have increased mental health concerns. Increased rainfall in Bangladesh had effects on incidence of cholera. The arsenicosis patient's number has also been increasing.

The reasons for the deterioration of the effectiveness of the hardware intervention is mainly because of microbiological contamination of drinking water at source and storage, loss of WASH infrastructure (water supply and sanitation technology) due to climatic extreme events like flood, storm, and tidal surges etc. The heavy draw down of water table increased the non-functionally of water supply interventions and non-functionally enhanced community people's behaviors in WASH usage; increased chemical contaminants in the source water like arsenic, manganese, salinity iron etc.; lack of facilities of hand washing among the poor community people and lack of intentions of hand washing among the economically capable people; access to the WASH infrastructure in hard to reach area etc. The frequency of such deterioration may be regular or irregular therefore, the effectiveness also varied.

It is recommended for further rigorous and systematic scientific research to evaluate the effectiveness of WASH interventions and strategies for building resilience to climate change. It is important to identify the key knowledge gaps and the best possible way for addressing the impact of climate change on WASH interventions and subsequent health problem. It would be useful for setting up future terms of references or strategy for directing research. A combined strategy is required between government departments of health, WASH organizations, disaster management, environment and the non-governmental organization in order to strengthen the effectiveness of household and community WASH interventions in building resilience to climate change.

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Abbreviation

AIRP	Arsenic Iron Removal Plant
BBS	Bangladesh Bureau of Statistics
CSD	Climate Sensitive Disease
DGHS	Directorate of Health Service
DOE	Department of Environment
DPHE	Department of Public Health Engineering
DTW	Deep Tube Well
GLASS	Global Analysis and Assessment of Sanitation and Drinking-Water
ICDDR,B	International Center for Diarrhoeal Diseases Research, Bangladesh
IEDCR	Institute of Epidemiology and Disease Control Research
INGO	International Non Government Organization
JMP	Joint Monitoring Programme
MDG	Millennium Development Goal
MOHFW	Ministry of Health and Family Welfare,
MPO	Master Plan Organization
NAPA	National Adaptation Plan for Action
NGO	Non Government Organization
PSF	Pond Sand Filter
RWH	Rain Water Harvesting
SDP	Sector Development Plan
SST	Sea Surface Temperature
Unicef	United Nations international Children Emergency Fund
V&A	Vulnerability and Adaptation Assessment
VBD	Vector Borne Disease
VRA	Vulnerability Reduction Assessment
WASH	Water Supply, sanitation and hygiene
WHO	World Health Organization

Chapter I
Background

1.1 WASH Interventions in Bangladesh

1.1.1 Intervention Type

The water sanitation and hygiene sector (WASH) of Bangladesh comprises policy/strategy, hardware and software interventions. These interventions are composed of different type of activities as presented in Fig. 1. The government, NGOs, INGOs, research institutions and the private sector implemented and have been implementing WASH sector development activities since the independence of Bangladesh. The sector development plan[1] for the Water and Sanitation Sector in Bangladesh took an extensive participatory and analytical approach at the national and local levels to provide a framework for planning, implementing, coordinating and monitoring of all these activities. The most pertinent element of the water supply and sanitation sector development plan is the presentation of the progressive development of water supply and sanitation services in conformity with global analysis and assessment of sanitation and drinking-water (GLASS) and the the Joint Monitoring Program (JMP).

1.1.2 Water Supply Sanitation and Hygiene Situation

Bangladesh has achieved significant success in increasing the coverage in water supply in past three decades primarily due to the abundance of suitable ground water aquifers at shallow depth. Presently ground water is the principal source of drinking, cooking, industrial and irrigation water to the people of the country. The national water supply coverage in Bangladesh with improved water[2] is more than 95%. Since 1990 about 38 million new people gained access to improved water supply sources. The sanitation

[1] *Water Supply and Sanitation Sector in Bangladesh (2011): Sector Development Plan (2011-25) Local Government Division, Ministry of Local Government, Rural Cooperation and Development, Government of the People's Republic of Bangladesh.*
[2] *JMP (2014): Progress on Drinking Water and Sanitation, WHO, Unicef*

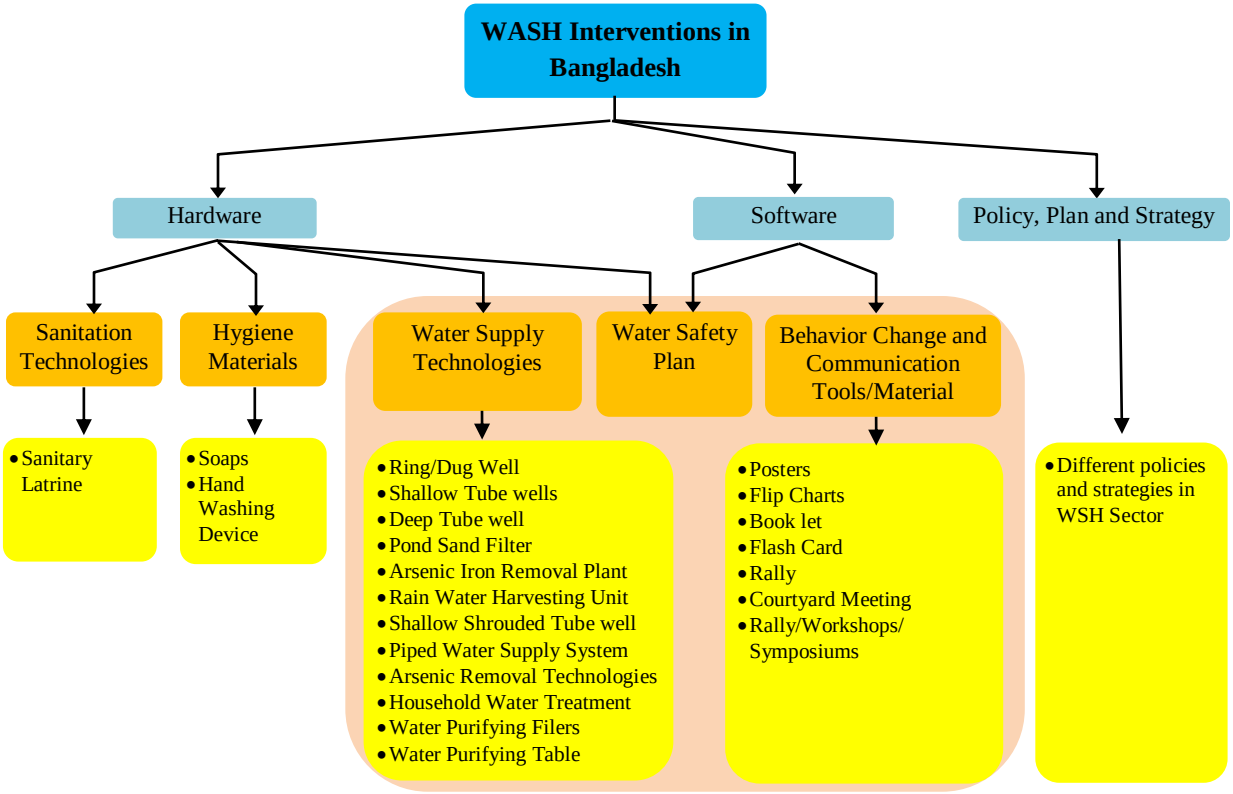


Fig.1: Water supply and sanitation interventions in Bangladesh

coverage with improved latrine was 54 % by population (WHO-Unicef, JMP-2010) which was increased to 57% in 2014 (WHO-Unicef, JMP-2014). Bangladesh is in track for achieving the MDG targets. But challenges remained like sustainability and continuation of collective hygienic behavior by the entire community, arsenic contamination of the shallow aquifer, urban water and sanitation service, especially for the growing low income community including the slum dwellers, fecal contamination of drinking water, presence of other health significant chemical constituents in ground water, climate extreme events etc. A concrete and demand responsive effort can address the challenges in a sustainable manner.

Table 1: National water supply and sanitation coverage form different document

Source of Information	Water Supply		Sanitary Latrine	
	Improved (%)	Unimproved /Basic (%)	Improved (%)	Unimproved /Basic (%)
Sector Development Plan of Bangladesh (SDP) (2011)	50	74	51.5	80.4
Joint Monitoring Programme (JMP, 2014)	85	15	57	43

Apart from the above mentioned indicators of coverage the Bangladesh Bureau of Statistics presented the national water supply situation by three indicators namely proportion of people using tap, tube well and other water devices and sanitation by four indicators namely proportion of peoples having water-sealed, no water-sealed, non-sanitary latrine and no sanitary latrine facilities. The division wise findings are presented in Table 2.

Table 2: The division wise status of water supply and sanitation facilities in Bangladesh (Census 2011)[3]

No	Division	Population	Household	Tap (%)	Tube Well (%)	Other Water Devices (%)	Toilet (Sanitary water-sealed) (%)	Toilet (Sanitary non water-sealed) (%)	Toilet (Non-sanitary) (%)	No Toilet (%)
1	Barisal	8325666	1862841	1.5	91.4	7	26.3	48	23	2.8
2	Chittagong	28423019	5626310	9.3	82.4	8.3	21.2	49.1	25.2	4.5
3	Dhaka	47424418	10849315	24.6	72	3.4	28.3	42.3	24.2	5.2
4	Khulna	15687759	3739779	2.8	88.6	8.6	28.9	34.6	32.2	4.3
5	Rajshahi	18484858	4486829	3.9	92.3	3.9	24.4	32	32	11.6
6	Rangpur	15787758	3817664	6.7	90.6	2.8	20.6	23.4	35.8	20.3
7	Sylhet	9910219	1790892	5.7	77.4	16.8	16.1	33.2	42.2	8.5
8	National	144043697	32173630	7.8	85.0	7.3	23.7	37.5	30.7	8.2

A national survey conducted by Department of Public Health Engineering found that 42 % of households had no definitive place for defecation and the 58% who had such access and among these only 33% points had hygienic toilet facilities, while for 25% lived in unsanitary condition. Thus, 67% of households had either no toilet or access to a poor-quality toilet. The percentage having hygienic toilets was higher in urban areas (51%) than in rural areas (29%), where 47% had no toilet facility whatsoever. The lack of money was given as the most important reason for not having a toilet facility (77%), while lack of space (11%) and lack of awareness were cited as other major reasons.

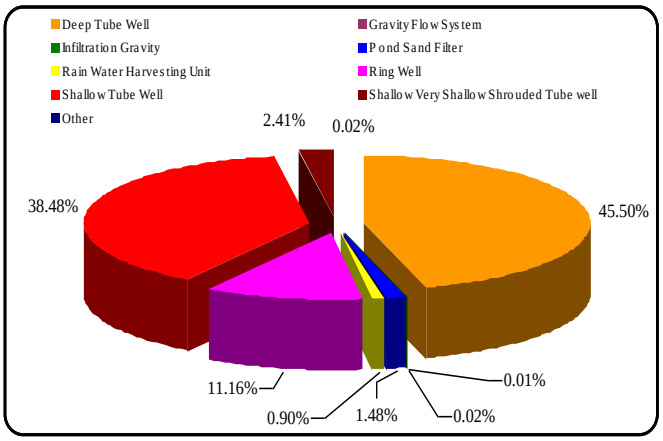


Fig. 2: Distribution of public water points of different types installed in rural area of Bangladesh

The Department of Public Health Engineering identified approximately 0.15 million public water points of different types installed from 2007 under different projects and programmes in rural areas under the initiative "Nation Wide Water Point Mapping Initiative" jointly conducted with UNICEF. The findings indicated that 0.9% used the rainwater, 1.5% used the surface water, 13.6% used the sub surface ground water, 38.5% used shallow ground water and 45.5% used the deep ground water as the source water. The technology wise distribution of the public water points is presented in Fig. 2. It was found from different assessment reports that approximately 200 pipe line water supply systems existed in the rural area and approximately 150 existed in the Pourashava/City corporation area.[4]

A national hygiene baseline survey was conducted[5] by Water Aid Bangladesh, ICDDR,B and Policy Support Unit (PSU) of local government division in 2014. The findings of the survey illustrated that among the households, a location near the toilet the post-defecation hand washing was detected for more

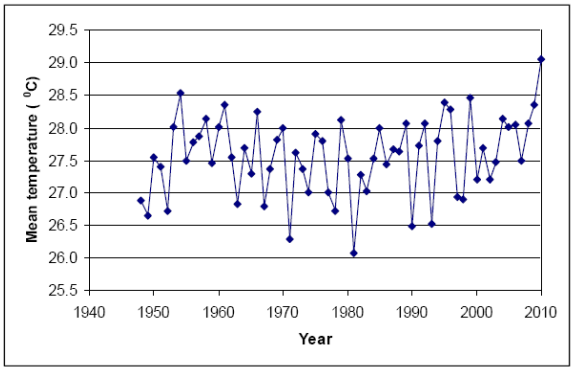
[3] *BBS (2011): National Population Census (2011)*
[4] *Kabir 2008, DPHE, JICA , Unicef 44 additional rutal piped water supply system, BWRSSP*
[5] *Bangladesh National Hygiene Baseline Survey (June 2014): International Centre for Diarrheal Disease Research, Bangladesh (ICDDRB), Water Aid Bangladesh and Policy Support Unit (PSU), Local Government Division, Ministry of Local Government, Rural Development and Co-operatives, Dhaka, Bangladesh*

than two-thirds of the households and only 40% of those had water and soap available. It was found during hand washing demonstration that 13% of children (3 to 5 years of age) and 57% of mothers/female caregivers washed both hands with soap. Among other WASH facilities approximately half of the households had an improved toilet, 34% had clean improved toilets, 99% had an improved water sources, <25% of the water points were clean and only 2% had no access to a toilet.

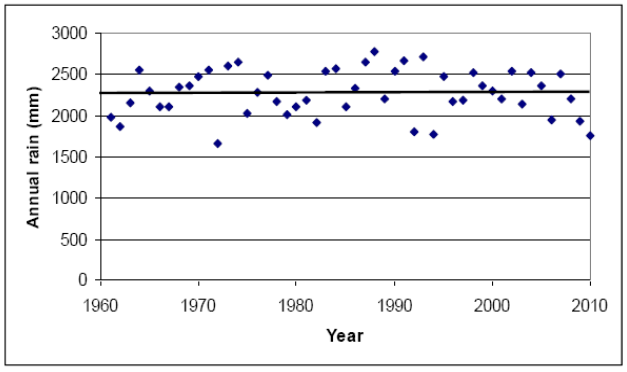
An improved functional drinking water source existed in 80% of the schools of which 41% appeared clean. In 35% of the schools the hand washing location with water and soap was found. Majority of the schools (84%) had a functional improved toilet for students with a limited access because one toilet is for 187 students. Approximately one-third of all schools had water and soap available inside or near (<30 feet) the improved toilet accessed by students and a quarter of toilets were clean. Menstrual hygiene management remained a challenge, especially in schools. Among menstruating girls and women, old cloth was the predominant menstruation management material (82-86%) among which 12% of school girls, 23% of girls at home and 27% of women washed cloth appropriately. Forty percent of surveyed girls reported that they miss school during menstruation for a median of 3 days a month.

