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Research Article

Rainwater Harvesting for Fighting Climate-Induced Water Poverty Problem in Coastal Bangladesh

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Abstract

Bangladesh is widely known as one of the most vulnerable countries to climate change effects with coastal areas prone to intense climatic extreme events. The climate-induced extreme events such as sea level rise, floods, cyclones, storm surges, and salinity intrusion greatly affect water supply system in that region. Rainwater Harvesting (RH) from the rooftops can be a good alternative source of safe water as the country receives ample (on an average 2400mm) rainfall per year that could reduce water crisis problem in the coastal region. Water demand and supply equation can be a measurement tool to measure rainwater availability to meet water demand over the whole year. But utilizing rainwater needs government support regarding the RH policy for sustainable use of rainwater, creating awareness, RH promotion for letting people know about its advantages, disadvantages and challenges, technical support for good maintenance and operation for rainwater harvesting system and finance for settings up the infrastructure. This paper examines the possibility of rainwater harvesting for reducing water poverty in coastal Bangladesh. The study found that rainwater harvesting can supplement the existing water supply systems and reduce the water poverty in the coastal region of Bangladesh.

Keywords: Climate induced; Coastal areas; Demand and supply; Extreme events; Government support; Rainwater harvesting; Water poverty

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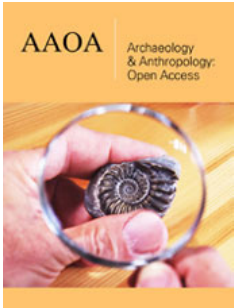

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Introduction

Climate change is the most discussed issue among the present global environmental changes and research studies worldwide because it links to extreme events that affect the socioeconomic and environmental wellbeing of populations [1] and each country is either responsible or affected by it or both. In terms of climate change effects, Bangladesh is regarded as one of the most vulnerable countries in the world. Adverse impacts of climate change are mostly on water sector in terms of reduced water supply, deteriorated water quality, reduced recharge of groundwater, and reduced water availability for rain-fed agriculture in Bangladesh [2]. These adverse impacts on water may arise from climate-induced hazards like sea level rise, cyclones, storm surges, floods, and salinity intrusion, [3]. These factors are directly or indirectly contributing to the water crisis in coastal Bangladesh. Water, as a critical resource, is seen as one of the most stressed resources that need the attention of policymakers, businessmen, resource managers, and governments. "Access to safe drinking water and sanitation is a human right" (WWDR). But access to safe water is not available everywhere. This scarcity of safe water is more severe in developing countries like Bangladesh due to climate change effects. Coastal people within the country suffer more from water shortages. This shortage of safe water can be defined as water poverty in terms of quantity, monetary expenditure for water purchase, and the number of months facing water scarcity. Water scarcity or shortage is a situation whereby water sources become insufficient for people because some factors such as population growth, climate change, increasing water demand, or other factors may lead to water shortage for consumption [4]. Oxford Dictionary defines Water Poverty (WP) as "the situation of not having access to enough water, or water of an adequate quality, to meet one's basic needs"[1]. This definition characterizes water poverty in terms of quantity and quality. For example, people in coastal areas in Bangladesh face water poverty not in terms of quantity but quality because major sources of water such as river water, pond water, and ground water are either contaminated by salinity or arsenic concentration.

[1]https://en.oxforddictionaries.com/definition/water_poverty

This makes water unsafe to drink. In Raskin et al. [5] where water poverty is measured in terms of quantity, three conditions are found:

a) When annual water supply is above 1700m3 per capita which indicates that little or no water scarcity.

b) When less than 1000m3 per capita which indicates water scarcity that threatens economic development, human health, and well-being.

c) When annual water supply is less than 500m3/capita which characterizes absolute water scarcity. In Islam [6] water poverty is measured in terms of monetary expenditure and number of months faced by water shortages (Table 1).

Table 1: Degree of water poverty in terms of monetary expenditure and number of months.

Water Shortage (in month)	Degree of WP	Monetary Expenditure for Buying Water (in BDT)
More than eight months	Very acute WP	4500-Plus
More than 6 but less than 8 months	Acute WP	3500-4499
More than 4 but less than 6 months	Moderate/average WP	2500-3499
More than 2 but less than 4 months	WP	1500-2499
More than one but less than 2 months	No WP	500-1499

In the nutshell water poverty is defined as a "situation where a nation or region cannot afford the cost of sustainable clean water to all people at all times" [7].

