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Impact of Climate Change on the Livelihood of Slum-dwellers: A Case of Dhaka City

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Abstract: *The main focus of this paper is to understand and assess the impact of climate change on the livelihood of slum dwellers in Dhaka city. Being one of the most climate vulnerable countries in the world, Bangladesh experiences frequent natural disasters like floods, river erosion and cyclones; these impacts adversely on the lives and livelihoods of millions. Due to the worst victim of climate change, every year a large number of people are becoming climate refugee. These climate refugees, after losing everything, are increasingly migrating to capital Dhaka and usually taking shelter in slums which lack basic services. These slum dwellers are important for Dhaka city since they are keeping the economy going through their hard labour and providing necessary services to the city dwellers. Therefore, it is important to increase the understanding of the actual climate change dynamics on the slum dwellers in Dhaka. This study addresses the questions how vulnerable they are and why, what are the institutional coping mechanisms and what are the constraints that exacerbate vulnerability. The study also suggests some institutional and policy guidelines to address the climate change-induced challenges on the livelihood of slum dwellers.*

1.0 Introduction

Today climate change is not merely a concern but a reality. Global climate change has already had observable effects on the environment. The global warming induced greenhouse gas concentration in the earth's atmosphere and the consequent sea level rise are going to add fuel to the fire. The disadvantageous geographic location, flat and low-lying topography, high population density, reliance of many livelihoods on climate sensitive sectors like agriculture and fisheries and inefficient institutional aspects of Bangladesh have made the country one of the most vulnerable ones to climate change. Many of the anticipated adverse impacts of climate change in the form of recurrent flood, severe cyclones, water logging, droughts and river erosion, will aggravate the existing stresses that already slow down the development of Bangladesh, particularly by reducing water and food security, damaging essential infrastructure and therefore, migrating a large number of coastal and countryside population to capital Dhaka (Huq and Ayers, 2008).

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Dhaka, covering a population of 14 million with 4.4% annual growth rate, is the fastest growing megacity in the world (UN-HABITAT, 2009). This rapid growth has been due to unplanned urbanization coupled with migration of rural poor, particularly climate refugees who mostly take shelter in slums. In a 1996 survey, the Centre for Urban Studies (CUS) found 3,007 slums with a minimum of 10 households and roughly 1.6 million slum dwellers in Dhaka Metropolitan area (DMA) alone. The 2005 Slum Census about Urban Bangladesh identified 4,966 slums in DMA with a total slum population of 3.4 million and by 2015, the population of Dhaka city has been projected at 17.6 million, with up to 60% in the slums.

The expected impact of climate change to this city and its potential for disaster is frightening. Experts believe that the melting of glaciers in the Himalayas, along with increasing rainfall attributable to climate change, will lead to more flooding in Bangladesh in general, especially in cities located near the coast and in the delta region including Dhaka. Dhaka may also experience increased temperature from rising levels of vehicle exhaust emissions, increased industrial activity and increased use of air conditioning (Alam and Rabbani, 2007). The slum dwellers are therefore, vulnerable to the impacts of climate change due to poor infrastructure, lack of sanitation, scarcity of safe water and employment insecurity.

The impact of climate change puts extra burden on the socio-economic security of the slum dwellers. Their vulnerabilities are likely to be increased due to the dependence of livelihoods on climate sensitive natural resources and weak social protection structures. Climate change is likely to increase the frequency of extreme weather events such as floods, cyclones. While there is uncertainty in the projections about the exact magnitude and patterns of climate change, its consequences will change the fate of many generations to come if no appropriate measure is taken. In order to minimize the consequence, the article attempts to assess the climate change impact on the slum dwellers of Dhaka city. In addition, the article will also provide some policy guidelines which will help the authority concerned to undertake effective adaptation measures as well as to formulate pragmatic policies to address the climate change-induced challenges on the livelihood of slum dwellers.

2.0 Literature Review

There is a plethora of literature on the impact of climate change on the coastal population but there is a paucity of literature exclusively focusing

on the vulnerability of low income slum dwellers. However, the core findings of the researches so far attempted to assess the impact of climate change on slum dwellers in Dhaka city are pointed out here.

Among the 11 coastal and delta cities in Asia examined to climate change impact, Dhaka is identified as the most vulnerable one. Being situated just meters above the sea level, it is regularly impacted by cyclones and flooding (WWF, 2010). In the last 50 years severe flooding has impeded the development of Dhaka. The industry, commerce, utility services and infrastructure are the key sectors badly affected. Productivity reduces during and after major flooding which increases the vulnerability of the urban poor (Reid and Sims, 2007).

Climate change is associated with hotter summers and colder winters. Temperatures in Bangladesh have increased about 1°C in May and 0.5°C in November between 1985 and 1998. Temperature extremes are increasing and winter temperatures as low as 5°C have been recorded in January 2007 which was the lowest in 38 years (Reid and Sims, 2007). Changes in temperature and rainfall may change the geographic range of vector-borne diseases such as malaria and dengue. Young children and pregnant women are especially vulnerable to malaria that leads to low birth weight and maternal anaemia (WHO, 2002).

Slum dwellers in Dhaka city are the key player to provide essential services as laundrymen, barbers, newspaper boys, food vendors, rickshaw-pullers, sweepers, carpenters and electricians. Even the life of the middle and upper classes is impossible without the services of slum dwellers as domestic help. But it was found that at least one in thirteen people lived in slums had been forced to change their occupation during the 1998 flood, while the floods left 27.4% of people unemployed (Reid and Sims, 2007; Moser and Satterthwaite, 2008).

Most of the slum dwellers in Dhaka live on the edges of rivers and canals and on flood prone embankments which are vulnerable to climate change (WB, 2007). 46% slum houses are of poor quality which becomes more vulnerable during the flood and cyclone. Moreover, population density in slums of Dhaka ranges from 700 to 4,210 per acre and a minimum of four and maximum of ten people share a room, which is highly congested and unhealthy. Utility services such as water supply and sanitation, solid waste management are still inadequate in slums. Consequently, both household waste and human generated wastes go directly or indirectly into the low-lying lands or water bodies which significantly influence the

incidence of waterborne and airborne diseases (CUS, 2005; UN-Habitat, 2009).