1.1.3 Short Term Weather Variation and Climate Extreme Events

Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures and humidity. In general, maximum summer temperature ranges between 30°C and 40°C. April is the warmest month in most parts of the country and January is the coldest month, when the average temperature for most of the country is about 10°C. The annual temperature of Bangladesh (between years 1948-2010) has been rising at a rate of 1.2°C per century[6] and has been becoming stronger in recent years with an increasing trend of 2.4°C. The winter (Dec-Feb), pre-monsoon (Mar-May),



Time series of all-Bangladesh annual mean temperatures



All-Bangladesh annual rainfall time series (1961-2010)

Fig. 3: The trend of annual temperature and rainfall

monsoon (Jun-Sep) and post-monsoon (Oct-Nov) trends in recent temperatures are found to be 1.2°C, 3.2°C, 2.7°C and 1.5°C per century, respectively. The pre-monsoon, monsoon and winter trends have become stronger and the post-monsoon trend weaker in recent times. There were no significant changes in

[6] *Institute of Water and Flood Management, Bangladesh University of Engineering & Technology February 2012. Spatial and Temporal Distribution of Temperature, Rainfall, Sunshine and Humidity in Context of Crop Agriculture, Comprehensive Disaster Management Programme, Ministry of Food and Disaster Management, Government of the People's Republic of Bangladesh.*

the average annual rainfall yet, but notable changes observed in the regional annual rainfall pattern within the country. The trend of annual temperature and rainfall found from the study is presented in Fig. 3. The rainfalls in south-central and south-east regions are decreasing significantly and the annual rainfalls in the far north-west and south-west regions are found to be increasing at 90% level of confidence. The seasonal rainfalls at country level are also found to be free of trend except for the pre-monsoon season, when it has significant increasing trend. Rainfall in the post-monsoon season has also increased though not statistically significant. The inter-annual variability of rainfalls in most months has increased and indicated for uncertainty and unpredictability of rainfall.

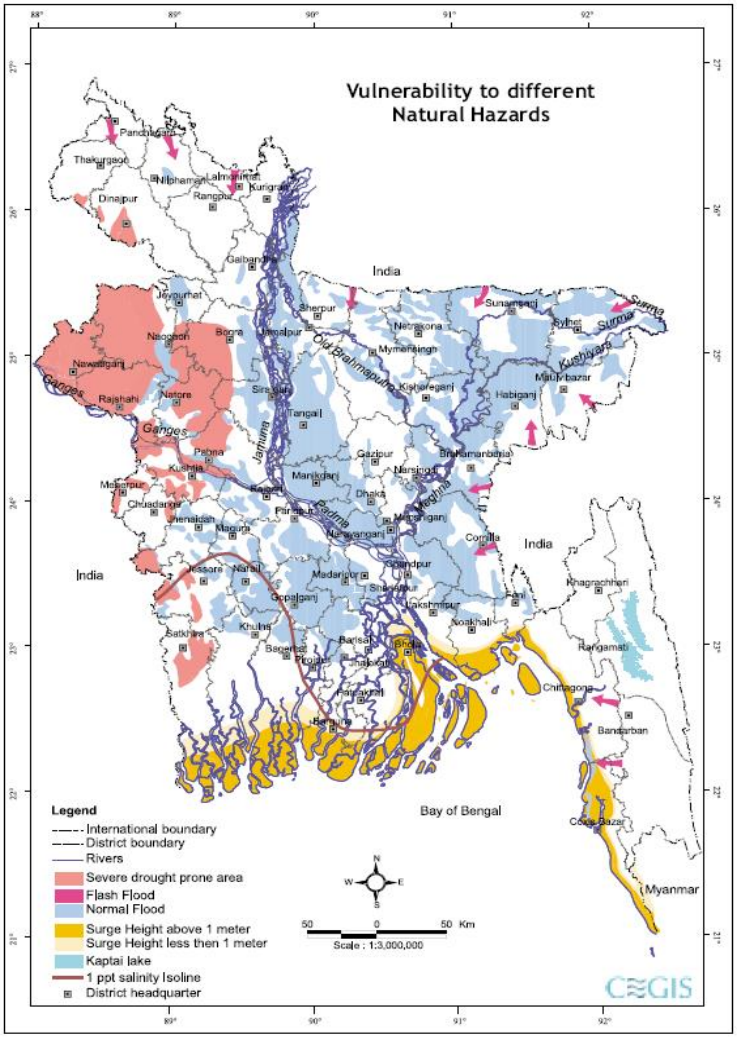


Fig 4: Areas affected by different types of climate-related disasters, source: CEGIS, Dhaka

Bangladesh is one of the most vulnerable countries in the world to the impacts of climate change and potentially will be one of the most adversely affected countries. The effects of climate change are expected to be uneven and the poorest people of the country are most vulnerable to the negative impacts of climate change.[7] The impact of climate change on Bangladesh is diverse in nature and affects through a number of complex mechanisms. Bangladesh's National Adaptation Programme of Action (2006) on climate change and Bangladesh Climate Change Strategy and Action Plan (2008) projected that the climate change will cause a greater intensity or spread of different types of diseases (water and vector borne) through different types of of extreme events. Increases of temperature, humidity, erratic rainfall, sea level rise and unpredictable extreme events such as flooding, cyclones, droughts, surges and storms etc. could impact the water supply and sanitation sector by creating water stress, water quality deterioration, saline intrusion and damaging water supply and sanitation infrastructure. According to the Fourth Assessment Report of the International Panel on Climate Change,[8] the world's temperature is expected to rise between

[7] *Kabir, I. et al., 2012. Climate change and health: Bangladesh, Adaptation Strategy Report, s.l.: s.n.*
[8] *IPCC, 2007. Fourth Assessment Report of the International Panel on Climate Change, Cambridge, UK: Cambridge University Press.*

1.1 °C and 6.4 °C over the next century. Sea levels are projected to rise by 18-59 cm. More frequent heat waves, erratic rainfall, tropical cyclones, extreme high tides and floods are also projected.[9]. Based on the experiences and future prediction a vulnerability map was prepared for Bangladesh and is presented in Fig. 4[10] and extent of devastation of the climate extreme events is presented in Box 1.

BOX 1: Climate Extreme Events[11]

Flood: Flood is a recurring phenomenon in Bangladesh. Across most models the flooded area is estimated to increase for most of the flood season due to climate change. By applying future flooding scenarios for Bangladesh using the Master Plan Organization (MPO) flood depth classification, it is estimated that the flooded areas will increase by 6% (2030s) and 14% (2050s).Flooding and other events are likely to increase. In the most extreme scenarios, a 2°C rise in global mean temperature could result in the average flood discharge for the Ganges, Brahmaputra, and Meghna Rivers being as much as 15, 6, and 19% higher, respectively.[12]

The World Bank's Country Environmental Analysis estimates that environmental factors account for as much as 22% of the nation burden of diseases, with diarrhoeal diseases a major contributor.[13]

Drought: The Global Water Availability Assessment (GWAVA) model has been used to identify water availability including changes in distribution for two scenario years, 2025 and 2050, respectively.

The model results indicated that compared to the baseline condition, the western parts of Bangladesh will be at greater risk of drought during two periods, the months of January–May and June–October. Drought severity will increase with increasing temperatures.

Cyclone and storms: Another study showed that by 2050, cyclones and storm surge affected areas will increase from 20,876 sq km at

present to 23,764 sq km as a consequence of climate change and sea level rise. Currently about 8.7 million people live in cyclone High Risk Areas (HRAs). This may increase to 33.67 million (without climate change) and 38.33 million (with climate change) in the 2050s.

Sea level rise: The Intergovernmental Panel on Climate Change (IPCC) estimates that by 2050, 17 % of Bangladesh will have been claimed by rising seas, forcing 20 million people to relocate (Pervin, 2013).'It is predicted that the lives and livelihood of 36m people in the southern coastal regions are directly affected by climate change. If the seawater rises further by about one meter, most of the coastal belt will go under water (Kabir, et al., 2012).[14]

1.1.4 Vulnerabilities of WASH Intervention

Globally, the climate change will not change the basic nature of threats to water supply and sanitation technologies, but is likely to change the severity and magnitude of those threats.[15] Bangladesh is a country already prone to natural disasters, climate change will therefore, threatens to undermine many of the gains

[9] *Cracknell, A. & Varotsos, C., 2007. The IPCC Fourth Assessment Report and the fiftieth anniversary of Sputnik. Environ Sci Pollut Res Int, 14(6), pp. 384-387*

[10] *Ministry of Environment and Forest, 2005. National Adaptation Programme of Action (NAPA), Dhaka, Bangladesh: The People's Government of Bangladesh.*

[11] *Photograph Courtesy: Internet*

[12] *IPCC, 2001. Working Group II: Impacts, Adaptation and Vulnerability. [Online] Available at: http://www.ipcc.ch/ipccreports/tar/wg2 index.php?idp =171 [Accessed 25 November 2014].*

[13] *IMF, 2013. Bangladesh: Poverty Reduction Strategy Paper, Washington, D.C.: International Monetary Fund.*

[14] *Kabir, I. et al., 2012. Climate change and health: Bangladesh, Adaptation Strategy Report, s.l.: s.n.*

[15] *Calow, R. et al., 2011. Climate change, water resources and WASH: A scoping study, London: Overseas Development Institute.*

made in developing regions with regards to WASH-related Millennium Development Goals (MDGs).[16] The type, magnitude and frequency of the impact is basically depends on the geographical area of the country namely coastal, flood, drought, hilly and low lying area. The community people's vulnerability in those geographical areas further varies considering the poverty, education, life style, adaptive capacity etc. The WASH interventions are also interlinked e.g., the loss of water supply and sanitation infrastructure due to climate extreme events or short term weather variation will be resulted in the decreases of the water supply and sanitation coverage and will increase the use of unsafe water and bad sanitary practice. It will also impact on the hygiene behavior of the people due to lack and bad quality water. However, the ultimate impact of the depleted WASH interventions to the community people due to the impact of climate change and short term weather variation and the causal relationship between the climate change and water supply and sanitation was established and presented in Fig. 5.[17]

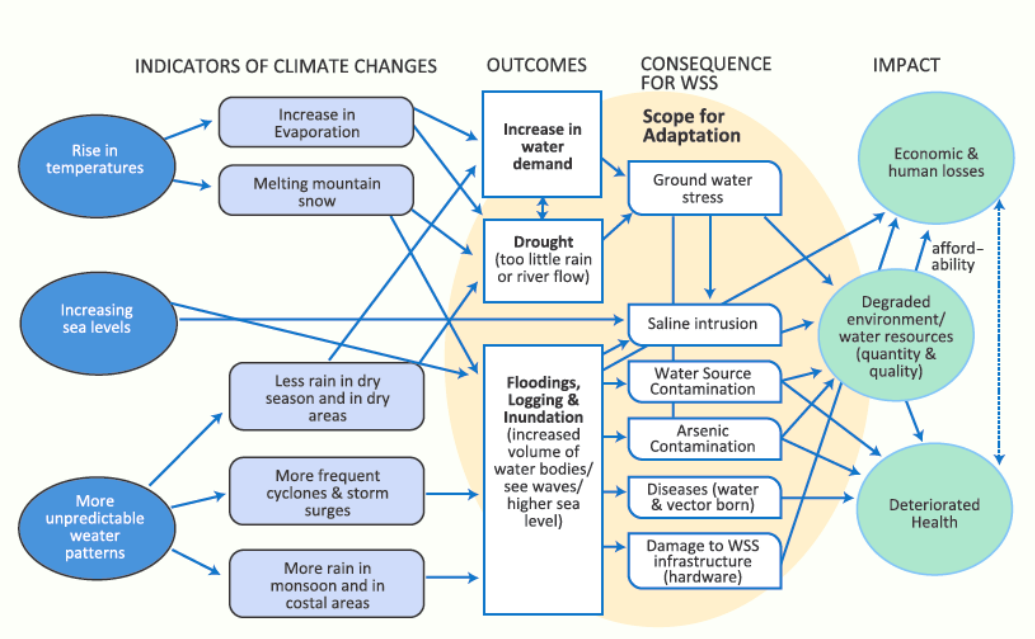


Fig. 5: The cause and effect diagram of climate change with water supply and sanitation and impact on human life

Considering the causal relationship of impact of climate change and short term weather variation on water supply and sanitation, the dimensions of the WASH vulnerabilities can be explained interms of four factors namely functionality, access, availability and quality which impacts hardware, software and management intervention's effectiveness as well as the policy and strategy. The frequent occurrence of climate extreme events like floods, droughts, cyclones, storms, tidal surges and sea level raise etc. depending upon the geographical location the above mentioned WASH factors became more influenced and ultimately depleted the long term achievements as well as the MDG targets. Eventually, it will also lead to the deterioration of the livelihood through economic loss and health disruption. A matrix of different factors which influences the effectiveness of WASH is presented in schematic Fig. 6.

[16] *Rutherford, S., Islam, Z. & Chu, C., 2014. Piloting of Vulnerability Reduction Assessment Tool in Bangladesh, Griffith University: Center for Environment and Population Health*

[17] *Sector Development Plan FY 2011-25 (November 2011), Policy Support Unit, Local Government Division, Ministry of Local Government, Rural Development and Cooperatives, Peoples Republic of Bangladesh*

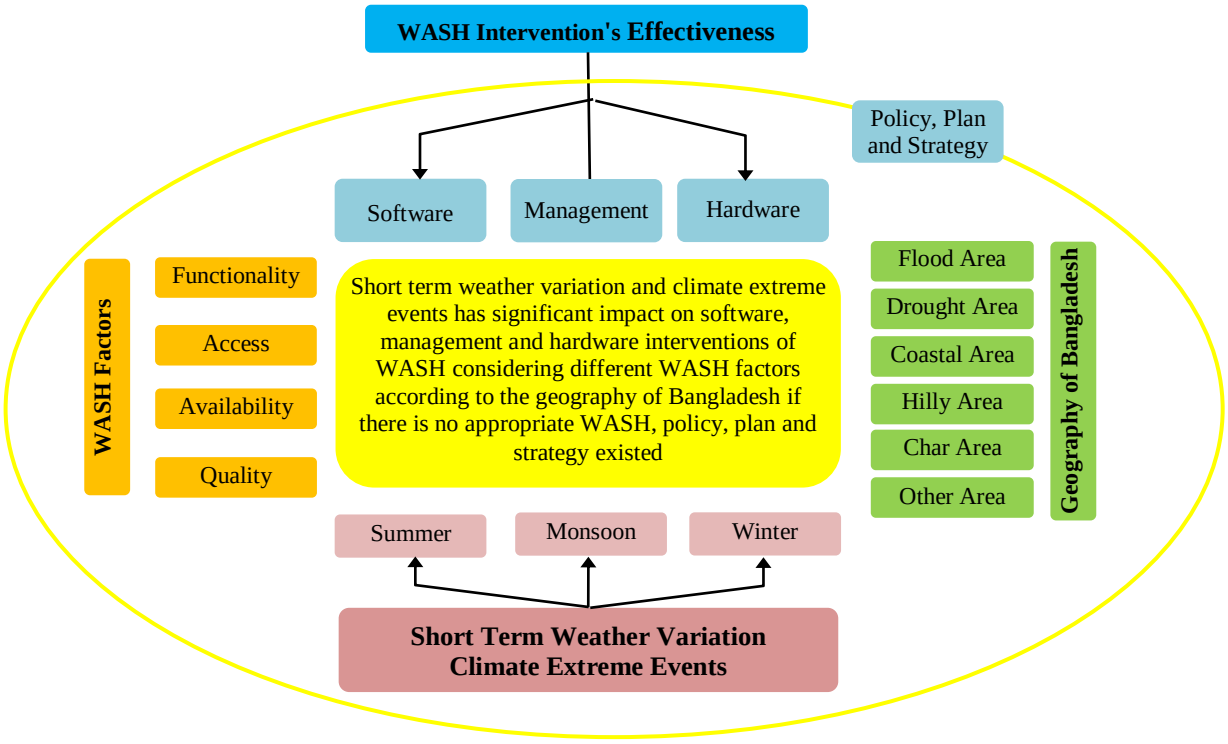


Fig. 6: Schematic diagram of different factors those influences the effectiveness of WASH

The water quality is one of the most dominating factors in relation to the effectiveness of the safe water supply as well as the health concern. The contents of the constituents of the surface, ground and rainwater naturally differs but due to the short term weather variability and climate extreme events the composition of the constituents changes. The surface water quality usually deteriorated during the floods and droughts due to the effects of the temperature rainfall and evaporation. These impacts depend on natural or man built environment and the consequences can be different according to water body type (rivers, lakes, dams, ponds, wetlands) and characteristics (water residence times, size, shape, and depth). For streams, the main parameters affected are dissolved organic matter (dissolved organic carbon, dissolved organic nitrogen etc.), nutrient contents, pathogens and cyanobacteria/cyanotoxins are more related to lakes.