Water poverty in Coastal Bangladesh

Coastal region shown in Figure 1 is the place for opportunities and threats. On one side, it has some advantages in terms of beaches, coral reefs, estuaries, seagrasses, mangroves, transport, commerce, and other natural resources [6] and on the other side, the risk of extreme events lessens the opportunities arising from advantages. Coastal people do not face physical scarcity of water but rather the scarcity of water quality which intensifies by extreme events. Extreme events such as cyclones, floods and storm surge that damage water supply infrastructure is main contributing factors to water poverty in coastal Bangladesh. These extreme events may increase in the context of intensity and frequency with anticipated climate change effect. In the last decade, coastal people in Bangladesh faced two most devastating cyclones, namely Sidr and Aila. During and after these extreme events people faced acute drinking water shortage as almost all water supply infrastructure in the coastal belt in Bangladesh was destroyed. These extreme events mostly affected the Barguna, Khulna, Bagerhat, Patuakhali, Sathkhira, and Priojpur districts [8,9]. These districts are located in the coastal zone where water supply systems are damaged by climate- induced cyclones. After Aila hit the coastal areas in Bangladesh, the WASH (Water Sanitation and Hygiene) sector assessment, carried out during May and June 2009, found that some 4,000 protected ponds, 1,000 pond-sand filters, and 13,000 tube-wells were damaged. This damage adversely affected water supply coverage by 50%. In addition, over 210,000 household latrines were fully or partially damaged, accounting for 32% of the total sanitation coverage by cyclone Aila [4] in most affected areas in Khulna and Sathkhira. People in Sathkhira district depended on Aid Water (63%) for their drinking purpose during Cyclone Aila [4] and only 1% of people could rely on Tube well [3]. An outbreak of diarrhoeal diseases due to severe water scarcity caused the death of approximatelay 15 people in Khulna during the hit of Aila in 2009 [9]. However, people faced difficulty with seawater engulfing their land [10], fresh water in ponds, and groundwater that made the water unsuitable for potable use. After Aila, almost every family in Sathkhira and Khulna districts suffered from diarrhoea, typhoid, and skin diseases due to excessive contaminated water and the crisis of drinking water supply [9]; (Figure 1). Water- related climate change impacts, especially coastal flooding and riverine flooding, are among the most critical issues for Bangladesh due to its location in deltaic floodplains of Himalayan Rivers. Heavy monsoon rain with low floodplain gradient, congest drainage channels, and storm surges in coastal areas cause severe floods in coastal Bangladesh [11].

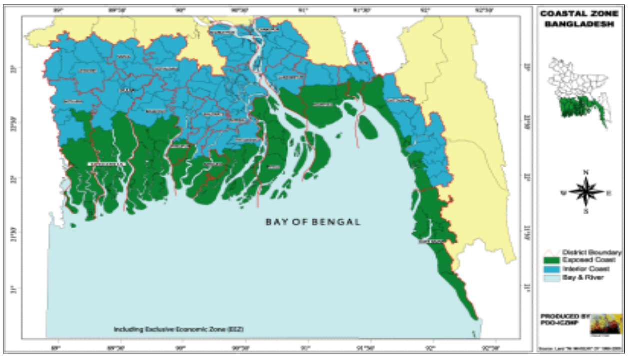

Figure 1: Coastal areas in Bangladesh [33].

Both, coastal flooding[2] and inland flooding[3], are predicted to increase. These floods are recurrent extremes for coastal people in Bangladesh that lead to devastating impacts such as loss of life from drowning, the outbreak of water-related diseases [12], destruction of water supply infrastructure and agricultural production. One-fifth of Bangladesh is inundated every year, and in an extreme event two-thirds of the country can be inundated [13]. The frequency of floods may increase due to climate change that will lead to the reduction of water quality and the increase of freshwater scarcity as these floods can damage water treatment and supply infrastructure [11]. The study by the World Bank [14] found that total flooding areas will be enhanced by 6%, 10%, and 20% against

[2]Water from sea and river.

[3]Water from river or rain.

sea level rise of 15cm, 27cm, and 62 cm respectively [14]. The study has considered 13% enhancement of flooding areas by 2050 under climate change condition. The freshwater sources can become extinct as floods destroy them [11].

