Kolkata and Climate Change

Asish Ghosh
Calcutta, now re-named “Kolkata”, is situated in a low, flat alluvial plain within the lower orbit of the Gangetic Delta. A typical riverine city, in the earlier days, it was surrounded by marshes, tidal creeks, mangroves, swamps and wetlands. But now all these have changed. As the capital of the Indian state of West Bengal, it is located in Eastern India on the East bank of the River Hooghly, making it India’s third largest metropolitan area and as well as the world’s 8th largest urban agglomeration. The Kolkata Municipal Corporation (KMC) area covers 187.33 sq. km. (it is worthwhile to note that the size of the city was 53 sq. km. in 1901) whereas that of the Kolkata Metropolitan Area (KMA) extends to 1854 sq. Km.

Long acknowledged as “the Cultural Capital” of India, Kolkata is located at 22° 33’ N, 88° 20’ E, at an elevation ranging between 1.5m (5ft.) to 9m (30ft.) and a distance of approximately 180 km from the Bay of Bengal, on the East coast of India. The coast has the largest estuary formed by the rivers Ganges and Brahmaputra; the Gangetic Delta is the biggest of its kind in the world and it stretches over an area of 20,000 sq. km., major part of which, however, is in Bangladesh. The Ganges and its associated rivers open through several estuaries collectively called Hooghly-Matla Estuary. It is worthwhile to mention that the silt and the loam carried by these rivers were deposited on the salt marsh eventually leading to the unique formation of more than 100 islands with the world’s largest mangrove forests, the Sunderbans; half of these islands are inhabited by more than 5 million human populations; the islands are protected only by earthen bundhs, stretching over 3500 kilometers. The Sunderbans region is now acknowledged as the major system protecting the City of Kolkata from the possible ravages in the era of Climate Change.

Kolkata is spread linearly along the banks of the River Hooghly in a N-S direction. The topography of the city played a vital role in shaping the form of the metropolitan area. The land slopes down from the West (the River Hooghly) towards the hinterland in the East. The KMA stretches for about 85km in the North-South direction. ‘Given the under-employment and associated growth of the informal sector of the economy, space in the city is becoming increasingly costly and difficult to get; the pavement shops, squatters, homeless people have dotted the street-scape.’ (Ghosh S., 1991).

According to the Bureau of Indian Standards, the town falls under Seismic Zone III, in a scale of I to V (in order of increasing proneness to earthquakes) the wind and cyclone zoning is “very high damage risk”, according to UNDP Report. [1]
History
Kolkata was a commercial city, a port town of great economic importance to Europeans and Bengalis alike, in the late eighteenth and early nineteenth centuries.

With the shifting of India's centre of external trade from the Western to Southern to Eastern India, it was but natural that in 1690, Job Charnock, an agent of the East India Trading Company, should establish a trading settlement on the site of Kolkata on behalf of the Company. The city served as a capital of India from 1776 till 1911, then as the capital of Bengal till 1947, and finally as the capital of West Bengal to the present day. [2]

The River and the City
The Hooghly river acts as the major life-line for the city, providing sources for the drinking water as well as water for industrial, power and other commercial uses. The flora and fauna found along river banks are vital to nutrient and water conservation, and control of soil erosion. Out of the keystone species, the Ganges river dolphin (*platanista gangetica*) is found in India in the Hoogli river system.

Economic Significance-
The river, as mentioned, remains the main source of drinking water for the city, industries, port, power station, railway lines and human habitation which dot the river-side on both the East and West banks. The Ganges has been used for irrigation since ancient times. West Bengal still uses the waterways to transport jute, tea, grain and other agricultural products. The hydroelectric potential of the Ganges is 13 million kilowatts, two fifths of which lies in India and the rest in Nepal. [3]

Population Changes
Kolkata has a population of 4.6 million persons within the KMC Area (Census of India, 2001), showing a decadal growth rate of 3.78%, which may not be an impressive growth figure but it also indicates that the city has become super saturated.
Currently Kolkata Municipal Corporation (KMC) shows an average density of 24,454 persons/ sq. km. while the Kolkata Metropolitan Area (KMA) shows a population density of 24,718 persons/sq. km. However, in some areas of Central Kolkata the population density reaches up to 45,000 persons per sq. km which is much higher than the density of Manhattan Island, New York.