The quality of the ground water was deteriorated by a number of naturally occurring chemicals. Some of these were aesthetic namely, iron, salinity, odor, color and taste and some were health significant namely arsenic and manganese. The arsenic was detected in the ground water in early 90s and millions of peoples were exposed to the contamination. Recent information provided by UNICEF in 2008 that there were approximately 8.6 million tube-wells in Bangladesh of which 4.75 million tube wells (55%) have been tested for arsenic. Among these tested tube wells 39% were arsenic safe and 16% were unsafe due to the high arsenic level over the Bangladesh standard of 0.05 mg/l.[18]A recent cross sectional illustrated that exposure to manganese at levels common in groundwater of Bangladesh is associated with intellectual

[18] *UNICEF Arsenic Primer (2008): © United Nations Children's Fund (UNICEF), New York, UNICEF, 3 UN Plaza, New York, NY 10017*

impairment in children.[19] There was significant role of iron, manganese and sulphate bacteria in the process of formation of deposits in water pipes. Iron binding bacteria impart metallic smell and tart taste when occur in large amounts in water. The iron and manganese binding bacteria change the turbidity and color of water.[20] The coastal areas of Bangladesh have been facing saline intrusion and fresh water scarcity during the dry season. The iso-saline lines of 1, 5 and 15 ppt have been projected to penetrate northward (i.e., inland) for the year 2050. Consequently, brackish water area could increase and continue to do so by up to 7% from 2005 to 2050. As a result, an additional 7.6 million people could be exposed to high salinity (>5 ppt).

The microbiological quality of the drinking water of different technologies found to be varied considering the system, time and geography. A recent study in that Dhaka city area indicated[21] that the municipal tap water was contaminated with a number of enteric bacteria such as *E. coli.* It need to be noted that the micro-organisms associated in drinking water of Dhaka city area was comprised of Escherichia coli (60%), Klebsiella (40%), Enterobacteria (20%), Pseudomonas (70%), Proteus (10%), Staphylococcus (40%) and Salmonella (0%). The systematic analysis of fecal contamination of shallow aquifers[22] with 125 tube wells of 6−36 m deep tube wells showed that on any given month, *E. coli* was detected at levels exceeding 1 most probable number per 100 ml in 19−64% of all shallow tube wells, with a higher proportion typically following periods of heavy rainfall. The author also mentioned that the frequency of *E. coli* detection averaged over a year was found to increase with population surrounding a well and decrease with the As content of a well, most likely because of downward transport of *E. coli* associated with local recharge. Another assessment showed that the bacteriological quality of alternative drinking water supply options in southwest coastal areas of Bangladesh consisting of household based rainwater harvesting systems (RWH), community based rain water harvesting systems (CBRWHS), pond-sand filters (PSF) and ponds showed varying degrees of E. Coli contamination. The median E. coli concentrations measured for RWH, CBRWHS, PSF, and ponds were 16, 7, 11, and 488 cfu/100 ml during the wet season, respectively. A maximum pH of 10.4 was found in CBRWHS. Estimation of the disease burden for all options in disability adjusted life years (DALYs) showed an increased disease burden during the wet season.

The non-functionality and deteriorated water quality of different technologies installed in different parts of the country have significant impact on access, availability of water round the year presumably the effectiveness of the WASH technologies varied and vulnerabilities increased . The challenge before Bangladesh is to build resilience and capacity to cope with changing climatic conditions in relation to WASH interventions, education and capacity building at the community and household level.

[19] *Bouchard et al (January, 2011): Intellectual Impairment in School-Age Children Exposed to Manganese from Drinking Water, Environmental Health Perspectives, volume 119 | number 1*

[20] *Adam Postawa and Colin Hayes (Aug 2013): Best Practice Guide on the Control of Iron and Manganese in Water Supply, ISBN13: 9781780400044 , eISBN: 9781780400747*

[21] *Housne Ara Begum et all (2014): Bacteriological Safety Assessment of Municipal Tap Water and Quality of Bottle Water in Dhaka City: Health Hazard Analysis Bangladesh, J Med Microbiol 2010; 04 (01): 9-13,. Bangladesh Society of Medical Microbiologist*

[22] *Alexander van Geenn et. all (2011): Fecal Contamination of Shallow Tube wells in Bangladesh Inversely Related to Arsenic, Environ Sci Technol. 2011 Feb 15; 45(4): 1199–1205. Published online 2011 Jan 12. doi: 10.1021/es103192b. PMCID: PMC3037737*

1.2 Health Vulnerabilities

Water is predicted to be the primary medium through which people, ecosystems and economies will feel the early effects of climate change, with freshwater sources projected to be significantly impacted.[23] Bangladesh's low economic strength, inadequate infrastructure, low level of social development, lack of institutional capacity, and a higher dependency on the natural resource has made the country more vulnerable to climate stimuli (including both variability as well as extreme events).[24] It is expected that the communities will face challenges to maintain good health as climate change will exacerbate the magnitude and distribution of many environmental determinants of health risks.[25] Therefore, the effects on water will mean a significant impact on health, through increases in climatic disasters and increases in communicable and non-communicable diseases despite the evidence of the cost-effectiveness of pre-emptive disaster risk management. Many countries failed to prioritize WASH investments as a means of increasing resilience.

Water, sanitation and hygiene (WASH) have significant impact on human health and, of particular concern as described in the recent Intergovernmental Panel on Climate Change Special Report on Extreme Events, are the risks of more frequent and intense extreme weather events such as floods, cyclones and droughts, alongside increasing temperatures. Such extremes pose particular challenges to the capacity of WASH programmes to protect health, and there is accumulating evidence that climate change has been worsening these risks.[26] The bacteria, parasites and disease vectors breed faster in warmer, wetter conditions and where there is poor draining and sanitation system, the conditions caused by climate change are likely to increase the occurrence and spread of disease. In Bangladesh 90% cases of diseases (dysentery, typhoid, cholera and diarrhea) have been reported due to the water borne microorganisms. Due to climate change, maximum daily temperatures are expected to increase while rainfall patterns are also likely to change which may increase (or change) depending on locations where conditions favorable for disease causing bacteria and viruses exist. The chemical constituents of ground water have also been increasing the health vulnerabilities. The recent findings showed that about 20 million people in Bangladesh has been using tube-wells contaminated with arsenic over the permissible level (>50 ppb).

One of the major concerns of the drinking water quality in coastal area of Bangladesh was the salinity. Generally the population of coastal area collects water from different source namely rivers, tube well (groundwater) and ponds for different purposes use including the drinking and cooking. Approximately 20 million people living along the coast are affected by varying degrees of salinity in drinking water[27] (>4 ppt) obtained from various natural sources. The high level salt in drinking water has been becoming a public health concern in the area.[28] Hypertension in pregnancy was associated with increased rates of

[23] *Calow, R. et al., 2011. Climate change, water resources and WASH: A scoping study, London: Overseas Development Institute.*
[24] *Ministry of Environment and Forest, 2005. National Adaptation Programme of Action (NAPA), Dhaka, Bangladesh: The People's Government of Bangladesh.*
[25] *Kabir, I. et al., 2012. Climate change and health: Bangladesh, Adaptation Strategy Report, s.l.: s.n.*
[26] *Rutherford, S., Islam, M. & Chu, C., 2013. Review of relevant policies/strategies, plans and programmes relating to health and climate change in Bangladesh, Dhaka, Bangladesh: World Health Organisation.*
[27] Rahman AA, Ravenscroft P. Bangladesh (2003): Groundwater Resources and Development in Bangladesh, 2nd Edn, Centre for Advanced Studies, University Press Ltd;
[28] *Aneire Ehmar Khan et all (Ssep 201): Drinking Water Salinity and Maternal Health in Coastal Bangladesh: Implications of Climate Change, Environ Health Perspective, 119(9): 1328–1332, PMCID: PMC3230389, Published online 2011 Apr 12. doi: 10.1289/ehp.1002804*

adverse maternal and fetal outcomes, both acute and long term, including impaired liver function, low platelet count, intrauterine growth retardation, preterm birth, and maternal and peri-natal deaths[29] (The adverse outcomes were substantially increased in women who develop superimposed (pre) eclampsia.

Water, sanitation and hygiene (WASH) issues are important in influencing the diarrhea and other gastro-enteric diseases. Tremendous efforts was paid by different government and non-government organization as well as the development partners in recent decades through providing significant numbers of hardware and software interventions all over the country which reduced the mortality and the morbidity among peoples from water borne, water washed, water based and water related diseases as observed in the recent decades. The trend of mortality and morbidity of one of the most common WASH related disease diarrhoea is presented in Fig. 7.

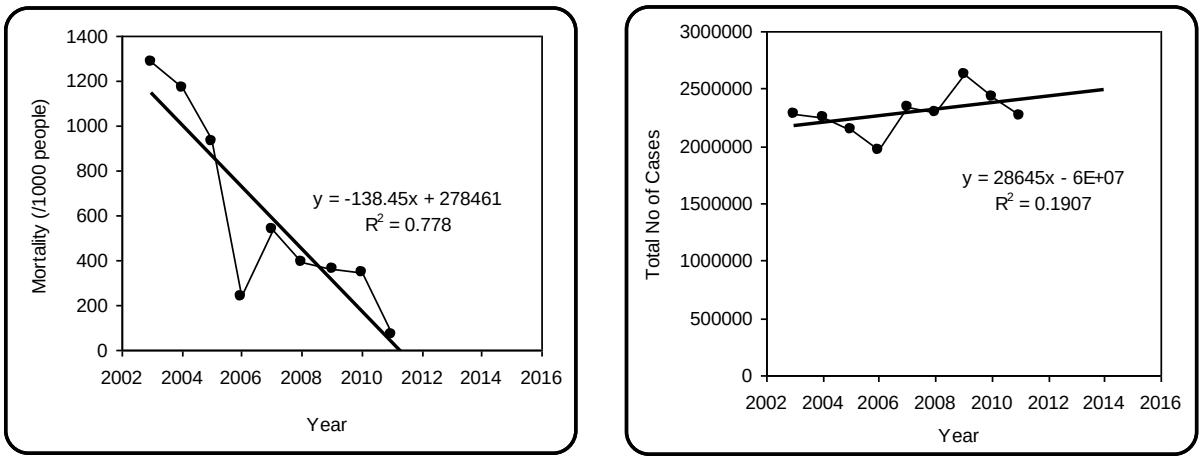


Fig. 7: National Trends of diarrhoeal mortality and morbidity in between 2003 to 2011
(Source Health Bulletin 2012, DGHS Communicable disease)

The Department of Environment of Bangladesh recently forecasted a significant impact on human health caused by the climate change induced spread of infectious diseases, such as diarrhoea, skin diseases, kalaazar and salinity related diseases.[30] The prevalence of waterborne diseases such as diarrhoea, cholera, and dysentery usually increases during the summer months and are closely interlinked with quality of water supply and sanitation facilities. The initial national communication[31] also showed that disease like diarrhoea, skin diseases, asthma, hypertension, malaria and dengue have higher incidence in the recent years. The increased warmer and cooler weather condition in the respective seasons are also increasing the mortality and morbidity of heath related diseases as found in the recent years.

The drinking water sources and sanitation facilities are markedly different in urban and rural households. Poor sanitation facilities are identified as a key determinant of disease incidence in urban but not in rural areas. During the pre-monsoon season in urban areas, a child living in a household with unsanitary toilet

[29] *Sibai BM. (2002): Chronic hypertension in pregnancy, Obstet Gynecol. 100:369–377*
[30] *Climate Change Cell, 2009. Climate Change and Health Impacts in Bangladesh, Dhaka, Bangladesh: Ministry of Environment and Forest.*
[31] *Secretary Ministry of Environment of Forest, Peoples Republic of Bangladesh (2002): Initial National Communication Under the United Nations Framework Convention on Climate Change, Bangladesh Secretariat , Dhaka*

facilities (slab, pit, or open latrine) is two times as likely as a child living in a household with access to a flush toilet (septic sink) to experience an episode of ARI and nearly three times as likely if living in a household with no toilet, holding all other factors constant. The localized nature of health risks and population vulnerability elevates the importance of community engagement in identifying risks and proposing locally appropriate solutions. Fresh water risk due to increased salinity is 80% and estimated health risk for salinity is 61%. Reduction of crop production due to salinity is 61% likely. Among the vulnerable population 97.8% people think their health care expenditure increased after extreme event. Some of the climate sensitive diseases (CSD) are discussed in the following.

1.2.1 Diarrhoea

Diarrhoea is one of the major causes of mortality and morbidity in Bangladesh particularly of children. The disease is associated with the use of unsafe water and poor sanitation coupled with poor food handling practices and bottle-feeding of infants during the first few months of life. The main cause of death from acute diarrhoea is the dehydration resulting from loss of fluids and electrolytes. Several microorganisms cause the disease, but the major ones among them are *Shigella*, *E. coli* and *rotavirus*. *Rotavirus* remains the leading cause of childhood diarrhoea worldwide. A study[32] found significant positive association between the number of hospital visits for rotavirus diarrhoea and temperature above a threshold. The risk increased as the temperature increased above 28°C - 29°C and for 1°C increase above the threshold, the number of *rotavirus* diarrhoeal cases increased by 40·2%. According to the World Health Organization (WHO), climate change is projected to increase the burden of diarrhoeal diseases in low income regions by approximately 2% to 5% by 2020. The precipitation may increase in the future due to climate change, which may result in more area being flooded. The flood-related diarrhoeal disease cases and the number of death due to diarrhoea in Bangladesh have increased in recent years as found by the Department of Environment (2008). It was also mentioned that the central, eastern and southern parts of Bangladesh will be highly vulnerable to diarrhoeal incidence due to climate change. The availability of safe drinking water supply was especially poor for coastal communities, as fresh groundwater is only available at great depths. Inadequate access to safe water contributes to a high incidence of diarrhoeal diseases pre-monsoon diarrhoea outbreaks are common in the coastal belt.