The following Table 2 shows flooding coverage in the coastal zone in Bangladesh. Storm surge is another climatic factor that is responsible for water poverty in the coastal region in Bangladesh. It has the direct impact on water sources by bringing salt water into land and making the freshwater unusable. Coastal drinking water sources are vulnerable to contamination from seawater particularly during climatic extreme events like storm surge due to cyclonic tropical storm [15]. The country might experience increased intensity and frequency of climate-related extremes like the storm surge that would impact most parts of the country particularly the coastal zone [3]. Shortage of safe drinking water may be severe in the coastal region in Bangladesh due to climate-induced hazards like storm surges [16]. Sarker & Ahmed [11] mentioned that about 45% of coastal area is threatened by storm surge of >1m and 4% of coastal areas is threatened by storm surge of <1m height respectively. The following Table 3 shows district wise areas for the risk of inundation by storm surge in coastal Bangladesh. Salinity intrusion in surface and groundwater due to lowering groundwater level, excessive water extraction from aquifers, lack of recharge, and sea level rise reduce freshwater availability [17-21] in coastal Bangladesh and make the region more susceptible to water poverty in Bangladesh. Climatic disasters like floods, cyclone, sea level rise, and storm surge accomplice salinity intrusion that contaminate freshwater sources and create water poverty for coastal people [11]. As the floodplain (with the height of less than 1 meter above sea level) covers 80% of the total area of the country with tributaries and distributaries [2], the coastal region becomes susceptible to water poverty arising from the probable more sea level rise. There are 14,698 square kilometer areas that are highly exposed to the extreme salinity of 1ppt of zero sea level rise [11]. Additionally, predicted more sea level rise as a consequence of climate change will exacerbate the situation significantly. Most of these highly saline exposed areas are in the southern part of Bangladesh besides the Bay of Bengal. In these areas, salinity intrusion creates the problem for potable water supply and agricultural practices. The salinity level of some coastal districts is presented in the following Table 4.

Table 2: District wise flooding coverage in the region in bangladesh (adapted from [11]).

Districts	F3 Area (in sq.km)	F3 Area (in %)	F4 Area (in sq. km)	F4 Area (in %)	F3 and F4 Area (in %)
Bagerhat	279.72	7.08	1680.91	42.57	49.65
Barguna	188.4	12.41	79.35	5.23	17.64
Barisal	111.53	4.48	1916.84	76.99	81.43
Bhola	188.9	5.95	638	20.1	26.05
Chandpur	4.67	0.28	1386	81.63	82.03
Gopalganj	10.25	0.69	1433.94	97.23	97.92
Jessore	58.53	2.27	1407.72	54.5	56.77
Jhalokati	153.1	20.75	502.61	68.13	88.88
Khula	85.17	2.03	1125.94	26.78	28.81
Lakshmipur	114.21	7.33	245.16	15.75	23.08
Narail	2.34	0.24	951.93	95.67	95.91
Patuakhali	268.62	8.5	891.93	28.21	36.71
Pirojpur	67.85	5.34	1038.77	81.68	87.02
Shariatpur	0.37	0.03	1001.39	80.05	80.08
Total	1533.66		14300.49		

Table 3: District wise storm surge risk areas in coastal region in Bangladesh (Adapted from [11]).

Districts	Area (in sq. km with Storm Surge >1m)	Area (in % with Storm Surge >1m)	Area (in sq. km with Storm Surge <1m)	Area (in % with Storm Surge <1m)
Bagerhat	2271.58	57.52	399.7	10.11
Barguna	1287.3	84.82	0	0
Barisal	1512.3	60.74	259.65	10.43
Bhola	1819.84	57.31	0	0
Chandpur	86.6	5.1	7.55	0.44
Chittagong	1723.62	34.58	0	0

Cox's Bazar	742.29	32.78	0	0
Feni	685.63	73.44	0	0
Jhalokati	693.57	94.02	11.43	1.55
Khula	1340.51	31.89	522.33	12.42
Lakshmipur	905.78	31.89	108.55	6.97
Noakhali	2480.69	78.76	72.87	2.31
Patuakhali	2418.29	76.54	0	0
Pirojpur	984.39	77.41	130.08	10.23
Satkhira	1153.98	29.52	110.64	2.83
Shariatpur	323.62	25.87	7.42	0.59
Total	20429.99		1630.22	

Table 4: Salinity presence in surface water in some coastal districts [33].