Climate change impacts on human health both directly and indirectly. For example, the floods in 2004 caused 800 deaths, while the cyclone Aila in 2009 affected 8.5 million people, causing 3,500 deaths in Bangladesh (Sayeed, 2007). Climatic changes will also affect the distribution of climate sensitive diseases such as malaria, diarrhoea, dengue and hypertension associated with heat stress, asthma and skin diseases which have increased significantly in Bangladesh over the last 30 years (Reid and Sims, 2007). Though a causative connection between climate change and these diseases is difficult to verify, the conditions related to climate change (temperature, rainfall) and its impacts on water supply and sanitation generate favourable environments for the spread of such diseases (Hashizume et al., 2007).

Hossain (2005) stated that slum dwellers invariably live below the poverty line and have limited access to employment in formal sectors. Dhaka City Corporation (DCC) has little initiative to create opportunities for them. The slum dwellers therefore, try to cope with urban life through 'household strategies' such as putting more family members into work force, withdrawing children from school, establishing patron-client relationships with local leaders.

People develop coping strategies to deal with climate variability as with other shocks or stresses. These include building social networks as forms of insurance, traditional forecasting in order to be prepared for climatic changes and ingenious means of protecting assets. However, the poor's range of coping strategies is naturally restricted by their lack of assets which is further accelerated with environmental degradation (DFID, 2004).

Today climate change is the most talked about issue in Bangladesh. The adverse impacts of climate change on rural areas cause increased migration to urban areas in pursuit of non-agricultural employment (Kelkar and Bhadwal, 2007). The city is vulnerable to the impacts of climate change because of high concentration of economic activity and migrated population. The economic and social costs of climate change is higher in Dhaka, where high-valued infrastructure is located than elsewhere. However, as climate change has no boundary, the slum dwellers have to be part of the equation to solve the climate change crisis.

3.0 Objectives

The main objective of the article is to assess the impact of climate change on the livelihood of slum dwellers in Dhaka city. In this study, the effects of flood, heavy rainfall and extreme temperature are the considerable factors in addressing climate change challenges in Dhaka. Among various parameters involved in the slum dwellers' livelihood only housing, water supply, sanitation, health and income are considered. Focuses are also given to identify the negative impacts of climate change on slum dwellers.

4.0 Methodology

A case study research strategy is undertaken for intensive analysis of climate change impacts on the slum dwellers. In-depth interview method, with households, urban institutions officials and experts, is used to collect the primary data while the secondary data is gathered from published journals, reports from Bangladesh Meteorological Department (BMD), Dhaka Water Supply and Sewerage Authority (DWASA), Institute of Flood Control and Drainage Research (IFCDR) and newspaper report. To get a comprehensive overview of the impacts of climate change on the slum dwellers in Dhaka city, 30 households were randomly selected from two slums namely, Karail Slum at Mohakhali and Baganbari Slum at Mirpur - 14 based on location, density and structure. Detailed interview with the Director of BMD, Executive Engineer of Drainage Division of DWASA, environment expert of CAS and flood expert of IFCDR was held to realize the climate change trends, impacts and vulnerabilities.

5.0 Climatic Condition of Dhaka City

The climate of Dhaka is marked by six seasonal variations. It is hot and humid during May to October while cool and dry during November to February. 90% of the annual rainfall occurs in rainy season which generally prevails from May to October. The average annual rainfall is approximately 2000mm. The lowest temperature during November to February may drop down to around 50C while it may rise as high as 420C during March and April. Monthly evaporation varies from 80 to 130 mm.

6.0 Slums in Dhaka City

In a survey carried out by the United Nations, Dhaka is identified as a mega city and it would be an eighth populous city of the world. Dhaka is now experiencing a period of cramped population growth and migrants are mainly responsible for high growth rate. In 2011 the population of

Dhaka city was around 12 million (BBS, 2012) and a report expects it to cross 25 million by the year 2025 (Democracy Watch, 2002). This influx of people in the capital city has forced many low-income groups to live in slums. About 60% of the population in Dhaka city is migrants; 65% of them live in slums (Alamgir et al., 2009). The 2005 survey identified some 4966 slum clusters in DMA with a population of 3.4 million. Of the 4966 slum clusters, 4342 were within DCC limits. The slum population in the DCC was 2.5 million with an additional 0.9 million in the DMA areas outside of the DCC (CUS, 2005).

The slum dwellers are those residents who are mainly climate refugees, migrating to Dhaka after losing everything. It has been estimated that nearly 50% of the city's poor population live in slum areas (CUS, 2005). The physical condition of slums is characterized by high density living, poor-quality housing, lack of basic amenities such as water supply, sanitation, poor literacy rate, unemployment, poor health. The poor and hard-core poor people who live here mainly provide informal labour market such as garment industry, rickshaw pulling, street vending, construction works and small businesses (Alamgir et al., 2009).

7.0 Profiles of the Studied Slums

Two slums: Karail Slum and Baganbari Slum in Dhaka city were selected for this study.

7.1 Karail Slum

During late 80's the informal settlements at Karail started developing on the vacant higher ground. Later on it is expanded encroaching the vulnerable water edges of Gulshan lake. At present Karail covers around 90 acres with a population of over 100,000 (CUS, 2005). It easily attracts low income people like cleaners, household helpers, workers of garment industries for its location near the high-end residential and commercial (Gulshan-Banani-Mohakhali) areas of Dhaka city. 32% of the households are permanent and semi-permanent structures belonging to middle-class households, 36% of shelter units are katcha type, belonging to lower-middle and poorer classes and nearly 32% of units are Jupri type, belonging to the poor and hard-core poor.

7.2 Baganbari Slum

Baganbari stands beside the Dhaka Dental College at Mirpur 14. A narrow ditch is passed by the slum. This slum is vulnerable to flood and heavy rainfall. Almost 1200 households now live in the slum in an unhygienic condition. About 32% of the households here are katcha type,

belonging to lower-middle and poorer classes and nearly 68% of shelter units are Jupri type, belonging to the poor and hard-core poor.