1.2.2 Cholera

In Bangladesh, cholera outbreaks mostly occur in January-March, during the period of low river flow. The low river flow allows seawater from the Bay of Bengal to move inland, transporting bacteria-carrying plankton. A second epidemic occurs in September and October, after monsoon rains have raised water levels. Cholera, an acute water-borne diarrhoeal disease caused by the bacterium *Vibrio cholerae*, has reemerged as a global killer in recent decades. It lives and thrives among the phytoplankton and zooplankton in brackish estuaries where rivers come into contact with the sea. It has been found that the blue-green algae provide *Vibrio cholerae with* the favorable environment in which it resides when there is no major outbreak of cholera. This has serious implications in terms of adaptation because the issue of blue green algae is important in reducing the application of nitrogenous fertilizer which causes major

[32] *Hashizume, M. et al., 2008. The effect of rainfall of the incidence of cholera in Bangladesh. Epidemiology, 19(1), pp. 103-110.*

release of nitrous oxide, an extremely potent greenhouse gas. Again it has been found that adaptation may be quite complex as trade-offs with other necessary interventions may exist. Cholera epidemics in Bangladesh have been historically linked to a range of environmental and climate variables including precipitation[33,34], floods[35], peak river level[36], sea surface temperature (SST)[37,38] , sea surface height[35] coastal salinity[24] and fecal contamination[39] (Islam et al., 2006). Cholera incidence is highly influenced by flooded area, salinity intrusion and sea surface temperature. Climate change related impacts on these three factors could increase the incidence of cholera. A Recent research also projected that the regions of Bangladesh where cholera is merely a seasonal disease could be associated with cholera in all months of the year due to climate change.

1.2.3 Vector Borne Diseases (VBDs)

The Bangladesh government in the 2008 prepared the Climate Change Strategy and Action Plan which highlighted the importance of addressing the emerging public health risks associated with three vector borne diseases namely malaria, dengue, and kala-azar. Malaria, dengue, and kala-azar are all transmitted between human hosts by vectors. The effect of climate variability on the incidence and case load of VBDs is mediated through its impact on each component of the transmission cycle of different pathogens. *Malaria* is one the most common vector-borne diseases in tropical regions and pathogens are protozoan are transmitted to humans by the anopheles mosquito. Anopheles mosquitoes tend to prefer a temperature ranging from 24°C to 27°C. If the overall temperature rises, their habitat may be reduced, and the breeding period may be shifted and prolonged, leading to a possible change in malaria distribution in Bangladesh. *Dengue fever* is transmitted by Aedes aegypti, a type of mosquito that feeds primarily on humans and thrives especially in urban environments where still water and plant containers are abundant. The intensity of dengue vectors is determined mainly by the availability of breeding sites such as water containers. Several studies have shown that dengue incidence was positively associated with rainfall and could facilitate the spread and transmission of the diseases by expanding breeding sites. Heavy rainfall contributed to inland water bodies and flooding almost every year in Bangladesh created a suitable environment for the vector. *Kala-azar* is caused by the female sand fly Phlebotomus argentipes on the Indian subcontinent, including Bangladesh. The disease is lethal if left untreated and affects approximately 500,000 new patients annually worldwide, with 60% of new cases on the Indian subcontinent. Climate adaptation measures (for example, building more embankments in response to sea-level rise) may be conducive to the spread of visceral leishmaniasis vectors, increasing the number of cases of kala-azar. Kala-azar cases in Bangladesh are found to be clustered near flood control embankments.

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[33] *Pascual, et. al., (2008): Predictability of endemic cholera: the role of climate variability and disease dynamics. Climate Research 36:131–140*

[34] *Hashizume, M. et al., 2008. The effect of rainfall of the incidence of cholera in Bangladesh. Epidemiology, 19(1), pp. 103-110*

[35] *Katia Koelle et all. (4 August 2005)): Refractory periods and climate forcing in cholera dynamics, Nature **436**, 696-700, doi:10.1038/nature 03820; Received 1 April 2005; Accepted 16 May 2005*

[36] *Schwartz, B.,J. Harris, A.Khan, R. La Rocque, D.Sack, M. Malek, A. Faruque, and E. Ryan (2006), Diarrheal epidemics in Dhaka, Bangladesh, during three consecutive floods: 1988, 1998, and 2004, Am.J.Trop.Med.Hyg.,74, 1067-1073.*

[37] *Lobitz et all (February 15, 2000): Climate and infectious disease: Use of remote sensing for detection of Vibrio cholerae by indirect measurement, 1438 –1443, PNAS, , vol. 97, No. 4*

[38] *Magny M. et all (2013): Holocene changes in environment and climate in the central Mediterranean as reflected by lake and marine records, Clim. Past, 9, 1447–1454, , , www.clim-past.net/9/1447/2013/, doi:10.5194/cp-9-1447-2013, © Author(s) 2013. CC Attribution 3.0 License*

[39] *Islam, et all (2007): Faecal contamination of drinking water sources of Dhaka city during the 2004 flood in Bangladesh and use of disinfectants for water treatment, Journal compilation,2006, The Society for Applied Microbiology, Journal of Applied Microbiology 103() 80–8*

Humidity is another critical climatic factor that can influence the survival and transmission of VBD pathogens and vectors. A longer monsoon season may affect the reproduction rate of pathogens and increase the coverage of still water to facilitate the geographic spread of mosquitoes and, consequently, the spread of VBD risk. However, the impact of climate variability on the incidence of many vector-borne and water-borne diseases can be significantly modified by local environmental conditions and human adaptation responses. In a tropical region such as Bangladesh, drought can lead to an increase in dengue fever because more people may store water in open containers in areas where access to piped water is limited, thus increasing the number of breeding sites for mosquitoes.

1.2.4 Arsenicosis

People of 59 out of 64 districts spread over 126,134 sq km. in Bangladesh are at risk of or suffering from drinking of arsenic contaminated water. A total of 75 million people are at risk, and 24 million are potentially already exposed to arsenic contamination. Chronic arsenic exposure is associated with many human health conditions, including skin lesions and cancers of the liver, lung, bladder and skin. It is also associated with many non-cancer health conditions, such as adverse reproductive outcomes, neurological disorders and impaired cognitive development in children. Cardiovascular effects in human drinking arsenic-contaminated water include black foot disease, atherosclerosis, cerebro-vascular diseases and ischemic heart disease. Moreover, maternal arsenic exposure via drinking water is associated with fetal loss, small size at birth, infant morbidity and mortality. Studies in other countries where the population has had long-term exposure to arsenic in groundwater indicate that 1 in 10 people who drink water containing 500 micrograms of arsenic/liter may ultimately die from cancers caused by arsenic, including lung, bladder and skin cancers. The highland population in the eastern hilly region is subject to the severe scarcity of drinking water with having a significant arsenic contamination of groundwater.

1.2.5 Skin and Other Diseases

Climate change will cause significant changes in river salinity in the southwest coastal area of Bangladesh during dry season (October to May) by 2050, which will likely lead to significant shortages of drinking and irrigation water in the coastal rural and urban areas. The findings of a recent study in coastal area illustrated that that the estimated salt intake from drinking water exceeded recommended limits. The problem of saline intrusion into drinking water has multiple causes and is likely to be exacerbated by climate change–induced sea-level rise.

1.3 Objectives

It is clear from the above discussion that water supply, sanitation and hygiene intervention could be affected from changing of primary climatic parameters, environmental extreme events and social issues. Presumably, the WASH policies and strategies should be reviewed for modification form the evidence base of the effectiveness of the software, hardware and management intervention of WASH. Therefore, the activity was taken with an overall objective to establish the current evidence base of effectiveness of household and community level WASH interventions in increasing resilience to climate change. It will also assesses the current knowledge for whether these strategies are effective at controlling the spread of

disease, by reviewing the scientific literature relevant to WASH strategies in Bangladesh, with climate change in mind.

The specific objectives are:

- To collect information and data from intervention trials and observations for the effectiveness of WASH interventions, with longitudinal monitoring of either disease (e.g. diarrhoea), or exposure (e.g. water quality) outcomes, at high temporal resolution (e.g. weekly reporting), over long time periods, (multiple years) in both control and intervention groups with coverage in different geophysical location of Bangladesh namely coastal, drought, flood plan, hilly and low lying area.
- To correlate the disease and the exposure outcomes with meteorological data with respect to time periods of the same geographic location of different types
- To assess the effectiveness of WASH interventions of intervention trials, but without long-term longitudinal monitoring of exposure or disease outcomes or correlation against meteorological variables.
- To assess qualitatively the degree to which the effectiveness of WASH interventions is affected by meteorological variables, including extreme weather events, seasonal variations and long-term climate change, in the national context

Chapter II
Methods and Material

2.1 Tools and Techniques

The method used in this evidence review was mainly a 'desk top review' of the documents those were available in Bangladesh and via the internet and organizational communication. Included in the review to establish the evidence around the effectiveness of WASH interventions were government policy documents to provide policy context, high-level research reports by various development partners and scientific journal and articles. The following sources were used to identify the significant and relevant literature:

- Stakeholder engagement to identify relevant documents
- An internet search using Goggle and Goggle scholar: To find out the relevant general articles, reports, workshop/conference papers and also for published articles in various journals. The internet search was conducted involving an initial exploration of potential sources through Goggle, followed by a more systematic and detailed exploration of the scholarly literature through Goggle Scholar, using the same key words in different combinations.
- Journals and reports through electronic databases: To identify relevant published scientific papers and journals. The search for published literature was carried out in Ovid MEDLINE, EMBASE and PUBMED.
- The references cited in the collected list of articles were also used to identify additional relevant studies.

2.2 Circumference of Information Collection

This report examined policies and strategy documents published by the Government of Bangladesh. These documents were collected by searching government websites and search engines, the authors were able to find most of the government reports directed at improving the country's resilience to climate change. The authors examined high level reports produced by different organizations such as the World Health Organization, as well as government departments and university researchers. Different scientific literature, peer-reviewed articles, published scientific journals were also reviewed. This was done to establish the current body of evidence of effectiveness of WASH interventions in Bangladesh in response to climate change. The authors also collected some documents from Dhaka, Bangladesh, through their research assistants.

2.3 Review of NGO Projects and Programmes

During the months of September to November 2014, three research assistants met with a number of NGO stakeholders in Bangladesh. The purpose was to collect data and observations on approaches taken by NGOs to build resilience to diseases and other threats to the WASH sector caused by climate change. As part of this project, the authors sent a selection of NGOs a questionnaire, designed for self-reporting their actions, achievements and challenges, to discover the types of WASH strategies they are putting in place. The responses were reviewed as part of this project. In addition, 'desktop research' on NGO websites was also employed. Annual reports and program documents from a selection of NGOs working in Bangladesh were reviewed for their actions relevant to WASH.

2.4 Criteria for WASH Effectiveness

This review examined different reports and documents from stakeholders working in WASH sector of Bangladesh, particularly to examine approaches already in place in Bangladesh. This report may provide context and direction for future research on the effectiveness of WASH interventions in response to climate change. Systematic reviews were searched electronically. Then during the organization visit it was also searched for programmatic approach of evaluation. It was difficult to set criteria for testing the effectiveness of WASH intervention. The basic problem for effectiveness study is setting the baseline criteria. Water, Sanitation and Hygiene has separate initiatives with program and project approach but no such study found to test the effectiveness of water and sanitation facilities with hygiene promotion. Thus, the major developmental challenge for the country is to match the availability of water and sanitation facilities with hygiene promotion to effectively reduce the transmission route of water and sanitation related diseases. Combating diarrhea is usually the prime reason for investing in water and sanitation improvements. However, it is the combination of improved water and sanitation facilities, and good hygiene that contributes most to reducing diarrheal disease, as is apparent from the fecal and oral transmission route.

Chapter III
Findings and Discussion

3.1 Search Results

The key database targeted for search of relevant studies was PubMed (1966 – Nov 2014). The database was searched for English-language articles mentioning the following keywords individually anywhere in the article text: 'Bangladesh' (16191 articles), 'hygiene' (104741 articles), 'sanitation' (31440 articles), 'water' (870919 articles), 'WASH' (159668 articles). As this systematic review is of Bangladesh in particular, the keyword 'Bangladesh' was searched in Pub Med for mention in the abstract of articles, yielding 1650 articles. This search was further narrowed down to 'Bangladesh' (abstract only), 'hygiene', 'sanitation', 'water' and ' WASH intervention trials', 'climate change adaptation', 'effectiveness of WASH interventions', yielding a total of 16 relevant articles. The articles reviewed were those that discussed WASH strategies in

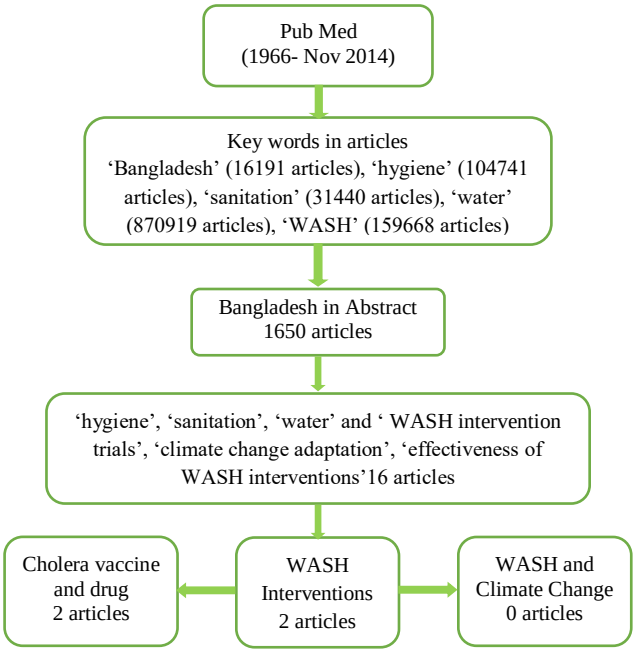


Fig 8: Flow chart for the systematic review

Bangladesh. ***None of the studies considered the issue of climate change, but were still included here to demonstrate the current body of research around WASH strategies in Bangladesh***. The search results are presented in Fig. 8. These documents were used to explain the evidence of effectiveness of the WASH interventions.

3.2 Effectiveness of WASH Interventions in Local Context

The effectiveness of the water supply, sanitation and hygiene intervention in its intended use is generally induced by the natural, climatic reasons and by the behavior of its users. Apart from these it also influenced by the geographical setting, socio-economic condition of the communities and availability of resources. In the following sub sections the evidence of effectiveness of hardware, software and policy interventions are explained from different available documents.