District	Salinity in Surface Water in ppm
Bagerhat	5->10
Barguna	5-Jan
Barisal	0
Bhola	10-Jan
Patuakhali	10-Jan
Pirojpur	0-10
Satkhira	5->10
Khulna	5->10

Objective and research questions

The objective of this study is to examine the possibilities of rainwater harvesting to reduce water poverty problem in coastal areas of Bangladesh and to examine the role of government in promoting rainwater harvesting for mitigating water poverty problem in the coastal region of Bangladesh. In order to achieve these objectives, research questions are addressed in this paper are:

A. How climate-induced extreme events (cyclones, sea level rise, floods, salinity intrusion etc.) are responsible for water poverty in the coastal zone?

B. Is it possible to solve the problem by rainwater harvesting?

C. How can government play a role in facilitating rainwater harvesting system in the coastal zone in Bangladesh?

Methodology

Study site

The study was carried out in the coastal region, more specifically at Mongla Upazila[4] under Bagerhat district in Bangladesh. One village namely Chila was selected for the study due to its geographical location and proximity to the Sundarbans (one of the largest mangrove forests in the world, rich in biodiversity and ecosystem). People in the village use rainwater harvesting system for a long time. The village is highly vulnerable to climatic extremes due to a proximity of Bay of the Bengal and the bank of Passur River. The study site is located between 21° 49 and 22° 33 north latitudes and between 89° 32 and 89° 44 east latitudes [22]. The study site is surrounded by Rampal Upazila (North), Morrelgonj and Sarankhola Upazila (East), Bay of Bengal (South) and Dacope Upazila of Khulna District (West). Chila is a coastal village composed of seven para or sub-villages namely Purba Chila (East Chila), Paschim Chila (West Chila), Gabguniya, Dakshin Chila (South Chila), Sindpur Tala, and Ulukata [23]. Chila is the largest village with 7502 inhabitants (population density is 1097 per sq. km) under the jurisdiction of Chila Union that falls within Mongla Upazila.

Data collection and analysis

The data were collected by household survey, focus group discussions, and a case study method during the period of June and July 2017. Data were collected from 80 households by using structured questionnaire from Chila village in Mongla Upazila. The participants were invited either by researcher or research assistant to participate in the study. Before participation they were informed about the objectives of the study and nature of questions; they could leave any question unanswered or stop their participation in the study at any time. The random sampling strategy was used to select households, but some criteria were maintained: the

[4] sub district. It is the second tier of administrative units of local government in Bangladesh.

participants must be 18 years or older, one respondent from one household, the household must use rainwater harvesting system. After the household survey, focus group discussions were held to cross-check collected data. This study is strongly multidisciplinary in nature and uses qualitative and quantitative data analysis methods and SPSS and NVivo software used to analyze the collected data. The qualitative data were collected through observations, interviews, survey questionnaire with the description, and Focus Group Discussion with community people. The quantitative data were collected with questionnaire surveys with quantitative figures of the study site.

Findings and analysis

Linkages of climatic extreme events and water poverty: How climatic extreme events create water poverty in the coastal region of Bangladesh? To answer this question, the relationship between climate extreme events and water poverty need to be understood. People in Chila are highly vulnerable to the climate-induced tropical cyclone, salinity intrusion, river bank erosion, drought, and storm surge as the village is located just beside the bank of Passur River. These natural and climatic hazards create the freshwater crisis for the villagers. The topography of the village is almost flat and only a few feet above the sea level. Cyclone with high storm surge water and heavy wind speed causes heavy damage and jeopardizes the livelihood of the people in Chila. Almost all sources of freshwater are inundated with saline water from the tropical cyclone, tidal surge, storm surge, and floods, and destroy freshwater and sanitation facilities. Figure 2 shows the reasons for water poverty in Chilla Bangladesh.

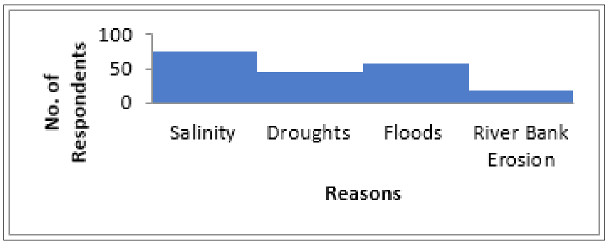

Figure 2: The reasons of water poverty in Chilla, Bangladesh.