8.0 Impact of Climate Change on the Slum Dwellers: Framework for Analysis

A multitude of approaches and methodologies are usually used to assess the impact of climate change on the livelihood of slum dwellers. Vulnerability assessment is useful not only to evaluate the climate change impact but it also helps to inform policymakers to facilitate decision-making process of particular stakeholders of a sector about their options for adapting to the effects of climate change within the scope of their resources. The impact of livelihood assets (social, physical, financial, human) on the slum dwellers is analysed based on local climatic data, impacts, vulnerability and coping strategies. Based on the DFID's Livelihood Framework[1] and CARE's[2] Livelihood Approach , a framework has been developed to assess the impact of climate change on the slum dweller's livelihood which is shown in Figure 8.1.

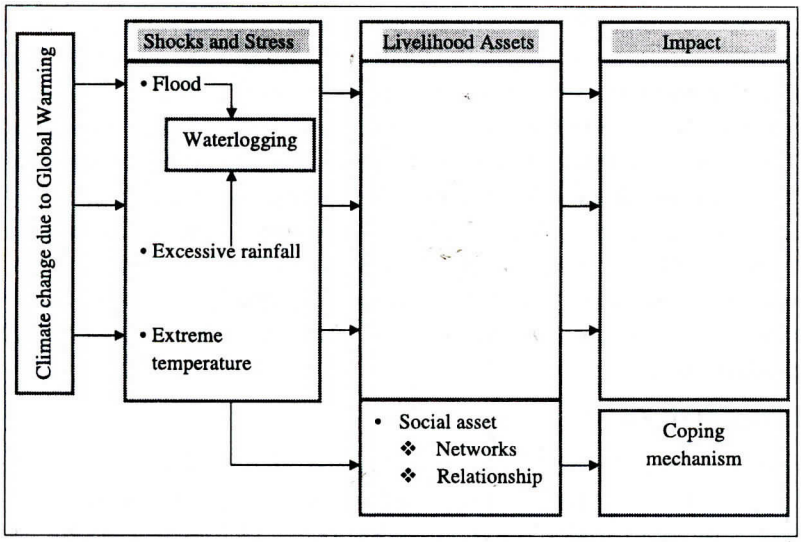


Figure 8.1: Framework for Climate Change Impact on the Slum Dwellers

[1] DFID's Livelihood Framework is a conceptual framework which takes asset/vulnerability approach including social capital, human capital, natural capital, physical and financial capital to analyse the livelihood of poor people.

[2] CARE's Household Livelihood Security Approach presents a tool for understanding the concerned living household activities such as sustainable and adequate access to income and other resources to meet basic needs and to build up assets to withstand shocks and stresses.

The climate change causes an impact on livelihood assets. However, the societies across the world have a long record of adapting to and reducing their vulnerability to the impacts climate related events (Pachauri and Reisinger, 2007) and thus, the coping strategies used to reduce the impact and the presence of other internal and external stressors determine the societal vulnerability to climate change. Identification of the current climate change, its impacts on livelihood, current coping strategies and identification of vulnerabilities help to assess the future possible changes, impacts and coping strategies.

The trend of climate change due to global warming is collected from secondary sources. The impact of these climatic events on livelihood asset is collected from the slum dwellers. In the framework social capital is used as a positive impact as friends, relatives and neighbours are found first for immediate coping mechanism.

9.0 Impact of Climate Change on the Slum Dwellers: Empirical Findings

The slum dwellers in Dhaka city are vulnerable as regards access to basic amenities. Climate change-induced challenges such as flooding, extreme temperature, excessive rainfall and waterlogging make their life more vulnerable and have its strong impacts on livelihood assets. To minimise the stress, the climate change is read into extreme weather events based on the trends of climate in Dhaka. To assess the impact of climate change on the slum dwellers in Dhaka city, the survey was conducted in Karail Slum and Baganbari Slum. The respondents' perception has been analysed with secondary data focusing on housing, water supply, sanitation, health care and income scenario related to climate change. On the basis of empirical data, the major findings have been drawn which is presented chronologically.

9.1 Impact of Flood

Dhaka has been periodically experiencing floods and some of those devastated the city. Due to the overflow of surrounding rivers, Greater Dhaka city faced major floods in 1954, 1955, 1970, 1974, 1980, 1987, 1988, 1998, 2004 and 2007. Among these, the 1988, 1998 and 2004 floods were catastrophic. Flooding due to rainfall is also a severe problem for city areas which sometimes swamped for several days, mainly for ineffective drainage system. Floods left untold sufferings and huge damages for the poor people particularly the slum dwellers in Dhaka city. In this study the impacts of floods in 1998, 2004 and 2007 on housing, water supply and sanitation, health and income scenario of the people

lived in Karail and Baganbari slums are taken into consideration.

Items	No. of response	%
Teachers' lack of expertise with ICT	53	60
Lack of confidence in using ICT	27	31
Insufficient knowledge of appropriate software	48	55
Insufficient knowledge of how to use ICT equipment	40	45
Lack of knowledge of how to evaluate the use and the role play by ICT in teaching and learning	35	40

9.1.1 Shelter

Most of the respondents in Karail and Baganbari were affected by the flood of either in 1998, 2004 or 2007 or both. As the severity of the flood in 2004 was high, they were affected more. Karail is adjacent to Gulshan lake and over-flooding of the lake affected its adjacent area. Baganbari is criss-crossed by a narrow ditch which is vulnerable to flood and waterlogging. As a whole, 100% respondents were affected in the last two floods while 50% of them had to leave their slums and took shelter on the road or in different schools or flood centres. Very few people took shelter in their relative's houses. Some households preferred to remain in their homes despite the terrible conditions in the slums.

Slums in Karail and Baganbari are on the government land and most of the dwellers built their houses there. However, the structure and construction materials used for building shelter are not so durable to resist flood or heavy rainfall. When flood strikes on the poor structure situated on the flood-prone areas, the houses become demolished. In this study, 72% households described that the most devastating loss for them was the irreparable damage to their houses and they were distressed at having their bamboo walls, tin and other house materials destroyed. 55% of those affected settlements were made of CI sheet. Reminders' qualities were comparatively inferior as those were with bamboo or polythene fence and roof.

Among the flood affected shelters, 67% households repaired their shelter by themselves or by their landlords. According to the respondents, the maximum repairing cost ranged Tk. 20000 to Tk. 25000. Managing money for repairing became tougher since some of them became jobless due to flood. Most households managed loans from relatives or friends. Repaying that extra money was a challenge for them and some did it even

by sacrificing their meal. Neither government nor NGO provides any help for repairing of the devastated house.