Climate
Kolkata has a Tropical Wet and Dry Climate (Köppen Climate Classification-Aw). The Annual Mean Temperature is 28.3° C (82.9° F) while Monthly Mean Temperatures range from 19° C (66.2° F) to 30° C (86 ° F). The average Relative Humidity varies between 47% and 83%, while the Mean Wind Speed varies between 16.2 and 3.5 kmph. [4]

Kolkata gets most of its rainfall from the South-West Monsoon between June and September. The Annual Rainfall is about 1600mm and the highest rainfall occurs usually during the month of August.

In the past two decades, a disturbing trend in the rainfall pattern has been unevenly distributed, very often with no rainfall for several weeks and then changing into sudden downpour towards the end of the Monsoon period. This phenomenon often leads to flooding of the city areas.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TOTAL POPULATION</th>
<th>POPULATION DENSITY (Persons per sq. km.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>43,99,819</td>
<td>23,783</td>
</tr>
<tr>
<td>2001</td>
<td>45,72,876</td>
<td>24,718</td>
</tr>
</tbody>
</table>

[Source: Statistical Handbook, West Bengal, 2007]

A study of the Monsoon pattern (1905-1980), shows the earliest onset of monsoon to be on 26th May in 1937 while the latest onset was on 25th June, 1976. This has further shifted during the 1980-2009 period. Late Monsoon arrival has been noted between 1939-1980 on 29 occasions. Later, it almost became a trend. Delayed Monsoon leads to either a condition of late flood due to sudden, heavy downpour or causes widespread crop failure in West Bengal and elsewhere.

<table>
<thead>
<tr>
<th>YEARS</th>
<th>AVERAGE TEMPERATURE (° C)</th>
<th>AVERAGE RAINFALL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>30.28</td>
<td>133.79</td>
</tr>
<tr>
<td>1991</td>
<td>31.61</td>
<td>146.77</td>
</tr>
<tr>
<td>2001</td>
<td>31.39</td>
<td>117.17</td>
</tr>
<tr>
<td>2007</td>
<td></td>
<td>195.34</td>
</tr>
</tbody>
</table>

[Source: Census of India, 2001]
Frequency of Storms and Depressions

An average 28 depressions per year were witnessed. However, till 1922, there were less than the average number of depressions per year. Their frequency, however, increased after 1934 and again after 1964. During the 40-year period between 1891-1930, 93 depressions had occurred whereas between the next 40-year period between 1931-1970, a total of 371 depressions, about 4 times the number, had taken place. This trend seems to be continuing.

Water Supply:

The daily water demand of Kolkata is 290 million gallons (1320 million liters/day). Kolkata’s drinking water is largely taken from the River Hooghly. At first the purified water reaches the booster pumping stations, which serves as containers. From there it is distributed to the neighboring taps and wells. For every 39 slum dwellers, the municipality has provided 1 tap. The most important surface water supply is from Palta Water Works. After 1982, Garden Reach Water Works started providing drinking water with the present capacity of about 120 million gallons of water.

Along with surface water, a good amount of groundwater is also abstracted by means of tube wells. About 308 heavy-duty tube wells and 11,877 small diameter tube wells are working within KMC area.

Drainage, Sewerage and Waterlogging:

Kolkata’s drainage works through a network of underground drains, which are more than 100 years old, opening into a series of canals flowing from West to East. In the earlier days, the water from the River Hooghly used to flush out the sewage towards the Eastern estuary, during high tide. The main drainage basin is in East Kolkata Wetlands; the whole right bank of Hooghly drains its sewerage towards the lowlands. Drainage canals have increasingly been blocked by accumulated waste and suffer from lack of maintenance; canal sides have been occupied by
unauthorized slums, without any civic services. The result can be anyone’s guess. The canal network used to serve for small boat traffic till 1960s, but gradually due to sheer neglect, canals got silted and thus the waterway was lost.

East Kolkata Wetlands is the south-eastern drainage basin of Kolkata city, which covers an area of approximately 12,000 ha. In the Wetlands, acts as a natural system of using sewage waste and providing primary treatment to remove the pollution load from the waste water of the city.