Climate change is expected to cause the significant change in river salinity particularly in the south-west coastal region. As the study site is located in the same region, salinity problem is highly integrated with the villager's daily life. The river water is salty because the river has a direct connection with the Bay of Bengal. Salinity is the main factor for creating water poverty in the coastal region and other climatic extreme events accomplice this factor in different ways. Flood and storm surge are contributing to salinity problem as it brings saline water from the Bay of Bengal to Pasur River and pollutes the water sources. According to the household survey, 75 respondents informed that salinity intrusion causes water poverty by polluting water sources like groundwater, pond water, canal, and even collected rainwater with Ferro cement storage tank as the tank absorbs water from the soil and mixes it with the collected water. The saline water mainly comes from the Bay of Bengal and inundates the village via Pasur River. Here, Pasur River works as the channel flowing saline water from the Bay of Bengal to Chila. The land of the village is low lying so the saline water can enter the village easily. During the rainy season, heavy rainfall increases saline water level of the river and flows over the road and contaminates freshwater sources of the villagers. The road is not well structured and has many leaks and saline water flows through those leaks which pollute the source of freshwater.

The household survey found that 45 respondents face water poverty due to drought. Due to the climate change effect, dry season period will extend in the coming future that can cause more frequent droughts which will deteriorate the water poverty crisis in the village. During the dry season, the villagers face the acute freshwater crisis due to salinity in river water and less rainfall. On the other hand, 57 respondents revealed that they face water poverty due to floods. Water poverty is more severe during floods as flood water drowns water collector[5], collected water, sweet pond, and makes entire water sources salty and unusable for potable purposes. The floods also damage the infrastructure and water supply systems. Moreover, 19 respondents in Chila village informed that riverbank erosion creates water poverty for them by bringing the village nearer to the saline water which is responsible for destroying roads, embankment, and other infrastructures. Some factors such as lack of navigability of Passur River, heavy rainfall, poorly managed sand and gravel extraction, sediment, and the extreme stream of Pasur River are responsible for river bank erosion. Two respondents have lost their entire land holdings and become landless and three respondents lost all croplands due to riverbank erosion of Pasur River in Chila. The following Figure 3 shows the dimension of water poverty in Chilla, Bangladesh.

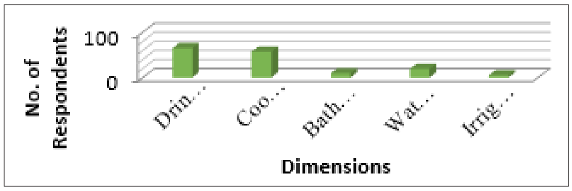

Figure 3: Dimensions of Water Poverty in Chilla, Bangladesh (Source: Field Data, Author, mutually inclusive).

Water has the connection to every aspect of life. Improvement in access to freshwater can turn the problem into the possibility. But this improvement is not an easy task to achieve and climate-induced disasters make it more difficult by creating water poverty from different dimensions. These dimensions are drinking water scarcity, cooking water crisis, bathing water crisis, water collection, and irrigation. The Figure 3 shows that 65 respondents face drinking water crisis due to climate-induced extreme events and they are forced to use and drink saline water. Besides the drinking water problem, cooking water crisis is the second top (57) severe

[5]Container to keep water (storage tank).

water poverty dimension in Chilla as water from the river, canal, and the ground source is not suitable for cooking purposes. The community in Chila needs to collect water from the sweet pond (freshwater source privately owned) which is far distance and is the third top dimension of water poverty 19 shown in Figure 3. The men, women, and children need to spend almost the whole day to collect water from the nearest (four kilometers away) sweet pond. Moreover, during stormy weather, they cannot collect water as they need to cross Pasur River. They have to wait until the weather is clear and no signal for the storm. Furthermore, the sweet ponds became salty during 2007 and 2009 due to the cyclone Sidr and Aila. During these cyclones, the villagers became fully dependent on bottled water, water supply by charitable organizations, Non-Government Organizations, and government support during these extreme events.

The bathing water crisis is the fourth 9 shown in Figure 3 water poverty dimension in Chila. As the river water is salty, people cannot use it for bathing purposes for a long time as it creates skin problems but they do not have an alternative. Moreover, the farmers cannot cultivate their land, the vegetable gardeners cannot grow their vegetable, fish farmers cannot farm white fish (like common carp, grass carp, kalibaus, rui, sarputi, tilapia) and other local fish due to salinity problem. The salinity of the water in agriculture sector is the fifth water poverty dimension in Chilla. No agricultural products can be grown except shrimp and crab farming. But how to mitigate this water poverty problem in coastal Bangladesh will be addressed further when answering the second research question. Is it possible to mitigate this water poverty problem by rainwater harvesting?