9.1.2 Water Supply

Water supply is a severe problem for the slum dwellers in Dhaka city. Normally most of the people use WASA's supply pipe water for drinking. 85% of the respondents use supply water for drinking and other purposes while a few uses tube well water. The supply water is not available within slums for all dwellers. Consequently, some households (25%) collect it from outside the slum with a monthly payment of Tk. 100 to Tk. 150. A very few people use artificial well water for other purposes. The sources of water in the slums are as follows -

Table 9.1 Sources of Water in the Studied Slums

Area	Supply Water within Slum (%)	Supply Water brought from outside (%)	Tube well
Karail	60	40	0
Baganbari	80	0	20

Source: Field Survey, 2012 N=30

During or after flood, slum dwellers face more difficulties to collect water. 90% respondents suffered badly since they struggle to manage water for drinking and other purposes during flood and 38% during heavy rain. Among them 40% of the respondents found difficulties for managing water and traditional chores for women, such as cooking and fetching. Kitchen utensils and clothes were usually washed in the flood waters. Though some government organizations and NGOs provided limited amount of drinking water and purifying tablets, all did not get that. Many of the women stood in line for hours to gain access to free water. Some respondents also bought water from owner of deep tube well.

Households of Karail slum bought water from T&T colony during flood. Many went to nearby school, mosque and hotels for collecting water. During the 1998 flood, 44 deep tube wells of WASA were affected by floodwater and water production was suspended in 13 of them (Alam and Rabbani, 2007). Water became contaminated as many pipes damaged due to water pressure. During the 2004 flood, more than 2 million city dwellers faced drinking water crisis as supplies had become contaminated. Thirty water pumps operated by WASA were inundated by

floodwater. Water pipelines of a few hundred kilometres and many reservoirs were under water, posing a serious threat to public health.

9.1.3 Sanitation

Sanitation is a major problem for the slum dwellers in Dhaka city. As they live in informal settlements, their place of defecation is very poor with unhygienic condition. During survey, it is observed that 55% respondents use katcha latrine, 33% use pucca latrine and the rest use hanging latrine. Those who live on the elevated dwellings over water have no option but hanging latrine. Some NGOs has constructed community latrine in collaboration with DCC.

Table 9.2: Place of Defecation in the Studied Slums

Area	Katcha Latrine	Pucca Latrine	Hanging Latrine
Karail	40%	30%	30%
Baganbari	70%	30%	0%
Total	55%	30%	15%

Source: Field Survey, 2012 N = 30

The unhygienic sanitation scenario of the slums in Dhaka city becomes acute during flood. In the last three floods and heavy rain like of 29th July in 2009, 85% and 50% respondents respectively faced defecation problem. Some did the task beside rivers while some went to the adjacent dry latrine. People stayed in flood shelter have to wait in queue for defecation.

Table 9.3: Opinion about Sanitation Problem during Flood/Heavy Rain

Area	During flood	During heavy rain
Karail	80%	40%
Baganbari	90%	60%
Total	85%	50%

Source: Field Survey, 2012 N = 30

In this study, majority respondents suffered badly in gaining access to sanitation as most of the latrines were submerged by floodwater. Women faced more problems since they had no option to sit here and there for urination as well as for defecation. As a result, they resorted to a number of desperate measures to cope with this predicament. During day women

could not sit nearby the people but at night they had no option except sitting behind any tree or obstacles. Likewise women, young adolescent girls were unable to use a latrine until late at night; while others out of desperation used their immediate surroundings as a toilet and some stood in the floodwaters to urinate or defecate (Rashid and Michaud, 2000).

9.1.4 Waste Disposal

Structured sewerage system has not yet developed in slums in Dhaka city. There is no fixed place for waste disposal in the studied slums. The katcha latrines are connected to the nearest ditches and rivers. Scattered wastes therefore, are visible in open places. River or ditches are used for waste disposal by 55% of the respondents whereas only 10% use dustbin. The rest 35% throw waste here and there. Exposure to such dirty environment is risky for children as they spend most of their time playing outside. The overall scenario is depicted in Table 9.4.

Table 9.4: Waste Disposal Places in the Studied Slums

Area	Beside room	Into ditch/river	Dustbin
Karail	10%	80%	10%
Baganbari	60%	30%	10%
Total	35%	55%	10%

Source: Field Survey, 2012 N=30

9.1.5 Health

Climate-induced disaster and the surrounding environment impact on slums dwellers' health. Flood has been shown to spread waterborne and vector-borne diseases. Water-borne outbreaks of diarrheal illness during and after flood are thought to result primarily from contamination of water caused by disruption of water purification and sewage disposal system. The study areas are characterized with the adjacent heap of wastes, poor sanitation and polluted ditch which are the breeding ground for mosquitoes. 65% respondents suffered from diarrhoea and a few respondents suffered from dengue and malaria.

Diarrhoea is related to water and sanitation whereas vector-borne diseases are connected with cleanliness. Flood makes water sources contaminated. The majority respondents, who personally or with their family members suffered, identified flood as responsible for diarrhoea while a few

respondents argues for extreme temperature. Children were mainly affected with diarrhoea as many of them played in the dirty water, even drinking and bathing in it. A study of ICDDRB[3] (2006) also identifies the existence of a good relation between diarrhoea and flood. Except diarrhoea and dengue, the respondents also found flood as the source of other health problems like scabies and fever. In 2004, the prevalence of diseases such as diarrhoea, dysentery, fever and skin diseases during floods increased significantly (Alam and Rabbani, 2007). The scenario of diseases people suffered once or more in recent five years in the studied slums is shown below -

Table 9.5: Health hazards scenario during Flood

Disease / Area	Diarrhoea	Dengue	Malaria	Fever	Scabies
Karail	60%	10%	0%	10%	10%
Baganbari	70%	10%	10%	10%	10%
Total	65%	10%	5%	10%	10%

Source: Field Survey, 2012 N = 30

Though most of the people in slums are poor, they had to expend on treatment sometimes even if they went to the government hospital. 12 respondents (40%) reported that they spent from Tk. 20 to Tk. 20000. Among the respondents who suffered from diarrhoea, 30% respondents went to ICDDRB and 25% respondents went to other hospitals for treatment. In ICDDRB, the treatment is almost free. The average expenditure for diarrhoea treatment is Tk. 200 or 300 whereas for dengue treatment it is expended up to Tk. 12000. Moreover, due to waterborne and vector-borne diseases, some respondents faced health problem like weaker than before. Some children did not attend school and some people even lost their job.