The KMA has a century-old sewerage system which is divided into 20 Sewerage Zones. The KMC has a combined system for sewerage and storm water. The Kolkata town sewer network system is almost 140 years old, the sub-urban system is around 100 years old. The trunk sewers laid along the East-West direction carry the waste water and storm run-off from the Western part of the city to the East through a total of 19 pumping stations, like Palmer’s Bridge Pumping Station (PBPS), the Ballygunge Drainage Pumping Station (BDPS) and Dhapa Lock Pumping Station (DLPS). The water is pumped to the Dry Weather Flow (DWF) channel and Storm Water Flow (SWF) channel, depending on the season for final disposal into the Kulti River, 36 km away from the city. City planners feel that the combined sewer system may be adequate for the DWF but is grossly inadequate for the SWF. [8]

Old Kolkata has mostly British made Brick Sewers of two types: Man Entry Cleanable & Non-Man Tide cleanable. The rain water is cleared as follows:

Drains > Sewers > Pumping Station > Trunk Sewer > Canals > River OR Wetland

Now the Sewers are on an average has become 50% silted up and uncleanable as it is not easy to clean them up in a busy City by
conventional methods. It is also alleged that old sewer maps are missing for many parts of the city. Hence the KMC is now searching for specialists in such cleaning by modern hi-tech microtunnelling method. The added areas of Kolkata (Ward 101 – 141) do not have much of a planned sewerage system even. The current 19 Drainage Pumping Stations with their 93 Pumps appear inadequate to tackle the situation, especially due to malfunction of the pump or reduction in the pumping capacity. The KMC had to deploy 250 portable pumps in various areas in addition, to tackle this deluge during monsoon period in the recent times.

The KMC and KMDA have taken up two major Projects to tackle this situation in future. These are: Project NIKASHI and Kolkata Environment Improvement Plan (KEIP). But even after three years of work, the results are yet to be evidenced. [9]

As a result of the ill-maintenance of the underground sewer system, combined with the lack of dredging of the open canals which has raised the level of the canal-bed, frequent blockages leading to flooding are faced by the city. Along with this is the problem of malfunctioning pumping stations which are unable to pump the waste-water into the canals; and whatever waste-water is pumped into the canals, tends to overflow as a result of the already mentioned raised canal beds.

The end result of conversion of spill-basin in the Eastern part of Kolkata, lack of coordinated action to ensure quick disposal of monsoon rain; the result is continued water logging and flooding with every heavy downpour, and collapse of the city-life.

**Energy Supply:**

CESC or the Calcutta Electric Supply Corporation supplies electricity to area under KMC in the city of Kolkata. [10] CESC of Kolkata has a total electric energy generating capacity of 975 MW.
This total capacity is distributed between four Generating Stations—Southern, Titagarh, Budge Budge Power Station and New Cossipore Generating Station, all located by the side of the river. All stations are fed by coal and therefore the city largely depends on non-renewable energy. [11]

Health:
There are direct and indirect links between water availability and quality and human health. The citizens of Kolkata largely suffer from two major types of ailments viz., enteric diseases and cardio-pulmonary diseases. Besides the water and air quality related diseases, the inadequate garbage disposal system provide habitat for vectors, which in turn can cause serious vector-borne diseases, most notably malaria and dengue. Because of air pollution from industrial and transport sector, Kolkata is ill-reputed for having one of the largest numbers of child asthma cases.

Flooding and impact on Public Health—
A special mention may be made to the direct health effects that occur during the flood.

- Mortality from drowning, heart attacks and injuries. The number of deaths associated with flooding is closely related to the life-threatening characteristic of floods (rapidly rising waters, deep flood waters, objects carried by the rapidly flowing water) and the behavior of victims.
- Injuries (sprains/strains, lacerations, contusions, etc.). These are also likely to occur in the aftermath of a flood disaster as residents return to their homes to clean up damage and debris. Indirect health effects can be the consequence of damage to major infrastructure and property. They include the following:
- Infectious diseases (gastrointestinal diseases, dermatitis, and conjunctivitis) and increasing cases of vector borne diseases, like malaria, can be regarded as the indirect health effects of flooding along with fluctuations in the temperature.
- Poisoning caused by the rupture of
underground pipelines, dislocation of storage tanks, overflow of toxic waste sites, or release of chemicals stored at ground level.