Possibility of rainwater harvesting to mitigate water poverty problem in Coastal Bangladesh: In this section, the possibility of rainwater harvesting as an alternative source of freshwater for solving water poverty problem will be analyzed. This analysis will be done based on demand and supply of water for household demand. To resolve water poverty problem in coastal Bangladesh, an innovative mechanism of rainwater harvesting has been developed by coastal people to cope with the problem. Rainwater harvesting system can be used in arid, semi-arid, countries, or regions, remote or scattered human settlements [24]. Bangladesh receives about 2400mm (on an average) rainfall per year. Collected rainwater is enough to supply water for 8-10 months even in the driest region (Rajshahi) of Bangladesh [25].

People can collect and store rainwater for future use in buckets, storage tanks, ponds, and wells for agricultural, domestic, environmental, and industrial uses and this is referred as rainwater harvesting [24,26]. "Rainwater Harvesting is an integrated system that includes rainwater catchments areas, water storage, and transportation systems. Rainwater harvesting is a system of inducing, collecting, storing, using, and conserving local rainwater either from rooftop or in open space for agricultural, potable, or industrial purposes" [6]. "Rainwater Harvesting strategies may vary from direct runoff concentration in the soil for direct uptake by crops to collection and storage of water in structures (surface, sub-surface tanks, ponds and small dams) and aquifers for future productive uses" [27]. They have also classified the rainwater collection systems as rooftop catchment system, in-situ catchment systems, and runoff catchment systems. Rooftop catchment system is the most popular system in coastal Bangladesh. Rainwater harvesting is a simple and low-cost technique that requires minimum specific expert knowledge and offers many benefits [24] like resolving drinking water crisis as it represents acceptable means of potable water and meets physical, chemical, and bacteriological quality [28]. The average family size in Chila community is 4.1 persons [23] and research indicates that each person requires 20 litre of safe water per day to maintain minimum essential levels for health and hygiene [29]. Based on that family size and water demand per day, total water demand and total water supply possibility per year by rainwater harvesting in Bangladesh can be calculated by using Worm & Hattum [24] formula:

Total Demand:

D = WxHxY

Demand= Water Use x Household Members x 365 days[6]

Where:

D = Demand

W = Water Use

H = Household Members

Y = Year (365 days)

So, total demand of water of a household in Chila is:

Demand= 20 litres x 4.1 members (Average household Member is 4.1 in Chila) x 365 days

= 29,930 litres per year.

Total Supply:

S = RxAxCr

Supply = Rainfall x Area x Runoff coefficient[7]

Where:

S = Mean annual rainwater supply (m3)

R = Mean annual rainfall (m)

A= Catchment area (m2)

Cr = runoff coefficient

So, the mean annual rainfall is 2400mm per year (=2.4) and the catchment area 3mX4m = 12m2

S=2.4m/yx12m2 x 0.9=25.92m3 per year=71 litres per day

[6]Worm and Hattum, 2006.

[7]Worm and Hattum, 2006.

Rainwater harvesting can supply 71 litres of water per day but every household (on an average) requires 84 litres[8] of water per day. It indicates that rainwater harvesting can be a good alternative source of water for coastal communities where climate-induced disasters are affecting water supply severely. From formula to practical field there are some factors to consider for effective demand and supply predictions and effective use of rainwater.

These factors are:

a. Children and adults require a different volume of water. In this study, all members of the household considered as an adult person.

b. Areas of rooftop vary depending on the size of the building. The total water collection also varies due to different roof size. The volume of water collection depends on the size of the rooftop of the house.

c. Water demand may be higher in dry seasons thus water demand varies as the people are more thirsty in dry season than other seasons

d. Rain does not fall equally all over the year. For instance, 80% rainfall does take place during the monsoon (June-October) in Bangladesh.

e. Number of household members also varies so that their water demand will also vary per household.

Besides these factors, water use also varies. Some particular types of water use need higher quality than other types of water use. For instance, drinking and cooking water need higher quality than washing clothes and irrigation. But the quality of collected rainwater depends on the number of factors such as environment, maintenance, and operation of rainwater harvesting. Quality of collected rainwater may be affected by air pollution, animal or bird dropping, insects, dirt and organic matter so that regular inspection, occasional repairing, and cleaning are important for effective use of the system [24]. Lack of awareness about maintenance and operation adversely affect the performance of rainwater harvesting [28].