9.1.6 Work and Income

During any disaster situation, work and wages become scarce for the poor. Most of the slum dwellers are unskilled and involved in informal sector. A majority tend to work as day labourers. In this study, 38% of the respondents were absent from their work during flood and 5% lost their job. The prices of basic food items generally multiply which imposed

[3] International Centre for Diarrhoeal Disease Research, Bangladesh

severe stress on the poor particularly those who were unemployed. Therefore, to save costs, most family members reduced their food intake and even in some cases parents sacrificed their meal for their children.

Female adults and children tended to work as housekeepers, labourers or in garment piecework, while male adults and children tended to work as rickshaw pullers, labourers, brick breakers, drivers or carpenters. Male adults worked an average of 9 hours and female works almost dawn to dusk every day.

According to survey data, 62% of households have income less than Tk. 5000 and 38% have income Tk. 5000 to less than Tk.10000. Survey data reveals that a major share of households' income is spent on food items (average monthly expenditure Tk. 3416) followed by house rent (Tk. 1242 on average) and non-food items (Tk. 879 on average) respectively. A significant number of households (72%) reported their expenses equal to income or greater than income and as a consequence they often depend on loans for survival. In case of medical treatment and repairing of damaged house, they take loan from their relatives or friends. To repay the loan they sometimes sacrifice even their meal.

9.2 Impact of Extreme Temperature

Climatic variability for the period 1981-2003 over Bangladesh has shown that in all seasons the mean maximum temperature is increasing except in winter for the northwest and middle zone (-0.004°C/year and -0.007°C/year). Overall the temperature is increasing over the country (the rate of max temp is +0.028°C/year) concurrent with the global temperature increase (Sarker, 2009). Since early 1990s a number of General Circulation Models (GCMs)[4] have been exercised for projecting possible future temperature and precipitation pattern in Bangladesh. The BUP- CEARS-CRU (1994) attempted first on GCM model where it reported 0.5°C to 2°C rise in temperature in Bangladesh by the year 2030 under 'business as usual' scenario. WB's (2007) study suggested that the mean rainfall over Bangladesh would be increasing with global warming. Agrawala et al.'s (2003) study suggested that the annual temperature of Bangladesh would increase up to 1.4°C and 2.4°C whereas the monsoon

[4] General Circulation Model (GCM) is a mathematical model of the general circulation of a planetary atmosphere or ocean and based on the Navier- Stokes equations on a rotating sphere with thermodynamic terms for various energy sources (radiation, latent heat). These equations are the basis for complex computer programs commonly used for simulating the atmosphere or ocean of the Earth. The Navier-Stokes equations describe the motion of fluid substances.

precipitation marked an increase up to 6.8 and 11.8% by the projection year 2050 and 2100.

Almost all the respondents in the studied slums feel that the summer is hotter and longer and winter is warmer and shorter than before. Their opinions comply with the two incidents of extreme temperature in 1995 and 2009. At the end of July of 2009 (on 26th) Bangladesh faced the highest temperature in last 14 years with a blistering 42.2°C in Jessore district and 38.7°C in Dhaka city. An unrelenting heat wave had swept the country for over that week. The highest temperature in 1995 was recorded as 43°C in Rajshahi and 39°C in the capital. This rising temperature gradually impacts on the poor people lived in slums in Dhaka city.

9.2.1 Shelter

Slums in Dhaka city is grown on the flood-prone area mainly beside the lake, on the embankment of river or ditches. The houses have been built with semi-permanent or temporary basis with poor structure and construction materials including CI sheet, tin, bamboo, polythene which is susceptible to extreme temperature. When the temperature becomes extreme, the load shedding reaches its peak. At that time, it is very hard for the slum dwellers to survive. The children are the worst victim of such extreme hot or cold weather.

9.2.2 Water Supply

People need more water in high temperature than normal. If the temperature becomes extreme, the load shedding of electricity reaches its peak. As the water supply is related to electricity run pump, restoration of water in reservation is interrupted frequently. 80% respondents noticed that they get less water and face problems in collecting water in summer.

Table 9.6: Opinion about Water supply amidst Extreme hot temperature

Area	Normal water supply	Getting less water
Karail	25%	75%
Baganbari	15%	85%
Total	20%	80%

Source: Field Survey, 2012 N = 30

Slum dwellers collect water from sources within slum and outside slum 4 or 5 times in a day. In summer or heat, they get 2or 3 times after waiting

in the queue for a long time. Those who (20% respondents) collects water from outside suffer most.

9.2.3 Health

People usually face some health problems due to extreme hot or cold weather. Fever, tiredness, diarrhoea, skin diseases, headache and prickle are observed in hot weather while cough and respiratory problem are significantly noticed in very low temperature among the poorer section of the city. High temperature is associated with the number of non-cholera diarrhoea cases (Hashizume et al., 2007). For a one degree increase in average temperature over lags 0-4 weeks, the number of cases increased by 5.6% by using a model that assumes a log-linear increase in risk. The independent effects of temperature at different lags showed that the positive association was observed in the same week and decreased to null at lags 2 and afterwards (Figure 9.1).

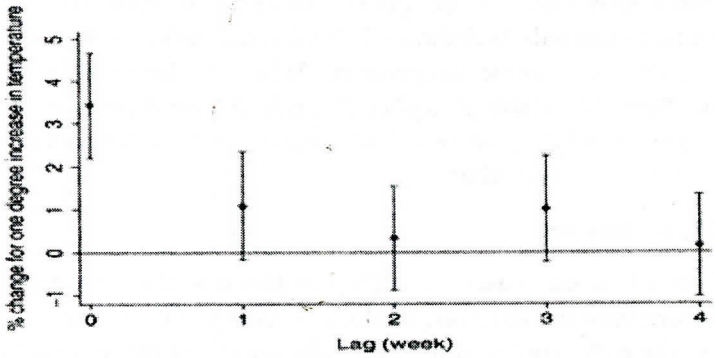


Figure 9.1: Change of non-cholera diarrhoea case for 1°C temperature rise at each lag (Hashizume et al., 2007)

According to IPCC (2007), all of Asia is likely to warm this century and warming in South Asia is likely to be above the global average at around 3.3°C. In the last 10 years severe cold waves have become common in Bangladesh, temperature as low as 5°C was recorded in January 2007. A recent study found that extreme climatic conditions enable the water living cholera bacteria Vibrio cholera to rapidly multiply and spread more easily (Huq, 2006).