- **Post-traumatic stress disorder**, including anxiety and depression, psychosocial disturbances and suicides. Aside from the trauma caused by the flooding itself, many mental health problems stem from geographical displacement, damage to the home or loss of familiar possessions, and often lack of insurance. They may continue for months or even years after the event itself. [12]

**Malaria and Climate Change:**
Certain health experts have attributed the rise in incidence, transmission and distribution of Malaria to three main climatic factors, viz., Temperature, Precipitation and Relative Humidity. Climate poses a new emerging threat to health, particularly those which are vector-borne.

Compared to the Malaria count between January and July of 2008, January to July of 2009 witnessed a drastic rise of 9 per cent Malaria positive cases i.e., from 7,770 to 17,271. [13]

**Transportation:**
The city of Kolkata perhaps exhibits the widest range of public transport system. Public transportation, such as buses, trams, trains, and subways, are the principal means of transport in the Kolkata metropolitan area; besides these nearly 50,000 odd auto rickshaws and the old hand-drawn rickshaws as well as cyclerickshaws form the part of transport scenario. Buses operate throughout the area, and trains have northsouth lines with a few east-west connections. There are two major train terminals: Sealdah in the east central part of Kolkata and Howrah across the river from the Central Business District. Electric trams operate in Kolkata proper. The aging buses, trains, and tram cars suffer from overloading. Subway construction was started in 1972 and now the subway carries an estimated 25 percent of Kolkata’s 7 million commuters. Available data indicate that the number of
registered motorized vehicles increased from 4,76,745 in 1991 to 9,86,814 in 2007 thereby showing an increase of more than double the number of vehicles within the last two decades. Air pollution caused by automobiles, buses, and industrial emissions is severe and efforts are being made to cut down the automobile emissions by imposing stricter standards and switch over to cleaner fuels. [14]

The ferries in the river connect the different parts of Kolkata. Ferries ply along the East-West banks of the river from Howrah in the West to Armenian Ghat in the East; from Howrah to Fairlie; from Howrah to Chandpal; and from Howrah to Bagbazar. [15]

**Industries and Industrial Profile:**

Today, most of the city's major functions and infrastructures are located along the Hooghly River. Kolkata's main train station, Howrah Station, the big colonial Fort William, ageing Jute Factories, Power Stations, Kolkata Port and the harbor and all warehouses can be found on either side of the river.

A total of 2780 industries of various types with majority in the sector of chemicals, acids, paint and varnishes (2153) besides glass, ceramics and leather, are causing primary water pollution. Within the KMC there are about 40 lead factories of which 22 are located in the Picnic Garden area. [16]

Along the segment around the Howrah Bridge to Nimtala Road there are warehouses in use for storage and sales of various commodities like minerals, building materials, edible oils, pulses, oilseeds, molasses etc. Beside the river, Central Kolkata houses the business district around the B.B.D. Bag area. The Governmental Secretariat, General Post Office, High Court, Lalbazar Police HQs and several other governmental and private offices
are located here. The erstwhile colonial district is still the central business area and is considered the heart of Kolkata.

About 150 large industrial plants are lined up on the banks of the Hooghly at Kolkata. Together, these plants contribute 30 percent of the total industrial effluent reaching the mouths of the Ganges. Of this, half comes from pulp and paper industries, which discharge dark brown, oxygen-craving slurry of bark and wood fiber, mercury and other heavy metals which accumulate in fish tissues, and chemical toxins like bleaches and dyes, which produce dioxin and other persistent compounds.

Some specialized trading centres make the city very distinctive. One such, the flower market is 125 years old and perched on the banks of the Hooghly River. The stalls start from under the Howrah Bridge and straddle Strand Road on the banks of the river. Thousands of people gather here daily to buy and sell flowers and plants. Flowers from the market are exported to West Asia and Europe. Some 2,000 growers visit the stalls every day to sell, the number increasing to 5,000 during festivals and wedding seasons. A salt market is located adjacent to the flower market under the Howrah Bridge. Earlier the salt trade used to be a business which took place on the river. That is the reason for its location on the river bank. [17]

Kolkata's famous docks and ship building enterprises are located in this region along the river. Kolkata Port Trust, set up during the British Colonial period is the first major riverine port in the country. Due to decline in the draught in the river and siltation in the area from sand head towards the port, Kolkata Port can no longer provide passage to the larger vessels. However, one of the largest ship building yard-Garden Reach Ship Builders, still functions from Kolkata. On the west bank of the river, across the city of Kolkata, lies Howrah, the major rail head, but also well known for foundry and cast iron industries.