Rainwater harvesting may be attractive regarding technical, economic, and ecological context but the possibility of health risk from intake of harvested rainwater related to microbiological and chemical contaminants needs to be taken into consideration. Chemical and microbiological contaminants found in the harvested rainwater sometimes exceed international and national guidelines for safe drinking water [30-32]. In order to tackle these challenges, the government of Bangladesh can promote the rainwater harvesting system as an alternative and sustainable source of water in the coastal region. In the next section of this paper, the third research question that is "how government can play role in promoting rainwater harvesting system in coastal Bangladesh?" will be answered.

Water supply and sanitation policies and strategies: Bangladesh context: To meet the demand of safe water, the government of Bangladesh has formulated several policies and strategies. Such policies are National Policy for Safe Water Supply and Sanitation 1998 (NPWSS), National Water Policy 1998 (NWP), National Water Management Plan 2004 (NWMP), Sector Development Framework on Water Supply and Sanitation 2004 (SDFWS), and Pro-Poor Strategy for Water and Sanitation Sector in Bangladesh 2005 (PSWSSB). However, these policies are rather general and do not have specific characteristics for supplying safe water to coastal people as water poverty problems differ in other regions. Additionally, these policies do not consider local context to solve water poverty problem [33].

For this reason, these policies cannot achieve the goal of supplying sufficient safe water to every household. For example, NPWSS emphasizes the groundwater supply for increasing access to safe water by enhancing a number of tube wells. But groundwater is salty and contaminated with arsenic in the coastal region so it is not a suitable source of safe water for coastal people. Instead, coastal people use rainwater as their safe water supplier as this source is free from both salinity and arsenic contamination but there is no specific policy or guidelines for this practice and no technical and financial cooperation has been provided by the government. In Chilla, 79 respondents informed that the government does not play any role regarding rainwater harvesting system for supplying safe water to the households. The river, canal, and pond water sources are salty and unusable before purification for domestic purposes. And purification process is expensive for households as most of them are poor.

The government neither purifies the water nor provides any other alternative to supply safe water to the households. It is the responsibility of the communities to ensure supply of the safe water to their households. According to one remaining respondent, the government has provided Ferro-cement storage tank for rainwater harvesting but no practical application has been confirmed. However, all respondents informed that they do not need any permission to set up rainwater harvesting infrastructure. There is no discipline to use rainwater as an alternative source of safe water. Anybody can set up rainwater harvesting infrastructure anywhere. In this context, it seems that the government does not have control over using rainwater in the coastal region and failed to ensure safe water supply to the coastal communities.

Moreover, the government does not provide finance for setting up rainwater harvesting infrastructure. As per the survey, 56.25% respondents financed their rainwater harvesting infrastructure from their own savings, and 41.25% respondents got finance from Non-Government Organizations (NGOs) and this type of finances was received in either with large storage tank and other materials or financial benefit like lending money. In providing the financial benefit, ASA (Association for Social Advancement) has been playing leading role but the NGO did not lend money for rainwater

[8]Based on 20 litres of water demand per day per person and family size is 4.1 (on an average in Chila community).

harvesting. The clients have taken the loan for other purposes but used it for purchasing rainwater harvesting materials. Besides this financial benefit, the other NGOs like World Vision, Sushilon, Prodipon, Rupantor, Concern Worldwide, and the Tearfund United Kingdom have provided large storage tank and other rainwater harvesting materials [34]. Remaining 2% respondent financed their rainwater harvesting infrastructure with getting help from neighbor. The following Figure 4 shows the sources of finance for rainwater harvesting in Chilla.

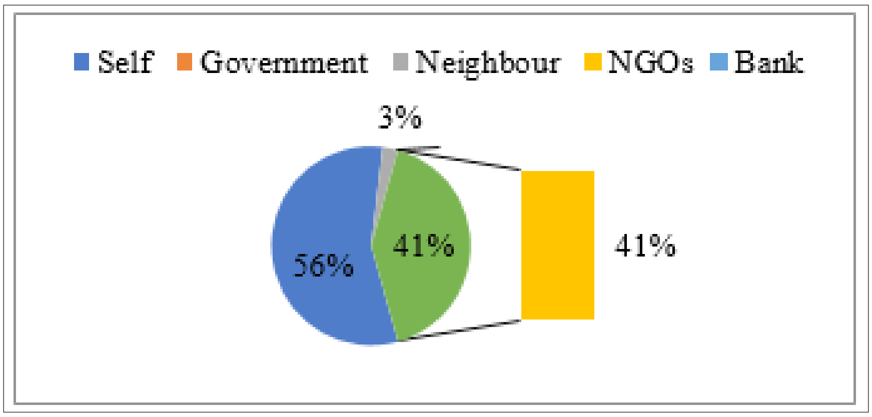

Figure 4: : Sources of finance for rainwater harvesting infrastructure in Chilla, Bangladesh.