9.2.4 Work and Income

Extreme weather disrupts the slum dwellers' work and income. Some occupations are largely influenced by weather like rickshaw pulling, daily labour, brick breaking. In heavy rain or flood the informal sectors are affected significantly. All respondents feel tiredness and take a pause for a while during their work in extreme high temperature. As a consequence, in profession like rickshaw pulling or vendor the respondents earn less.

9.3 Impact of Excessive Rain and Waterlogging

9.3.1 Excessive Rain

A study on climate change vulnerability based on certainty, timing, severity of impacts and importance of the sector, ranked water resources as the greatest concern due to climate change in Bangladesh (OECD, 2003). It has been predicted that due to climate change, there will be a steady increase in rainfall in Bangladesh (IPCC, 2007). Studies in different parts of the world indicate that global warming has altered the precipitation pattern and resulted in frequent extreme weather events like floods, droughts and rainstorms (WMO, 2003; Schmidli and Frei, 2005; Briffa et al., 2009). The time series of average monsoon rainfall between 1958 and 2007 from BMD shows (Figure 9.2) an increase in monsoon rainfall in Bangladesh.

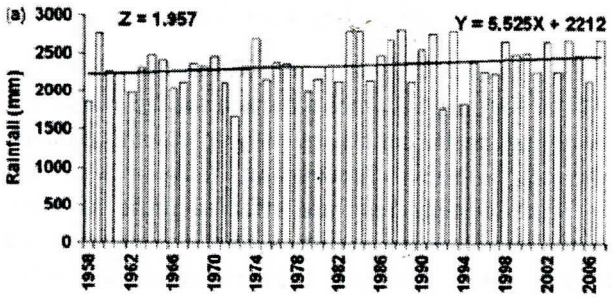


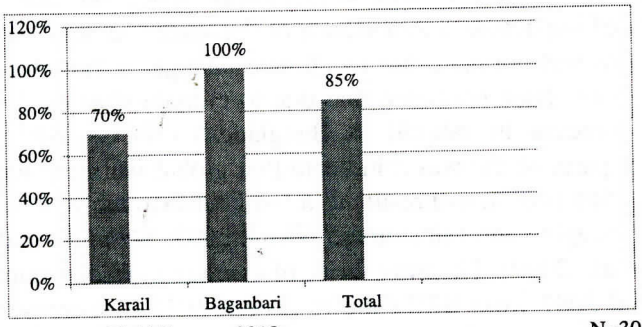
Figure 9.2: Trend of annual Rainfall in Bangladesh (1958-2006) (Shahid, 2010)

Rainfall data from the Dhaka station for 1958 to 2006 shows that the annual average rainfall in the city is about 2120 mm, of which about 50% falls during the months of June, July and August, generally referred to as monsoon season. Average rainfall during the winter months (December, January and February) is less than 2% of annual rainfall. While Dhaka's

long-term trend in annual rainfall shows no significant change, the trend in seasonal rainfall appears to be erratic. However, data indicates that rainfall intensity is increasing (Alam and Rabbani, 2007). In the 29th July, 2009, the heaviest rainfall (373 mm in 12 hours) occurred in Dhaka City and its devastating impact paralysed the city life.

9.3.2 Water logging

As the drainage system in Dhaka is very poor, water logging is a common problem for the city dwellers especially the slum dwellers. Most of the respondents (85%) in the studied slums faced this problem. The area-wise opinion is shown in Figure 9.3.



Source: Field Survey, 2012 N=30

Figure 9.3: Households affected by Waterlogging

In recent years Dhaka City is facing extensive water logging during monsoon. Water logging becomes a burden for the slum dwellers, usually lived in low lying areas, canals, railway tracts and embankments, as it poses challenges to social functioning, trade and economic activity. Children in waterlogged areas are affected more as they suffer from diarrhoea because of playing in dirty water. The alarming scenario is that the waterlogged water mixes with the raw sewage and solid waste which produces mosquitoes, flies and bad odour.

9.3.3 Shelter

Though the slums are mostly located in the flood-prone areas, water does not usually enter into room in average rain. As Baganbari and Karail slums are relatively on the low land and adjacent to ditch, those become affected in normal rain. Most of the households studied reported that they become severely affected due to heavy rainfall (Table 9.7). During heavy rainfall the poor people suffers a lot with their kids and necessary stuff.

Table 9.7: Respondents affected by Rainfall

Slum Area	Affected in normal rain (%)	Affected in heavy rain (%)
Karail	30	100
Baganbari	60	100
Total	45	100

Source: Field Survey, 2012 N = 30

9.3.4 Sanitation

Major portion of the slum dwellers (70%) use katcha or hanging latrines and 55% respondents throw their daily waste haphazardly. Those pits and hanging latrine are connected to the ditches and canals. Consequently, both household waste and human generated wastes go directly or indirectly into the low-lying lands, open spaces or water bodies and causes a number of problems including health. In a seminar, the DCC admits that among the 15 millions people lived in the city ; only 20% people are getting sanitation facilities. During flood or excessive rain, 68% respondents suffered for defecation as most of the latrines were on the edge of rivers, canals, ditches and outside of their rooms.

In Dhaka, WASA drainage system covers only 37% of the total area. Drainage Division spokesman of DWASA told that present drainage infrastructure is capable of taking the load of rainwater up to 15mm per hour whereas the record in the July 29 of 2009 was 50 mm per hour. Any excessive rain comparing to the capacity of WASA will often create waterlogging in the city. Slums, on the ditches, canal and embankment, are creating problem by themselves as those illegally encroached areas previously worked as the retention pond for rainwater. Though there are 43 canals on record in Dhaka, 26 are now operating with obstacles.

9.3.5 Health

Excessive rainfall leading to waterlogging causes health problems like diarrhoea, fever, scabies. The relationship between the number of non-cholera diarrhoea and heavy rainfall is positive (Hashizume et al., 2007). An increase in non-cholera diarrhoea can be seen with high rainfall at lag 0-8 weeks and at lag 0-16 weeks. For a 10 mm increase above the threshold, the number of non-cholera diarrhoea cases is increased by 5.1%.