Employment in the service sector has reached 61%, compared to 218% of the national percentage, and stands far above the average in India. IT and related services lead the current economic boom. These activities are growing at 70% annually, a rate that is twice the national average. The tertiary sector has reached 37% and the primary sector has reached 1.8%. [18]
The metropolitan economy, Gross Domestic Products-Purchasing Power Parity (GDP PPP) of Kolkata agglomeration is valued at US$ 94 billion, which is 2.5% of the national GDP PPP. The income per capita (GDP PPP per capita) of Kolkata agglomeration is valued at US$ 6,584 which is 190% of the national GDP PPP per capita. [19]

These industries and factories are the source of livelihood of millions of people who live in Kolkata as well as in the neighboring areas, who commute daily to earn a living.

**Climate Change: Possible impacts**

Changes to the earth’s climate have a direct effect on the global hydrological cycle and hence on water. Changes in climate are thought to be responsible for increasing the extremes of flood and drought, both of which, together with other circumstances such as increasing populations and environmental degradation, tend to affect the poor, the greatest. It is now recognised that one of the most serious result of climate change, is global warming, largely due to man-made emission of ‘greenhouse gasses’ (GHG), which include Carbon di-oxide, Methane and Chloro Fluro Carbon. [20]

The Ganga is now recognised as one of the most threatened rivers due to climate change. The Ganga River, like most of the important rivers in India, is fed by the Himalayan glaciers. But rising temperatures means that many of the Himalayan glaciers are melting fast due to Global Warming and could diminish significantly.
over the coming decades with catastrophic results. In the long run, the water flow in the Ganges could drop by two-thirds, affecting more than 400 million people who depend on it for drinking water. The rapid melting of ice high up in the Himalayas might cause river swelling and floods. The formation of glacial lakes of melt-water creates the threat of outburst floods leading to devastation in lowland valleys. Himalayan glaciers are already in retreat. Their dependence on glacier runoff makes downstream populations, especially those residing on the immediate bank of the river particularly vulnerable to the consequences.

Climate change and its devastating effects such as floods, increasing pollution and environmental degradation will have a direct effect on these industries and factories located right on the banks of this mighty river. Consequently the people who earn a living and sustain themselves and their family from these industries will be the sufferers. With climate change and a rising sea level, the city being located just barely above the mean water level, Kolkata's major industries and logistical infrastructure are in danger of being severely disturbed or even flooded. It is reported on the basis of the model study that the average sea level rise in Diamond Harbour, near the city of Kolkata, stands at 5.74mm per year as against 1.0-2.0mm per year elsewhere; while the number of cyclone may not be significantly increasing, the intensity of cyclone will undoubtedly be on the rise, with possible impact of storm surges becoming very high. (Unnikrishnan, NIO, 2009 at The Energy Conclave, organized by Bengal Chamber of Commerce and Industries, Kolkata).

Climate change may have devastating effects on the transportation system of the city by way of disrupting the Circular Railways running parallel to the river on the East bank and by flooding of the major road network, the entire surface transport system can be seriously affected. When a segment of a road network is closed by floodwater, the various flood-impacts can be observed on the characteristics of traffic flow, including the disruption of communication, traffic congestion, increased traffic volume, decreased speed limit and increased travel time. For this reason, any effect on the route network can be seen as a potential threat to the various characteristics of traffic flow. In the worst-case scenarios, some areas can be completely cut off from other parts.
because of the closure of a road by flooding. Coastal transportation facilities may be at risk of inundation as the sea level rises.

Climate change can have major effects on the water supply of Kolkata. Floods may damage the water supply systems and may also lead to the damage of the sewage disposal system. There may be acute shortage in the supply of drinking water and also the supply of water for domestic and industrial purposes.