3.2.1 Hardware Intervention

The ultimate objective of construction or installation of any water supply, technology is to supply safe water to its user. The term safe water means in general any water that is free of any harmful physical, chemical and biological ingredients. Therefore, effectiveness of the hardware intervention is ultimately expressed in terms of its functionality, access, availability and quality chemical and biological of its product. There are many reasons for the deterioration of the effectiveness of the hardware intervention. Some of these were loss of WASH infrastructure (water supply and sanitation technology) due to climatic extreme events like flood, storm, and tidal surges etc. heavy draw down of water table increases the non-functionally of the WASH interventions and non-functionally enhances community people's behaviors in WASH usage, microbiological contamination of drinking water at source and storage, increased chemical contaminants in the source water like arsenic, manganese, salinity iron etc., lack of facilities of hand washing among the poor community people, lack of intentions of hand washing among the economically capable people, access to the WASH infrastructure in hard to reach area etc. The frequency and magnitude of these events may be regular or irregular therefore, the effectiveness also varied. Few studies have been conducted for effectiveness of WASH interventions considering the short term weather variation and the climate extreme events. The findings form the literature review on the study of effectiveness of WASH interventions is presented in the schematic Fig.9.[40,41,42]

3.2.2 Software Intervention

Numerous types of software interventions were provided to the community people through different events like courtyard meeting, rally, miking, workshops, symposiums, bill board installation, TV and radio program etc. with the aid of visual communication materials composed of posters, flip charts, book let, flash cards etc. The objectives of these developed material is to improve the water supply and sanitation related hygiene behavior and practice among the people both in rural and urban areas of the

[40] *Rahman, M. et al., 2011. Climate change and health: Bangladesh, Vulnerability and Adaptation Assessment Report, s.l.: s.n.*
[41] *Milton, A., Hore, S., Hossain, M. & Rahman, M., 2012. Bangladesh arsenic mitigation programs: lessons from the past. Emerg Health Threats J, Volume 5.*
[42] *Delpla I, A V Jung, E Baures. 2009. Impacts of climate change on surface water quality in relation to drinking water production. Environment International, 35(8):1225–1233. DOI:10.1016/j.envint.2009.07.001.*

country. Greater emphasis has been paid to hand washing practices during different personal events like food preparation, breast feeding, cleaning of child's anal path after defecation and before eating etc. Numbers of studies have been employed for linking hygiene practices such as hand washing to

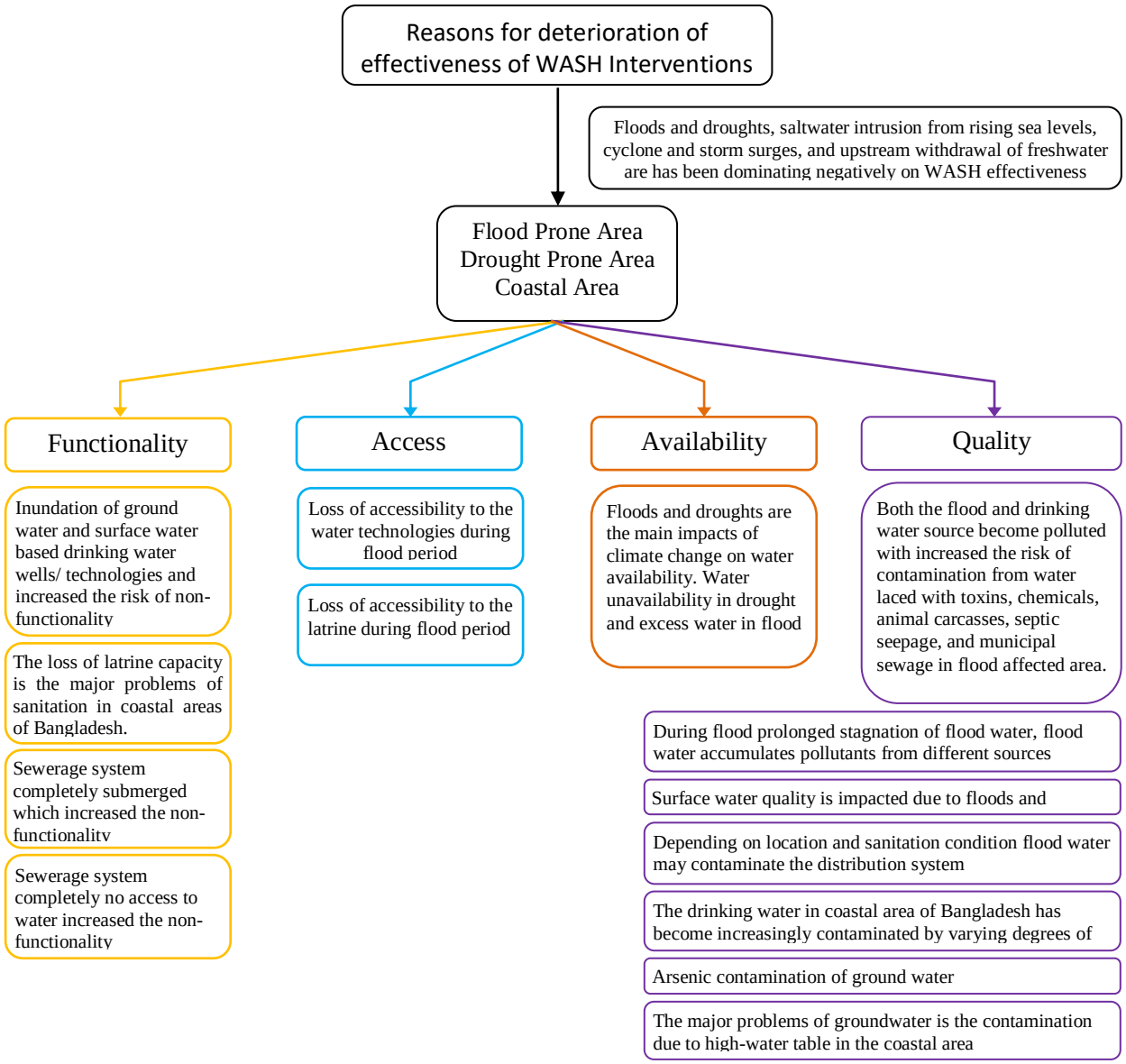


Fig. 9: Summary of findings found from different WASH effectiveness studies

improvements in health and fewer instances of communicable diseases. Greater emphasis has been paid to hand washing practices through the communication materials during different personal events like food preparation, breast feeding, cleaning of child's annus after defecation and before eating etc.

Some intervention studies have shown that the communities who had receive intensive hand washing promotion had less childhood diarrhoea and respiratory disease.[43,44] Washing hands at different key times

[43] *Ejemot, R., Ehiri, J., Meremikwu, M. & Critchley, J., 2008. Hand washing for preventing diarrhoea (Review).. The Cochrane Collaboration and published in The Cochrane Library, Volume 1.*

was particularly important for reducing diarrhoea but most critically before preparing food. Washing hands does not require any soap because one study reported that washing hands with water alone had a significant impact on reducing the spread of diarrhoea.[45] It was reported that three hand washing indicators were independently associated with less child diarrhoea mothers reporting usually washing hands with soap before feeding a child, mothers using soap when asked to show how they usually washed their hands after defecation, and children having visibly clean finger pads.[46] They found that hand washing with either ashes or soap at critical times, such as before preparing meals and after defecating, may reduce the spread of disease and may help to diminish transmission of diarrheal pathogens to children.[47] Thus, from the above review it is clear that hand washing at critical times with any locally available resource like soap or ash, or ash-detergent combinations or water alone may be effective for achieving sustainable improvements in hand washing behaviour.

Economic status and water availability at hand washing locations are significantly associated with hand cleanliness for both caregivers and children. A minority of rural residents actually washed both hands with soap at key hand washing times, while rinsing hands with only water was more common.[48] Water storage capacity, ease of use, maintenance, durability, quality of materials actually determined the acceptability and feasibility of specific hand washing station designs and also more than one hand wash station per household may be required.[49] Structural constraints, such as having water stations inside the home rather than outside, can influence the likelihood of washing hands at key times.[50] A hand washing matrix is provided in Box 2 to observe the best and worst possible cases.

3.2.3 Policy and Strategies

Policy: The Government of Bangladesh has a number of policies relating to WASH, health and the environment. The National Health Policy was updated in 2011 by the Ministry of Health and Family Welfare (MOHFW), making reference to climate change. The MOHFW have demonstrated that Bangladesh has made remarkable achievements in natural disaster/emergency response through better preparedness and proper management. However, they acknowledge that this progress has been slowed by the effects of climate change, including salinity intrusion in water supplies and drought. The health policy has identified threats to human health caused by climate changes, such as respiratory diseases, heat stroke, cold wave related illness, vector borne diseases (like malaria and dengue fever) and water borne diseases like cholera, as well as increased malnutrition caused by reduced food production. The health policy aims to monitor disease and health disaster and to discover ways to reduce the adverse effects due to climate change. The policy principally agreed to adopt a health safety net comprising of health services,

[44] *Luby, S. et al., 2005. Effect of handwashing on child health: a randomized controlled trial.. Lancet, Volume 366, pp. 225-233.*
[45] *Luby, S. et al., 2011a. The Effect of Handwashing at Recommended Times with Water Alone and With Soap on Child Diarrhea in Rural Bangladesh: An Observational Study. PLoS Med, 8(6).*
[46] *Luby, S. et al., 2011b. Using Child Health Outcomes to Identify Effective Measures of Handwashing. Am J Trop Med Hyg, 85(5), pp. 882-892.*
[47] *Baker, K. et al., 2014. Association between Moderate-to-Severe Diarrhea in Young Children in the Global Enteric Multicenter Study (GEMS) and Types of Handwashing Materials Used by Caretakers in Mirzapur, Bangladesh. Am J Trop Med Hyg, 91(1), pp. 181-189.*
[48] *Halder, A. K. et al., 2010. Observed hand cleanliness and other measures of handwashing behavior in rural Bangladesh. BMC Public Health, Volume 10.*
[49] *Hulland, K. et al., 2013. Designing a handwashing station for infrastructure-restricted communities in Bangladesh using the integrated behavioural model for water, sanitation and hygiene interventions. BMC Public Health, Volume 13.*
[50] *Schmidt, W. et al., 2009. Determinants of handwashing practices in Kenya: the role of media exposure, poverty and infrastructure.. Trop Med Int Health, 14(12), pp. 1534-1541.*

emergency relief, medicine, and instruments for people affected by natural disasters and climate change. This will include developing a national program, strengthening public services and supporting research needs to identify the short, medium, and long term effects of climate change on health.

The Government of Bangladesh's policies related to water and sanitation include the National Policy for Safe Water Supply and Sanitation, implemented in 1998, and The National Water Policy, promulgated in 1999. These policies are complimented by the National Water Management Plan, approved in 2004, and other WASH-related policies, such as the National Sanitation Strategy (2004), the National Policy for Arsenic Mitigation Policy (2005) and the Pro-poor Strategy for Water and Sanitation (2005). The policies focus on identifying safe water supply and improving sanitation, and on creating awareness and capacity building to access safe water from various sources. The policies need to be reviewed for incorporation of the climate change issue.

The sector development plan of the Water Supply and Sanitation Sector of Bangladesh (2011-25) has demonstrated the impacts that climate change on water supply and sanitation sector including the human health. They showed that increase of temperature, humidity, erratic rainfall, sea level rise and unpredictable extreme events like cyclones, surges and storms could impact the water supply sanitation sector by creating water stress, saline intrusion, water source contamination, diseases (water and vector borne) and by damaging the water supply and sanitation infrastructure. They found that increasingly saline drinking water may also result in health hazards, especially for pregnant women. The national baseline survey on hygiene indicated that poor quality and maintenance of water and sanitation facilities, cleanliness of toilets and water points and appropriate water disposal settings can contribute to the increase of disease burden. Therefore, the situation creates a significant concern among the stakeholders as they have found from different studies that the future progress of supplying safe water, sanitation facilities and improved hygiene need to consider the impact of climate change.

The WHO has undertaken a review of relevant policies, plans and programs relating to health and climate change in Bangladesh. It reviewed current global and national guidance on climate change vulnerability assessment and adaptation with a particular focus on health and water issues. The report described the current policy setting and processes in Bangladesh to implement climate resilience and health promotion strategies. The report makes a number of recommendations for the health and WASH sector in building resilience to climate change, such as greater collaboration across sectors, expanding research and implementing the WHO Vulnerability Assessment Tool.

Combined WASH strategies: The literature on WASH strategies in response to climate change in Bangladesh is limited, apart from reports discussed above. The authors of this report found a number of studies that link WASH practices to better health outcomes. These studies were not conducted with climate change in mind, and so do not account for the impacts that climate change is projected to have on health (especially the spread of communicable diseases) and WASH strategies. The findings from these studies could be adapted and considered when forming effective strategies for adapting to health concerns caused by climate change. All of the studies reviewed had taken place in Bangladesh, unless otherwise stated.

Less reported cases of diarrhoeal disease for people who had put in place the WASH interventions, though found many people in the population did not make a connection between WASH practices and reducing the spread of disease rather, they believed the WASH interventions improved their quality of life.[51] Households who had undertaken WASH strategies, such as hand washing and using clean water, had better reported health outcomes, such as less cases of diarrhoea. The household environmental cleanliness (including water quality, and sanitary and hand washing infrastructure) have on enteropathy has impact on the impair childhood growth.[52] The children from "cleaner" households had higher height-fr-age scores, lower lacunose mannitol ration in their urine and lower immunoglobulin G endotoxin core antibodies titers than children from contaminated households, thus linking environmental contamination with growth faltering in children.

The most vulnerable populations of Bangladesh would be most at risk to the effects of climate change to protect the health. Core public health infrastructure and services must further enable and equitable access to underlying determinants of good health.[53] The hospital cleanliness affects the patient's health and low cost interventions on hand hygiene and cleaning procedures for rooms and medical equipment should be developed and evaluated for their practicality and effectiveness in preventing the spread of disease. There is a need to develop climate-sensitive disease data sets for further studies to confirm the health impacts for climate change. The NAPA recommended for initiation of climate-sensitive disease surveillance,

The vulnerability reduction assessment[54] is set up in response to numerous WASH focused projects that have been implemented by the government and NGOs in Bangladesh. The VRA provided a mechanism to follow up the results of projects, assessing their ability to reduce vulnerability within the community to climate change by identifying current and future vulnerabilities.