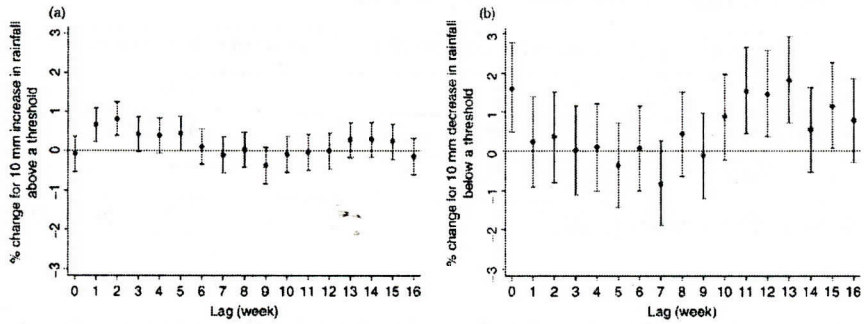


Figure 9.4: Changes in Non-cholera Diarrhoea for Rainfall rise (Hashizume et al., 2007)

9.3.6 Work and Income

Extreme weather disrupts the slum dwellers' work and income. During excessive rainfall with water logging, the informal sectors like rickshaw pulling, daily labour are affected in many ways: late arrival in workplaces, need more strength and time for rickshaw pulling, tough to move around for vending amidst water, no/less work as day labour/carpenter and therefore, the respondents involved into those professions earn less. Some respondents were absent from work for 5 days on an average and consequently some lost their job which put immense pressure to manage food for their families. On an average, they spend Tk. 3000 for food, Tk. 150 for electricity, Tk. 100 for water supply and Tk. 150 for fuel. If any extra burden comes, they manage it by cutting off their meal. The impact of any extreme weather events thus brings some loan, some hunger and ultimately more distress.

9.3.7 Climate Refugee

Migration to urban areas is a regular phenomenon but climate induced displacement forced to migrate to cities especially to Dhaka over the recent years is a matter of concern. Increased frequency and severity of flood, river erosion, cyclones and tide waves by climate change over the past recent years are not only displacing people physically but also exposing to enhanced poverty by threatening their livelihoods temporarily and permanently. Growing number of people rushed to city's slums creates urban crisis. In this study, 50% of the respondents were migrated to Dhaka since 1998 due to flood, river erosion or cyclone.

Table 9.8 Causes of Migration in the Studied Slums

Climate change -induced Disaster / Area	Flood	River erosion	Cyclone
Karail	3	4	1
Baganbari	2	2	3
Total	5 (16%)	6(20%)	4(13%)

Source: Field Survey, 2012 N = 30

Respondents from Chandpur, Barisal and Sirajgonj were compelled to leave their villages losing everything by flood and river erosion whereas respondents from Bhola and Barguna were resorted to these slums victimized by cyclone. These people living in urban slums are in search of a better life. Since their slums are located mostly in low lying environmentally hazardous area coupled with inadequate facilities like food, shelter, sanitation, pure drinking water, health care, the existing scenario make their life even worse. Those who migrated to Dhaka before 2004 already suffered again by the devastating flood of 2004 and 2007.

From 1970 to 2013, the total number of major cyclones striking Bangladesh was 28, where the number of occurrences increased significantly since 1990. It should also be noted that the highest number of affected people has been recorded after 1990. In 2007, the country was ravaged by Cyclone Sidr, which displaced 650,000 people and killed 3,447 (official record). In the year 2009, two cyclones: (cyclone Bijli, April 2009 and cyclone Aila, May 2009) hit. About 200,000 people were displaced by cyclone Bijli. The intensity of the damage caused by the cyclones in 2009 might not be as high as cyclone Sidr, but though the country was hit twice in the same year. Cyclone Mahasen hit Bangladesh on 16 May 2013 which destroyed 95,003 poorly constructed huts, killed 17 people and displaced 1.3 million across the country.

10.0 Role of City Service Providers

Different urban institutions such as Rajdhani Unnayan Kartripakkha (RAJUK), DCC, DWASA are responsible for providing basic services to the city dwellers. Moreover, some NGOs are working sporadically in sector specific services to the slum dwellers. RAJUK, the major city development authority is accountable to implement policies regarding

urban planning and building construction. The poor people who prefer to live in slums due to low rent or free of cost, construct settlements in the flood-prone or low land in the out skirt of the city which are defined as risky zones for living by RAJUK through the illegal contact with its staff. The accountability and transparency of RAJUK therefore, is in question in this matter. Good governance can largely help to diminish these spatial differences by ensuring accommodation for the low income groups in safe sites with good infrastructure.

Rapid urban growth coupled with around 300,000 to 400,000 annual new migrants in the city put tremendous pressure on land, accommodation and services of water supply, sanitation, waste management, health care provided by the government agencies (BBS, 2007). A mismatch between the growth of Dhaka city's economic bases and population and the competence, capacity and accountability of urban institutions, especially DCC, RAJUK and DWASA is evident. The loss of life and damage to property caused by disasters ought not to be seen only as natural events rather as a failure of urban management - in which institutions have been unwilling or unable to meet their obligations to urban residents. For example, absence of effective coordination between WASA and DCC is the prime reason for waterlogging. In addition, coordination gap among service delivery agencies lead to overlapping and fragmented social services. Inter-organizational coordination therefore, seems to be a sin-qua-non for achieving city dwellers' satisfaction.

The present water supply system of Dhaka entirely depends on groundwater. Recharge occurs primarily through direct infiltration and percolation, mostly from direct rainfall, river water and floodwater. Due to rapid urbanization, the recharge area of the city is declining significantly with time. DWASA therefore, needs to install more tube wells to serve the ever increasing population of the city. According to DWASA, about 450 deep tube wells are needed to be installed within the city to meet the present water demand. With this shortage of water DWASA cannot supply adequate water to the slum dwellers. Tenure security is a serious problem for the slum dwellers to get the DWASA connection, though some NGOs are helping in this aspect in collaboration with DWASA and DCC.