Generally, people have a lack of their working skills and need to overcome that lacking so that they need training. The training is more important in technical issues like managing rainwater harvesting infrastructure. In this study, 38.75% respondents got training while 61.25% respondents did not get training in rainwater harvesting from NGOs or government. In this study, no single respondent got training from the government body. The entire training receivers got training from several NGOs like World Vision (42%), Concern Worldwide (19%), Rupantor (14%), Prodipon (14%), Tearfund UK (5%), BRAC (Bangladesh Rural Advancement Committee) (3%), and Sushilon (3%). The following Figure 5 shows the training providers in Chilla.

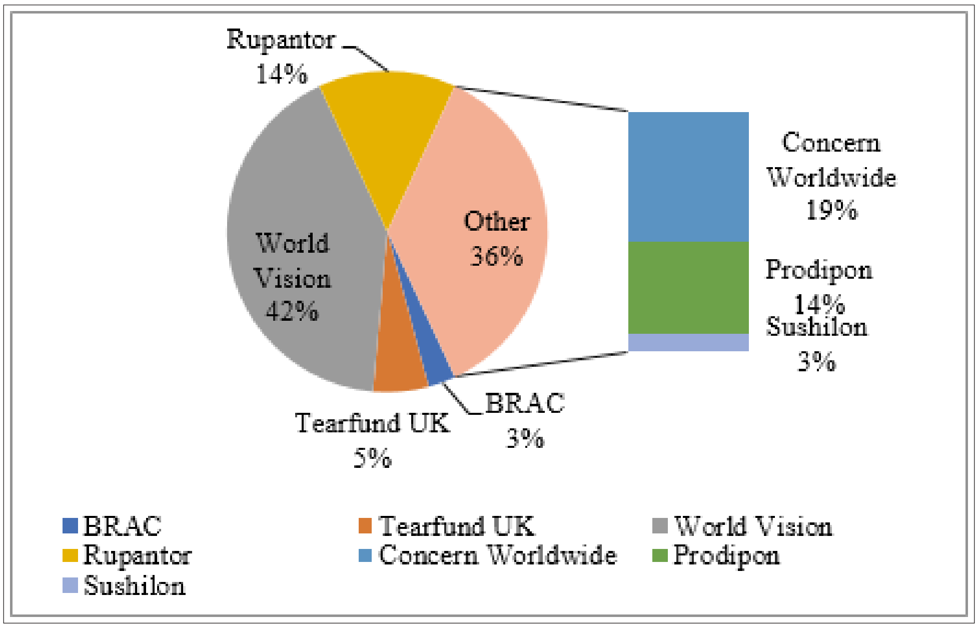

Figure 5: Trainers about rainwater harvesting in Chilla, Bangladesh.

Conclusion

Climate-induced extreme events and increasing demand for safe water are responsible for creating water poverty in the coastal region of Bangladesh. The coastal communities have their own understanding of the local context for safe water supply to their households. The rainwater seems to be a good alternative source of safe water in Chilla where communities face severe water poverty due to climate-induced disasters and that source is free from arsenic and salinity pollution. Rainwater harvesting is feasible regarding rainfall amount, family size, roof size, and safe water demand. But water supply and sanitation policies and strategies failed to recognize the local context and could not achieve goals (e.g. to supply sufficient safe water to the communities) that deteriorated the water poverty problem. To address these crises properly, policies and guidelines are required with the consideration of local context for using rainwater as an alternative source of safe water.

The government can play an important role in preparing and implementing the policy about rainwater harvesting, bringing the discipline of rainwater collection, use, and conservation for future use, and creating awareness about rainwater harvesting. The government can also provide trainings for local people in effective and efficient use of rainwater, and provide financial assistance (either in monetary value or providing materials like storage tank, gutter pipe, small container, switch, and other materials for rainwater harvesting) for setting up rainwater harvesting infrastructure in order to solve water poverty problem.

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