3.3 Sensitivity of Disease to Short-Term Weather Variations

Literature on health issues related to climate change is poor, and available data are often not well integrated in government plans. Very little work has been done globally to look into and analytically assess the different effects on human health caused by the impacts of a changing climate. Countries depend on reliable, relevant and up-to-date information in order to respond to the negative health effects of climate change. In least developed countries, weak capacity for research into producing informed adaptation is likely to deepen the social inequality in relation to health. Few comprehensive assessments on the effect of climate change on health have been completed in low-income and middle-income countries. Strengthening informational, technological and scientific capacity within developing countries is crucial or the success of a new public health movement. This capacity building will help to keep vulnerability to a minimum and build resilience in local, regional, and national infrastructures. Local and

[51] *Hoque, B. et al., 1996. Sustainability of a water, sanitation and hygiene education project in rural Bangladesh: a 5-year follow-up. Bulletin of the World Health Organization,, 74(4), pp. 431-437.*

[52] *Lin, A. et al., 2013. Household Environmental Conditions Are Associated with Enteropathy and Impaired Growth in Rural Bangladesh. Am J Trop Med Hyg, 89(1), pp. 130-137.*

[53] *Kabir, I. et al., 2012. Climate change and health: Bangladesh, Adaptation Strategy Report, s.l.: s.n.*

[54] *Rutherford, S., Islam, Z. & Chu, C., 2014. Piloting of Vulnerability Reduction Assessment Tool in Bangladesh, Griffith University: Center for Environment and Population Health*

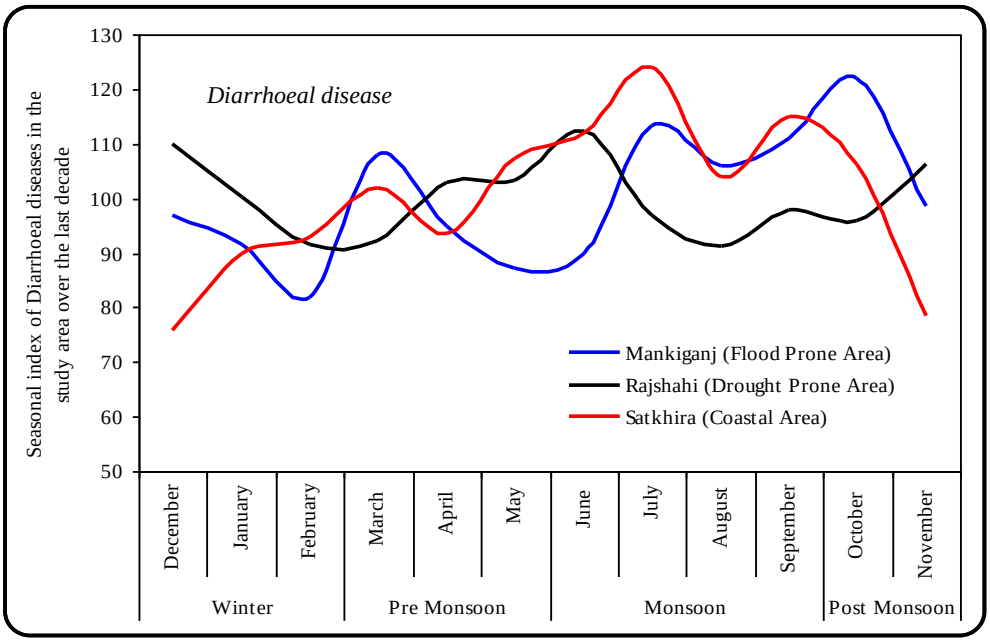
community voices are crucial in informing this process. Response of the health sector to climate change will need to be undertaken in wide collaboration with other sectors of government and social action. The health sector, in general, has been slow to perceive the enormous significance of global climate change and its threat to the world's life-support.

Diarrhoeal disease is one of the leading causes of morbidity and mortality in Bangladesh. Studies conducted elsewhere have found strong association between various climate parameters and diarrhoea incidence.[55] Climate change is therefore likely to change the rates of diarrhoeal diseases in the long-term. To quantify the extent of impact from extreme climate events on diarrhoea incidences, the review spotlights analysis of the relationship between temperatures and admitted cases of diarrhoea. These results could then be used to establish scenarios as indicative measures of potential climate change impacts to diarrhoea and other WASH sensitive diseases in Bangladesh.

The Department of Environment of Peoples Republic of Bangladesh has conducted an extensive study on "Climate change and health impact in Bangladesh" with an overall objective to find out impacts of climate change on human health of Bangladesh and specific objectives of analyzing climate and health related data for exploring the relation, assessing current knowledge base to understand the public health issue considering climate change and creating a database for further research in the area. The study was carried out in households of two villages in each of three districts namely Manikganj as flood prone area, Rajshahi as drought prone area, Satkhira as coastal area. The study was conducted in between 2006-2009. Information on the diarrhoea, malnutrition and skin diseases incidence were collected from upazila health complex over the period of 1995-2006 and the information of Kalaazar incidence was collected form DG-Health Health of the same period. The result indicated that all of these diseases have been increasing from 1995 to 2005. A closer observation indicated that diarrhea remained highest during monsoon in most of the year. Skin diseases incidences were observed with little variation for all the seasons of the year. However, total incidences of skin diseases during the reported period remained highest in monsoon followed by pre-monsoon. Occurrences of diarrhea and kalaazar were found highest in 2004 while skin diseases and malnutrition remained highest in 2005. Seasonal (monthly) index reflecting the variations in the incidence of diarrhoeal diseases for months of the year as calculated based on the time series data from the Upazila health Complex is presented in Fig. 10.

The IEDCR, along with DGHS and CCHPU of MOHFW, undertook a Vulnerability and Adaptation Assessment study. They found that climate change is likely to increase the rates of diarrhoeal diseases and vector-borne diseases in the long term. They also linked climate change with a rise in other non-communicable diseases, such as cardiovascular diseases caused by increased salinity in sources of drinking water, and increased mental health concerns caused by climatic events. The table 3 shows the direct and indirect effects of climate change on mental health.

[55] *Rahman, M. et al., 2011. Climate change and health: Bangladesh, Vulnerability and Adaptation Assessment Report, s.l.: s.n.*



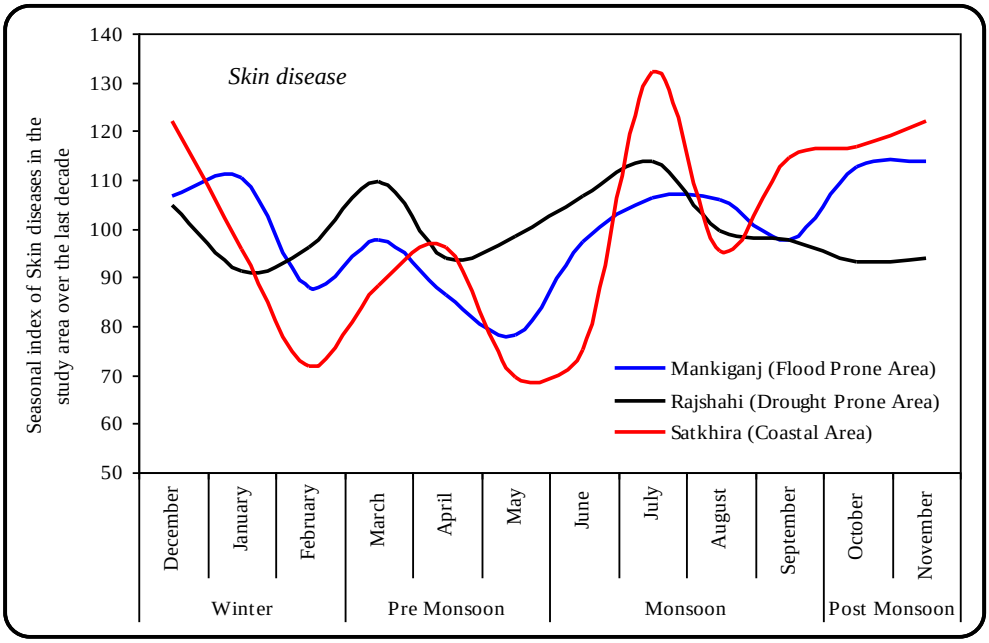


Fig 10: Seasonal (monthly) index of diarrhoeal and skin diseases in different study respective location during the study period in flood prone, drought and coastal area

Table 3: Direct and indirect effects of climate change on mental health[56]

Effects	Acute weather event, e.g. cyclone/flood	Sub-acute weather events (e.g. on hot days, droughts)
Direct effects	Post-traumatic stress disorder Acute anxiety disorders	Violence Aggression
Indirect effects (economic, social determinants)	Anxiety and mood disorders Substance abuse Somatoform disorders	Chronic mood disorders Schizophrenia Somatization Suicide

There was a growing concern for the impacts climate change on water and the outbreak of diseases. Increased rainfall in Bangladesh had effects on incidence of cholera[57]. The river level was a factor associated with the spread of cholera and found a significant causal link between high rainfall and the incidences of cholera. Low rainfall and high temperature were also associated with increases in cholera cases. The impacts of long term climatic-changes on cholera outbreaks and solutions for resilience development have yet to be studied.

3.4 Modifying Effect of WASH on Climate-Sensitivity

3.4.1 Modification of Water Source/Technologies

The most visible evidence of variable effectiveness or ineffectiveness of WASH intervention interms of its functionality, accessibility, quantity and quality is that many of the projects and programmes modified their use of freshwater sources including the technologies (Fig. 11[58]) due to the short term weather variability and climate extreme events. Publicity for promoting the rainwater harvesting unit in recent years was an example of alternative source and has been becoming a common initiative to address the scarcity of clean drinking water and arsenic contaminated groundwater in different parts of the country. Basically the rainwater harvesting unit was initially promoted as an alternative source of water in the arsenic contaminated area but afterwards its use and acceptability among the people increased and now it has been using in climate vulnerable area as an alternative or emergency source of drinking water.

Fig11: Photograph of raised platform of tube well

In coastal area of the country the peoples are familiar with the use surface water because of the salinity of the ground water. In recent years the due to the increase of sea level and un-repaired polders (destructed during to the storms) the surface water (pond, river, and cannel) water became highly saline. Some of the peoples in those areas have been mixing the rainwater with the tube well water for the reduction of the salinity. They collected the rainwater in the rain season

[56] *Rahman, M. et al., 2011. Climate change and health: Bangladesh, Vulnerability and Adaptation Assessment Report, s.l.: s.n.*
[57] *Hashizume, M. et al., 2008. The effect of rainfall of the incidence of cholera in Bangladesh. Epidemiology, 19(1), pp. 103-110.*
[58] *Photograph Courtesy: Internet*

and stored it for use in the other seasons. Sometimes they mixed stored the rain water with saline ground and surface water for the reduction of salinity. In the coastal area due to increase of the height of the low tide and the high tide peoples raised the platform the tube well as well as the sanitary latrine facilities. The CCHPU developed a strategy (Public Private Partnership (CBA-PPP) model) for the coastal people for ensuring the safe drinking water by using reverse osmosis (RO) system which effectively remove the salinity, pathogen and arsenic from water. The Public Private Partnership (CBA-PPP) model effectively reduced the cost and the reduced the waterborne diseases burden.

Fig. 12: Photograph of aquifer recharge system

Artificial aquifer recharge (Fig. 12[59]) was also and evidence of scarcity of fresh water. The Department of Public Health Engineering in collaboration with Unicef and Dhaka University and Acacia Institute of the Netherlands has been piloting artificial aquifer recharge in coastal area of the country. The outer coastal zone is desperately water scarce because both shallow and deep groundwater are saline, rainfall is variable, and land and surface water bodies are subject to inundation by cyclonic storm surges. Many existing water sources are heavily contaminated by bacteria. Cyclones Sidr and Aila showed that safer, more reliable and disaster resilient sources of supply are needed. It could be an effective climate resilient source to address the coastal area. Building deeper tube wells in barren areas and developing cluster villages with dams constructed around them, to prevent washing out in the event of floods and cyclones.

Fig. 13: Peoples are collecting water from almost dried up surface water sources

Pond sand filters are another innovative technology used to make pond water suitable for drinking. It is familiar in both coastal and drought prone area. Field experiences revealed that in coastal area the ponds banks were made height so that the saline water can not enter into the pond during the tidal surges. In drought prone area surface water (Fig. 13[60]) is familiar among the community people. The drought prone area ponds were re-excavated for increasing the climate resilience so that it can hold more water to supply round the year.

Dug well was used by the community peoples in 50s and termed as one of the suitable technology for drinking and household water. Gradually it disappeared when the ground water exploration by tube well technology appeared and over the period of time its appeal disappeared due to 'bad smells and tastes, high turbidity, distance and time constraints to fetch water from the dug wells and poor compliance[61] with water quality standards. But after the detection of the arsenic in the ground water it was again suggested

[59] *Photograph Courtesy: Internet*
[60] *Photograph Courtesy: Internet*
[61] *Milton, A. et al., 2007. A randomised intervention trial to assess two arsenic mitigation options in Bangladesh. Journal of Environmental Science and Health Part A, Volume 42, pp. 1897-1908*

as an alternative technology. A functional dug well could be offered as a long-term alternative to tube wells from a health perspective, though compliance with this option would be low unless appropriate behaviour change measures were also taken. Adequate research into discovering region specific suitable safe water options, adequate approaches using scientifically-sound methods, and adequate dissemination of the knowledge and experiences could address the arsenic problem firmly as the author mentioned. Some of the modified technologies considering the climate vulnerability are presented in Table 4.

Table 4: Features of different modified water supply technologies

Technology	Description of Modification/Characteristics benefits
Dual Platform Tube-well Area: Flood prone and Haor Area	1. Due to climate vulnerability (flood, water logging and etc.) the raised platform can be risen 2 feet to 5 feet more 2. Waste water cannot pollute these types of technology during food 3. Easy access of safe water during disaster 4. More people can be benefitted by adding two head
Modified RWH Area: In where rainwater is feasible	Flushing system is an important component of RWHS. First flush devices prevent the first portion of roof run-off from entering the tank and will reduce the amounts of bacteria from decomposed insects, lizards, bird and animal droppings and concentrated tannic acid. It may also contain sediments, water borne heavy metals and chemical residues, all of which are undesirable elements to have in a water storage system. Instead of flowing to the water tank, these pollutants are diverted with the initial flow of water. To maintain the quality of harvested water easy flushing system is very essential and the benefits are: 1. Water quality will be improved by adding a extra filtering media 2. Chance of pollutant mixing is low 3. In rainy season it is not mandatory to open the flushing stopcock every time
Multi Outlet/Headed DTW Area: In where Deep tube-well is feasible	1. No of beneficiary is increased by doing single boring 2. Environmental friendly 3. Reduce the risk of aquifer pollution 4. More economical/Cost effective
Surface Water Treatment Plant Area: where PSF is feasible but need to serve more community	1. Baffle reactor has been introduced in this technology which effectively helps treatment process 2. Introduced more travelling length, as a result sedimentation process is better compare to previous one 3. Reducing operational and maintenance difficulties 4. It can serve more people
Modified AIRP	1. Efficiency is increased compared to previous version 2. Working range of the plant is form 50 to 250 ppb 3. The flow rate is increased 4. Reducing operational and maintenance difficulties

3.4.2 Modification of Sanitation/Technologies

Some NGOs have modified the sanitation facilities in response to climate change. For example, pit latrine's bases have been raised up to plinth level so that the flood water cannot enter the pit in the events of flood or other extreme climatic events. There are many ways to raise the latrine depending on local conditions namely earth stabilized raised pit latrine, step latrine, mound latrine, sand enveloped latrine, sand enveloped raised latrine. Table 5 presented the features of a typical modified latrine

Table 5: Features of a modified latrine technology

Technology	Description of Modification/Characteristics benefits
Modified Latrine Technologies	Context-specific Modified Sanitation options 4 different types of sanitation technology were demonstrated. Modified Eco-San Toilet Raised Pit Latrine Bottom Seal Latrine Partially Leached Treat Latrine

3.5 Strength of Evidence

The overall findings indicated that none of the WASH interventions have been properly evaluated for its effectiveness in Bangladesh following rigorous scientific methods for its climate resilience. This is found after reviewing of peer reviewed articles, grey literatures including NGOs reports, governmental policies. Most of the studies have concentrated on estimated health effects such as diarrhea due to climate change in Bangladesh. Some of the studies have projected future changes in temperature and rainfall due to climate change in Bangladesh over the period of time. Therefore, it is very important to ensure a strong evidence base before promoting effective WASH interventions in climate vulnerable areas of the country. The effectiveness of WASH needs to be evaluated both in terms of health and technological compliance that is functionality, accessibility, availability and quality. The adverse effect of climate change is a priority for Bangladesh government as evident by relevant national policies. Government agencies such as Department of Public Health Engineering and NGOs have been addressing the WASH issues related to climate change in the vulnerable areas through adopting a number of WASH projects. These projects are mostly based on previous experiences.