Solid waste management is a crucial problem in Dhaka city. Though DCC is responsible for it, it is inflicted with some challenges such as lack of manpower and insufficient resources for drain cleaning. Recently

RAJUK finalizes the Detailed Area Plan (DAP) for Dhaka where Dhaka is divided into 17 land use zones like residential, commercial, industrial, flood flow, water body. DAP has proposed 24.7% area for flood flow zone, 1.75% for water retention area, 5.73% for water body to protect Dhaka from waterlogging which is appreciable. However, the implementation of DAP will be a great challenge for any government.

Though the slum dwellers are contributing significantly to the economy of Bangladesh, city governments have not yet undertaken comprehensive plans to protect them from climate change-induced environmental hazards. Moreover, the antagonistic relationship between the urban institutions and slum dwellers helps to keep them reluctant to address their local needs. Managing any loan from formal institutions for repairing or new construction is absurd as access is denied there for the slum dwellers. Although the nationalized commercial banks and the House Building Finance Corporation provide loan for building of houses and apartments, these loans are usually given to the middle and upper classes of the society. However, some NGOs are providing loans in a limited scale to the slum dwellers. Recently the present government has undertaken an accommodation project for the rehabilitation of slum dwellers.

11. The Way Forward

Slum dwellers in Dhaka were vulnerable before but now they are more vulnerable due to the intensity of climate change-induced natural disasters. Rapid urban growth and performance of urban institutions are two important catalysts in this regard. Extreme natural events are unstoppable. No country can ignore it. The whole world is trying to minimize the carbon discharge through United Nations Framework Convention on Climate Change (UNFCC) and the Kyoto Protocol[6]. The success of the convention or protocol is uncertain as the leading carbon producing country USA has not yet signed the Kyoto Protocol. Consequently, country like Bangladesh should concentrate on minimizing risk and on strong adaptation policies. Bangladesh has already developed National Action Plan for Adaptation (NAPA) and

[6] The Kyoto Protocol is an international agreement linked to the UNFCC. The major feature is that it sets binding targets for 37 industrialized countries and the European community for reducing greenhouse gas emissions (GHG). This amount is an average of 5% against 1990 levels over 2008-2012. The major distinction between the Protocol and the Convention is that while the Convention encouraged industrialised countries to stabilize GHG emissions, the Protocol commits them to do so.

Climate Change Strategy and Action Plan (CCSAP), though urban poor has got less focus there.

In view of the study findings, some recommendations are proposed to minimize the climate change-induced challenges of slum dwellers -

- Urban institutions need to develop a set of specific policies and action plans to address the climate change-induced challenges for low income slum dwellers.
- Land use planning mentioned in the DAP needs to be effectively implemented.
- RAJUK and DCC have specific roles in reducing climate change vulnerability. Zoning and planning controls, which often lead to the exclusion of huge population, can be used to help provide safe locations for low income households.
- Coordination between DWASA and DCC should be ensured regarding operation and management of drainage system for minimizing waterlogging.
- Awareness program on flood and extreme events related diseases should be started.
- Government financial institutions should adopt pro-poor financing strategy to disburse adequate loans for the lower income people for immediate adaptation.
- Effective adaptation strategies should be adopted acknowledging the effective traditional risk sharing strategies to address the potential impacts of climate change.

12. Conclusion

The slum dwellers of Dhaka, mostly (50%) being a victim of climate change-induced natural disasters like flood, river erosion and cyclone, migrated from different corners of the country for their survival. Empirical data shows that majority of them live in deplorable condition, due to poor basic services provided by the service providing institutions of the government. Being the centre of major economic and administrative operations, Dhaka's rapid urban growth due to incoming migration is putting extra pressure on the city service providers. There is a plethora of policies describing the rights of all citizens regarding basic

services. In fact, these laws are hardly practiced for the poor. Consequently, the slum dwellers of Dhaka city always remain in the vulnerable position in respect of different natural events.

The respondents' perception shows that the slum dwellers suffer most in access to basic services. Climate change-induced flooding, excessive rainfall, waterlogging and extreme temperature increase the degree of sufferings. It puts extra burdens on the social and economic challenges that the poor people already face. Their vulnerabilities will be increased due to the dependence on climate sensitive assets and weak social protection structures. The increased intensity of climate extremes like flood or heavy rainfall is of particular concern since it reduces the time for slum dwellers to recover from one climatic shock to another.

According to scientific literatures and survey results, the frequency of flood, extreme temperature and excessive rainfall due to climatic change is increasing in Bangladesh, both in terms of extreme weather frequency and gradual changes which eventually impact on livelihood assets. Some impacts are direct, such as more frequent floods or heavy rainfall-induced water logging while some are less direct including availability of freshwater and constraints on health, eventually led to less income and more expenditure. The study also identifies some crucial roles that individuals (income, asset bases), communities (micro-credit, awareness building program, social interconnectedness) and local government agencies (safety nets) adopt in their own adaptation processes. There are also limited institutional coping strategies for instance, emergency aid and awareness rising on saving and diseases both from urban institutions and NGOs. These coping mechanisms are not sufficient to address the challenges for the slum dwellers, since they even lose their earning sources due to climate shocks. It also shows the lack of governance and commitment in local government authorities including utility service providers to face climate stresses for the urban poor. However, where this commitment is made, it should be seen as an opportunity to address three key issues affecting the slum dwellers: climate change adaptation, effective local development and good governance. Wedded with lack of affordability of hygienic shelters and sanitation, scarcity of fresh water, poor income, climate change is more likely to continue speculating the urban poor's socio-economic activities and intensifying their vulnerability.

Most indicators show that climate change is evident in Bangladesh as well as in Dhaka. There is no way of ignoring the impact of climate change on the poor people. Climatic incidence cannot be altered but its adverse impact can be reduced through formulating and implementing effective policies and regulations. To minimize the impact, focuses should be given on reducing the hazard where it is possible (e.g. better drainage that stops a heavy rainstorm creating floods), or reducing disaster related health concern (e.g. launching awareness program to minimise flood and extreme temperature borne diseases), or reducing people's exposure to it (e.g. working with those who live in areas at risk of flooding to improve their housing or move to safer locations). Post-disaster response should be activated not only to help the urban poor particularly slum dwellers to build their homes and livelihoods but also encourage measures that reduce risk from possible future hazards. After all, the capacity, accountability and attitude of local government authorities including utility service providers should be developed or ensured to minimise the vulnerability to climate change in urban areas.

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