In order to analyze the magnitude of diarrhoeal attributable to climate change in Bangladesh[62] two different scenarios (Box 3) were considered namely baseline: 1981-1990 and climate change scenario: 2001-2010). As daily admissions for diarrhoea was reliably recorded in ICDDR,B, therefore decided to estimate the change in diarrhoea admission rates based on the data from the Dhaka Hospital only. Climate change predictions for the specific locality (catchment area of the Dhaka Hospital) as well as population growth, annual GDP growth rate, safe water supply, sanitation coverage, literacy rate were considered. The predicted exposure to climate change in Bangladesh by year 2030 is carried out for ~1°C temperature

[62] *Rahman, M. et al., 2011. Climate change and health: Bangladesh, Vulnerability and Adaptation Assessment Report, s.l.: s.n.*

increase based on the regional climate modeling of IPCC, A1B emission scenario. It was assumed that population projections for year 2030 will be in line with the UN projected population for Bangladesh and increase from 148,692,000 by year 2010 to 181,863,000 people by year 2030. The number of cases in each of the scenarios is estimated from the number of projected population year 2030 multiplied by the risk ratio of diarrhoea. The risk ratio varied between the scenarios. For the Scenario C_0 an initial risk ratio of 0.034 is estimated, based on the national burden of diarrhoea in 2001-2009 from MIS data, and for Scenario C_1, the risk ratio attributed to climate change is based on the trend with 1981-2010 data. The risk ratio of having diarrhoea for each of the scenarios is presented in Table 6, including for ~1 degree Celsius increase in temperatures by year 2030.

BOX 3: Climate Change Scenario

A. Scenario C_0, year 2030, is the baseline scenario where implications from climate change to disease patterns were not integrated in the analysis. The scenario includes assumptions of no human-induced climate change and the incidence rate ratio will be generated based on the admission data during 1981-1990 (the period when human-induced climate change is believed to be minimal).

B. Scenario C_1, year 2030, builds on data from 2001-2010 and estimates the number of admitted diarrhoea cases considering projected climate change impacts on diarrhoea cases based on the results of time-series analysis of the relationship between diarrhoea admission rates and climate variables including ambient temperature, humidity, cumulative rainfall, sea surface temperature, and ENSO index during the period 2000-2010 (the period when most of the human induced climate change is thought to occur owing to industrialization and greenhouse gas emission). The additional number, $N2030_{cc}$, of incidences of diarrhoea attributed to climate change impacts by year 2030 are hence estimated as: $N2030_{cc}$= **2030 *Scenario C_1*– 2030 Scenario C_0**

Table 6: Risk ratios for each of the scenarios

Scenario year (2030)		Risk ratio
Scenario C_0		0.034
Scenario C_1 (1°C 2030)		
	Lower	0.056
	Upper	0.060

For 1 degree Celsius increase in temperature by 2030, the risk ratio = initial risk ratio + additional risk ratio (derived from the 2000-2010 period risk ratio-1981-1990 risk ratio) 1 therefore the the incidence rate ratio for diarrhoea deaths could not be estimated due to limited data. The number of additional diarrhoea deaths attributed to climate change by year 2030, *Deaths 2030cc,* was not calculated. Instead the projected deaths in 2030 under the climate change scenario was calculated, assuming double of the mean national case-fatality rate of 0.0004 in Bangladesh during 2001-2009 ref as we expect an equal number of death in the community as in the hospital.

Table 7: Projected number of diarrhoeal diseases for the business-as-usual scenario if all other conditions remained constant

	Baseline scenario C_0 (2030)	Scenario C_1 (1°C 2030) Lower	Upper
Diarrhoea cases	6,183,342	6,529,609	6,554,343
Additional cases		346,267	371,001
Estimated Diarrhoea deaths (all ages) (Based on WHO 2004 estimates)	80,383	84,885	85,207
Additional deaths (all ages)		4,502	4,824

The total number of cases will consequently increased from the projected 6,183,342 cases to 6,554,343 with an additional number of 371,001 cases for the upper bound scenario and with a 1 degree Celsius temperature increase by year 2030. For the most moderate scenario, lower bound and 1 degree Celsius increase in temperature, the additional number of cases attributed to climate change will be 346,267. In regard to deaths, the ICDDR,B death rates was not considered as it will not represent the country situation, the DGHS, MIS data was taken into consideration as it does not report childhood diarrhoea deaths adequately. Using the rate derived from the 2004 GBD estimates from the WHO, the number of deaths of all ages will increase from the projected 80,383 deaths to 85,207 for the upper bound scenario with a 1 degree Celsius temperature increase.

3.6 Climate Change Health and WASH Research Needs

Scientific research plays a crucial role in building resilience to diseases caused by climate change. The Fig. 14 demonstrates that how the scientific studies and the research play a critical role in evidence-based decision making. The evidence based decision making significantly contributes to the development of sound policies which is then implemented by different projects and programmes initiated by the government as well as NGOs and other international bodies. In the health and WASH sector these projects and programmes addresses the health problems and leading to an improved health outcomes. Where the policies and practices are not developed or modified through proper evidence, then it becomes ineffective and there is a risk of missing the targets for making a difference which eventually leading to the waste of time resources.

The body of established scientific literature on WASH and health is valuable because those provide valuable understandings which can contribute to WASH strategies and policies. Some studies reveal that even a small change in behaviour or knowledge can have large returns in preventing the spread of disease and many examples existed. Simply washing hands after defecating or before preparing food, or even using water alone or any resources available, are better than not washing at all. If people do not use latrines, is it because of unavailability, convenience or safety issues related to latrines being too far away, or lack of knowledge about how and why to use them? If people reveal a lack of knowledge about how to use and the importance of using latrines, then strategies such as education programs in schools and the community should focus on educating people to use latrines; installing more latrines will not solve this. Alternatively, if people (women in particular) reveal that latrines are too far away from their home for convenience or threat to safety, then solutions should focus on making latrines more convenient or safe, such as installing latrines within households.

Overall situation necessitates for further research into the effectiveness of WASH strategies as well as the hardware and software interventions for building resilience to climate change. Areas of focus could consider examining region specific water technologies, and how these will cope under the extreme pressure caused by climate change which includes the functionally, accessibility, availability and quality. Considering short term weather variability and climate extreme events (flooding, cyclones, droughts, sea level raise) that may have increased impact on the WASH policies and strategies, health system and as

well as the respective interventions needs to be rigorously examined for functionally, accessibility, availability and quality in Bangladesh and acceptability for compliance.

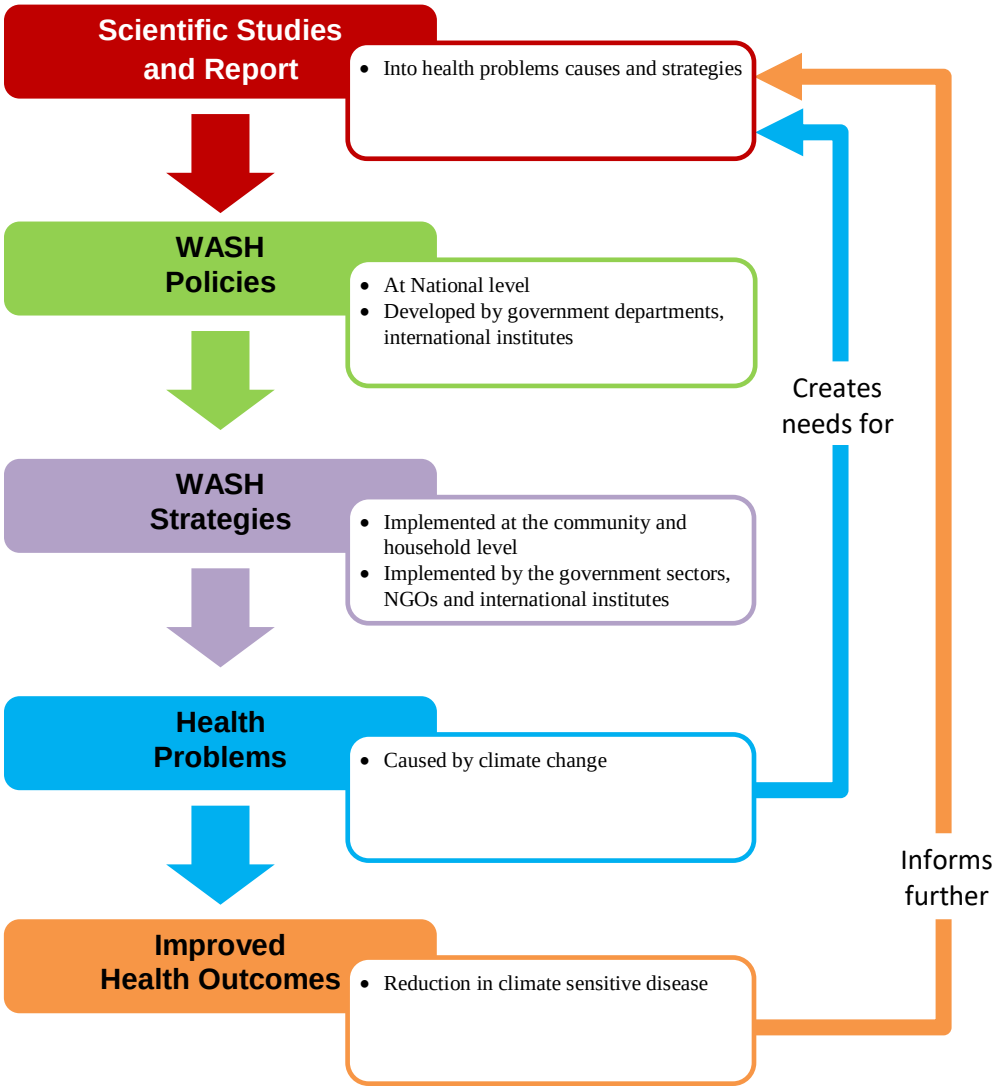


Fig. 14: The evidence-based process for building resilience to climate change through WASH strategies

3.7 WASH and Health Policy Gaps for Addressing Climate change

The Government of Bangladesh's commitment to adapting and building resilience to climate change has set the country on a strong platform for action. Policies such as BCCSAP put it on a strong course for building resilience to climate change. However, there are important parts of the government's policies and strategies where responding to climate change has not been integrated. The impact of climate change and short term weather variability and climate extremes are not sufficiently included or reflected in the National Water Policy (1999), the National Policy for Safe Water Supply and Sanitation (1998), and the

National Policy for Arsenic Mitigation (2004), Environmental Policy but the sector development plan (2011-25) has included the aspects of the impact of the climate change. The National Health Policy (2010) has a strategy for dealing with the health impacts of climate change. Climate change and its variability is expected to have a greater impact on environmental determinants of health namely water supply and quality, sanitation, hygiene, environmental cleanliness, which will catalyzes the spread of diseases An integrated approach considering the different policies of health and WASH can reduce the risk of spread of such diseases. .

The impact of climate change will be felt across different sectors. The NAPA demonstrated the intensity of the impacts that climate change will have on different sectors across Bangladesh as presented in Fig. 15. Since the climate change will be felt across different sectors therefore an integrated approach for responding to climate change is warranted. In order to create comprehensive environmental health capacity and a functional environmental health program in Bangladesh, there is need for improvement across sectors, including academia and research, government, industry and NGOs, as well as coordination and cooperation among these institutions.[63]

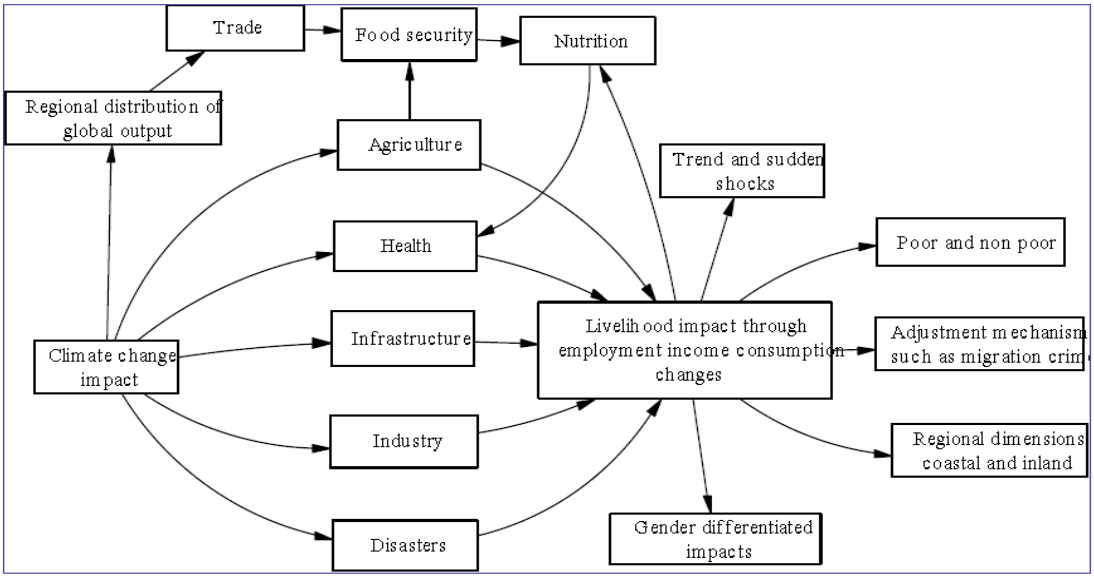


Fig. 15: Intensity of impacts on different sectors caused by climate change, (Ministry of Environment and Forest, 2005, p. 17)

There is also a need to build resilience at the community level, from the bottom up. The community based health and WASH interventions are cost effective, achieve higher acceptability within the community, allow for direct communication, reflect community choices and empower communities to act upon earlier warnings. The adaptation for climate change over the next 20-30 years will require strong community engagement and highly strategic interventions and mechanisms.[64]

[63] *IMF 2013*
[64] *Kabir, I. et al., 2012. Climate change and health: Bangladesh, Adaptation Strategy Report, s.l.: s.n.*

The country is looking out for the most vulnerable peoples, and a more integrated approach into policies (such as in the health sector and water sector) taken at the national level with further research to find out the most effective WASH strategies and interventions with its subsequent implementation at the community and household level so that the country will be more able to cope with the risks posed to health caused by climate change impacted WASH. In this regard the World Health Organization's pilot project 'Building adaptation to climate change in health in least developed countries through resilient water, sanitation and hygiene (WASH)' was notable which aims to promote a more integrated approach to addressing climate change concerns for the WASH sector. Their recommendations will be valuable for policies reform at the national level that promotes climate resilience across a number of sectors, notably health, water and sanitation. The commitment made by the Government of Bangladesh and organizations such as WHO, NGOs and IMF provides a positive outlook for Bangladesh's ability to adapt and cope with the risks caused by climate change.

3.8 Conclusion and Recommendations

This report has reviewed the government policies and strategies as well as the interventions for coping with the threats of climate change in WASH and health sector. It has also examined the current evidence of effectiveness of these actions. The climate change is anticipated to have devastating impacts in Bangladesh, especially felt through the health and WASH sectors. The government has different policies and strategies in place for coping with impact of climate change, such as the NAPA and BCCSAP. The relevant government departments of health and WASH sector including the NGOs have been initiating different strategies and interventions to assist households and communities for the adaptation of the impact of climate change as this report has revealed but more is still required. The policy makers and implementers should look to the scientific evidence when making decisions, such as which WASH and health strategies are most effective for promoting good health and preventing the spread of disease, as well as behavioral factors that impact on compliance and feasibility of use within the community.

As demonstrated in the report the evidence around building climate resilient WASH strategies and interventions are scarce. So far no studies in Bangladesh have specifically looked into the effect that climate change that will have impact on WASH interventions. There is a large body of literature that looked at the effects a specific WASH intervention especially hand washing practices) Many other reports make recommendations for building resilience to climate change. This report draw out the major recommendations and knowledge gaps find out from the literature. Updated research and government policies are required to accommodate for the impacts of climate change on the health and WASH sector.

Key recommendations

- Conducting research into the impacts of climate change, short term weather variability and climate extreme events on the health and WASH sectors in Bangladesh for finding out the probable modification of different interventions which includes different policies, strategies hardware and software in terms of functionality, accessibility, availability and quality.
- Conducting research to identify the most suitable water and sanitation technology for vulnerable population of different geographic area namely coastal, flood prone, drought, hilly and low lying area of Bangladesh

- Conducting research into factors that affects the long term compliance considering the functionality, accessibility, availability and quality including the acceptability and feasibility of uptake within the population and the strategies
- Exploring areas of WASH that are under researched, with the impact of climate change in mind.
- Ensuring improved coordination between government sectors (especially the Health and WASH sectors) on strategies to build resilience to climate change
- Taking initiative for updating different policies and strategies considering the impact of climate change/variability and climatic extreme events.
- Conducting monitoring of the policy implementation and taking appropriate measures

Summary of Literatures on WASH Effectiveness

No	Name of the Study	Study Area	Study Type/methods	Location (dist/Uz)	Sample Size	Principle Author/ Study Team
1	Cluster-randomized controlled trials of individual and combined water, sanitation, hygiene and nutritional interventions in rural Bangladesh and Kenya: the WASH Bene fits study design and rationale	Hand Washing	RCT	Kenya and Bangladesh - Gazipur, Mymensingh and Tangail districts.	13,760	Benjamin F Arnold,Clair Null, Stephen P Luby,Leanne Unicomb, Christine P Stewart, Kathryn G Dewey,Tahmeed Ahmed, Sania Ashraf, Garret Christensen, Thomas Clasen, Holly N Dentz, Lia C H Fernald, Rashidul Haque, Alan E Hubbard, Patricia Kariger, Elli Leontsini, Audrie Lin, Sammy M Njenga, Amy J Pickering, Pavani K Ram, Fahmida Tofail,Peter J Winch, John M Colford Jr
2	Association between Moderate-to-Severe Diarrhea in Young Children in the Global Enteric Multicenter Study (GEMS) and Types of Hand washing Materials Used by Caretakers in Mirzapur, Bangladesh	Hand Washing	Global Enteric Multicenter Study FGD	Tangail Kumudini medical college area	3,859	Kelly K. Baker, Fahmida Dil Farzana, Farzana Ferdous, Shahnawaz Ahmed, Sumon Kumar Das, A. S. G. Faruque, Dilruba Nasrin, Karen L. Kotloff, James P. Nataro, Krishnan Kolappaswamy, and Myron M. Levine
3	Observed hand cleanliness and other measures of hand washing behavior in rural Bangladesh	Hand Washing	Sanitation, Hygiene Education and Water supply-Bangladesh project (SHEWA-B) evaluation, comparative observational	Randomly selected 100 villages from 36 districts in rural Bangladesh	2692 households	Amal K Halder,Carole Tronchet, Shamima Akhter, Abbas Bhuiya,Richard Johnston, Stephen P Luby
4	Designing a hand washing station for infrastructure-restricted communities in Bangladesh using the integrated behavioral model for water, sanitation and hygiene interventions (IBM-WASH)	Hand Washing	The Integrated Behavioural Model for Water, Sanitation and Hygiene interventions or IBM-WASH, cohort	Mohammadpiu r of Dhaka (urban), Kishoreganj (rural)	10 household in each settings with 5-6 follow up visits	Kristyna RS Hulland, Elli Leontsini, Robert Dreibelbis, Leanne Unicomb, Aasma Afroz, Notan Chandra Dutta, Fosiul Alam Nizame, Stephen P Luby, Pavani K Ram and Peter J Winch
5	Impact of population and latrines on fecal contamination of ponds in rural Bangladesh	Hand Washing	The impact of the SHEWA-B interventions, case control	Rural Bangladesh	23 ponds	Peter S.K. Knappett , Veronica Escamilla, Alice Layton ,Larry D. McKay,Michael Emch,Daniel E. Williams, R. Huq, J. AlamL, Labony FarhanaB, rian J. Mailloux,Andy Ferguson, Gary S. Sayler,Kazi M. Ahmed, Alexander van Geen
6	Household Environmental Conditions Are Associated with Enteropathy and Impaired Growth in Rural Bangladesh	Hand Washing	the impact of the SHEWA-B inter-ventions-RCT	993 households from 100 communities to evaluate the impact of the SHEWA-B interventions	136 children	Audrie Lin, Benjamin F. Arnold, Sadia Afreen, Rie Goto, Tarique Mohammad Nurul Huda, Rashidul Haque, Rubhana Raqib, Leanne Unicomb, Tahmeed Ahmed, John M. Colford Jr., and Stephen P. Luby
7	The Effect of Handwashing at Recommended Times with Water Alone and With Soap on Child Diarrhea in Rural Bangladesh: An Observational Study	Hand Washing	Observation study on SHEWA-B	347 households from 50 villages across rural Bangladesh	1891	Stephen P. Luby, Amal K. Halder, Tarique Huda, Leanne Unicomb, Richard B. Johnston

No	Name of the Study	Study Area	Study Type/methods	Location (dist/Uz)	Sample Size	Principle Author/ Study Team
8	Using Child Health Outcomes to Identify Effective Measures of Handwashing	Hand Washing	Observation study on SHEWA-B	498 households in 50 villages in rural Bangladesh	2679	Stephen P. Luby , Amal K. Halder , Tarique M. N. Huda, Leanne Unicomb , and Richard B. Johnston
9	Variability in Hand Contamination Based on Serial Measurements: Implications for Assessment of Hand-Cleansing Behavior and Disease Risk	Hand Washing	Structured observation	Brahmanbaria and Sirajganj	55 caregivers	Pavani K. Ram ,Iqbal Jahid , Amal K. Halder , Benjamin Nygren , M. Sirajul Islam , S tewart P. Granger , John W. Molyneaux , and Stephen P. Luby
10	Is Structured Observation a Valid Technique to Measure Handwashing Behavior? Use of Acceleration Sensors Embedded in Soap to Assess Reactivity to Structured Observation	Policy and Strategy	Structured observation	Rural Bangladesh	45 households	Pavani K. Ram ,Amal K. Halder , Stewart P. Granger , Therese Jones , Peter Hall , Da vid Hitchcock , Richard Wright , Benjamin Nygren , M. Sirajul Islam , John W. Molyneaux , and Stephen P. Luby
11	Twenty-four-hour recall, knowledge-attitude-practice questionnaires, and direct observations of sanitary practices: a comparative study.	Policy and Strategy				Stanton, B. F., Clemens, J. D., Aziz, K. M. A. Rahman,
12	Knowledge of, attitudes toward, and preventive practices relating to cholera and oral cholera vaccine among urban high-risk groups: findings of a cross-sectional study in Dhaka, Bangladesh.	Policy and Strategy				Wahed, T. Kaukab, S. S. T., Saha, N. C.,Khan, I. A., Khanam, F., Chowdhury, F., Saha, A., Khan, A. I., Siddik, A. U., Cravioto, A., Qadri, F., Uddin, J.
13	Factors associated with relapse into drug use among male and female attendees of a three-month drug detoxification-rehabilitation programme in Dhaka, Bangladesh: a prospective cohort study.	Policy and Strategy				Maehira, Y., Chowdhury, E. I., Reza, M., Drahozal, R., Gayen, T. K., Masud, I., Afrin, S., Takamura, N., Azim, T.

Information from Organization visit to Bangladesh Stakeholders

Sl. No	Name of the Organization	Person(s) we met	Date of meeting
1	Max Foundation	Engr. Imam Mahmud Riad M.M Ahidul Islam kajol	07.01.14
2	Icddr,b	Dr. FarhanaHaque	10.9.14
3	NGO Forum for Public Health	Saha Dipak Kumar	14.9.14
4	Practical Action	Dr. HaseebMdIrfanullah	15.9.14
5	Bangladesh Center for Advanced Studies	Atiq Rahman Md Golam Rabbani	20.9.14
6	DPHE	Engr. Md. Monniruzzaman	23.9.14
7	DPHE	Md. Saifur Rahman	24.9.14
8	The World Bank	Farhat Jahan Chowdhury	11.9.14
9	Department of Environment	Md. Ziaul Haque	7.10.14
10	Plan International	Md Zillu rRahman	5.10.14
11	Water Aid	Arif Abdullah Khan	10.9.14
12	WHO	SG Mahmud	25.9.14
13	DGHS	Dr. Jahangir	10.9.14
14	IEDCR	Prof. Mahmudul Rahman	10.9.14
15	CCHPU, MOHFW	Subhas Chandra Sarker	10.9.14
16	Care Bangladesh	Harun Ur Rashid	21.9.14

Questionnaire provided to stakeholder NGOs, for information on WASH strategies they have employed

Review of nationally relevant evidence of the effectiveness of households and community WASH and climate resilient interventions.

Implementing agency: The University of Newcastle, NSW, Australia
Supported by: World Health Organization, Bangladesh

Name of the Organization:

Address:

Phone: Fax: e-mail:

Name of the contact person:

Sl no	Question	Response* Comments
1.	Has your organization ever implemented/been involved in any water, sanitation and hygiene (WASH) related project?	
	If yes, since when	
3.	Please name five large WASH projects in terms of finance** (Relevant documents will give you the idea about the geographical areas of intervention. In case this is not obtained, then please ask about the geographical areas of intervention)	
4.	Have you ever addressed the issue of climate change in your WASH projects? (If yes, ask to get a paraon how this has been addressed)	
5.	Have you ever implemented any climate resilient WASH intervention trial?	
6.	If yes, please name the project (s)** (i.e. what was the intervention? Please write at least a para on the intervention. If the respondent provides relevant documents)	

*Please circle the appropriate answer where appropriate, ** Please collect relevant document about these projects; you can add extra pages if needed.

Information provided by stakeholders in Bangladesh on types of WASH technologies they have employed

Installed Water Technologies

Shallow TW: Installed in Char and shallow water table areas.

- Cost effective
- Good quality of water
- Easy installation
- Easy O & M
- More people can be benefitted

Dual Platform TW: Installed in Char and flood prone areas.

Deep TW: Installed in the areas where shallow aquifer is contaminated with Arsenic, Iron, Salinity, etc and deeper aquifer is accessible in terms of hydro-Stratigraphy.

- Feasible in arsenic iron and saline contaminated areas.
- Easy O & M
- More people can be benefitted

Deep Set Pump: installed in the severe water table declination area in the drought zone.

- Effective solution for low water table areas.
- Good quality of water
- More people can be benefitted
- Easy O & M

Deep TW with DSP: Installed in Haor area where Shallow TWs are not working during dry season.

- Effective solution for low water table areas.
- Good quality of water
- More people can be benefitted

Multi Headed DTW:

AIRP: Installed as alternative option for safe water supply combating Arsenic contamination within 2 ppm where Arsenic and Iron are major water quality concern.

- Cost effective,
- Reducing operational and maintenance difficulties
- Able to remove 90-99.5% iron.

RWHS: Implemented mainly in coastal areas but feasible in Haor and Flood prone areas considering abundant rainfall in those areas and social acceptance of RWHS in the locality.

CBRWHS: Implemented considering rainfall & social acceptance in coastal belt but feasible in Haor and Flood prone areas also.

PSF: Slow sand filtration system, provided saline-free safe water facilities to the community.

- Safe water supply
- Able to remove Bacteria and virus
- Reducing operational and maintenance difficulties
- More people can be benefitted

Ring Well/Dug well: Installed in the flood-prone, hilly areas where shallow aquifer is contaminated with arsenic and iron.

- Easy installation
- Reducing operational and maintenance difficulties
- Good quality of water.

Pipe Water Supply System: by Deep Tube-well with Submersible Pump. The Option is context- specific solution in the drought areas.

Pipe Water Supply by Community-based Rain-water System: Water lifted from pond to filtration unit and collection unit to the overhead tank with solar energy. Safe water is delivered with pipe network to the beneficiaries through 26 Stand Posts

Aquifer Recharge System: A research is on with this and after success of this it will be replicated in other parts of drought & coastal area where serious sweet water scarcity is exist. This technology will fully be observed during the project time. Aquifer recharge has been one of the better options to quick recharge in shallow layer in rainy season in draught prone area.

Surface Water Treatment Plant:

Desalination Plant with Reverse Osmosis: Capacity of this Plant is 750 liters /hr and it can treat saline water of 46000 mg/l Chloride. The option is supporting-around 250 HHs getting salinity, Iron, Arsenic, TDS, Hardness, Manganese-free water. Coastal belt people's have access to saline and iron-free safe water at their doorstep.

Portable Water Treatment Plant: Ensured in a disaster-prone areas under concern Regional Office.

Installed Latrine Technologies

Installation of RCC Single Pit Latrine: increasing sanitation coverage among the poor in the project areas

RCC Alternative Twin Pit Latrine: were allocated among the poor segment of target unions at minimum cost as a long-run sustainable

Plastic Latrine: Promoted among the vulnerable community in the Char areas. It is long lasting, easy O & M and reusable.

Floating Latrine: installed in water-logged, coastal and flood prone areas where land is not much available for construction of latrine especially during disaster.

Eco-San Toilet: installed in drought zones as a dry sanitation options where water scarcity is acute. Easy to use for all, safe for water table, odor free and produce compost.

Construction of School Latrine: Latrines were constructed in boys, girls or combined schools. MHM were considered during installation of girls options. Hand washing facilities were inbuilt

Disable friendly Latrine: Latrine design & installation were done considering their physical condition (Disable People/Elder Group/Child/Pregnant Woman).

Hand washing practices at the community level, Max Foundation performance and progress report, (2012-2013, p 13)

Critical Times	Half yearly (June-Nov'13)		Yearly (Dec 12-Nov'13)	
	Achievement	% of achievement	Achievement	% of achievement
After Defecation	1264	66	1675	88
Before Eating	1398	73	1761	92
After cleaning child bottom	1347	71	1726	91
Before feeding child	1413	74	1751	92
After feeding child	1472	77	1760	92

Improvements in open defecation free status at the community level, Max Foundation performance and progress report, (2012-2013, p 13)