There is also a strong possibility in the rise of water borne infections. One of the major effects of floods is the contamination of water, especially drinking water. The damage due to flood may also lead to seeage of sewerage water into the drinking water pipeline. There is an increased risk of infection of water-borne diseases contracted through direct contact with polluted waters, such as wound infections, dermatitis, and conjunctivitis, and ear, nose and throat infections. The only epidemic-prone infection which can be transmitted directly from contaminated water is leptospirosis. Floods may indirectly lead to an increase in vector-borne diseases through the expansion in the number and range of vector habitats. The city is already ill-famed for malaria, dengue, encephalitis, and the resurgence of malaria is causing serious concern for the public health administration. Standing water can act as breeding sites for mosquitoes, and therefore enhance the potential for exposure of the disaster-affected population and emergency workers to infections such as dengue, malaria etc. [21]

The transport of water-borne pathogens such as Cryptosporidium is known to be affected by changes in precipitation and runoff intensities and by land-use practices. The distribution of Vibrio cholerae, the bacteria responsible for cholera, is affected by climate, including El Niño frequency and intensity, temperature, and ocean salinity. The impacts of flooding on health vary between populations for reasons relating to population vulnerability and type of flood event.

Energy production and use are sensitive to changes in the climate. Moreover, all the major thermal power plants are located by the side of the river and can face serious adverse impact. Further, increasing temperatures will reduce consumption of energy for heating but will increase demand for energy used for cooling buildings.
Changes in temperature due to climate change could affect our demand for energy. For example, rising air temperatures will likely lead to substantial increases in energy demand. On the other hand, energy needed for space-heating may decrease. The net effects of these changes on energy production, use and utility bills, will vary by region and by season.

There may also be changes in energy consumed for other climate-sensitive processes, such as pumping water for irrigation in agriculture. Rising temperatures and associated increases in evaporation may increase energy needs for irrigation, particularly in dry regions. [22]

Adaptation and Mitigation:
Disaster Management: Current Status-
For adaptation to climate change, preparedness to cope up with uncertainties of climate is the key issue. The issue calls for a Disaster Management strategy and an effective set-up to implement the strategy.

The key role in Disaster Management is played by the Kolkata Municipal Corporation and the Kolkata Police. The Relief Ministry, recently renamed as Disaster Management Ministry, plays a guiding and supportive role. The Police Commissioner and his team are the backbone of field execution and field coordination of activities during Disaster Stage. The Fire Brigade, renamed as Emergency Services, with its network of 20 Fire Stations in the city also plays a key role.

Though the KMC and the key agencies have a rudimentary Disaster Management Plan, it appears to be inadequate and is not Field tested, rehearsed and well-publicized. It also lacks Standard Operating Procedures. All this, coupled with the lack of coordination and cohesiveness of command, often leads to confusion and delay in starting operations though these are not acknowledged and also not so much felt as multiple agencies and voluntary organizations come forward to offer their services. [23]

The “Aila” Experience:
The failure of Administration to cope up with heavy rain and storm surges on May 25, 2009 is now well documented. More than 3,000 trees were uprooted, electrical wiring snapped, telephone lines
became dead and water supply was badly disrupted. The cyclonic storm hit the city at 80-90 Km/hr after initial hit at 120 Km in the Sunderbans. Even with serious warning of the Met Department civic administration collapsed. Called “Aila” the cyclonic storm is only one of the three possible storm surges and cyclone that could have affected the city-the other two, “Cyder” went off to Bangladesh causing severe damage to lives and livelihood, and “Nargis” hit Myanmar causing death of more than 100,000 people. But ‘Kolkata’ Disaster Management Authority virtually showed no possible ‘adaptation’ strategy. The city suffered four days of power cut due to disruption of electric supply and consequently had terrible time in coping with the shortage of water supply. The road transport suffered significantly due to blockade of roads by more than 3000 uprooted trees.

Post - Aila in May 2009, the Kolkata Municipal Corporation (KMC) had decided to upgrade its Disaster Management Unit with modern equipment and additional manpower.

Significantly, the drainage and sewerage up-gradation project under KEIP (Phase I) covering Behala and Garia (south Kolkata), Tiljala and Topsia (east Kolkata) and Cossipore (north Kolkata), which was supposed to be completed in 2007, is yet to be over. [24]

Under the present scenario, a CBDRM Scheme can be drawn up-

**Table 3: A Community based Disaster Risk Management (CBDRM) Approach to Natural Disaster Mitigation in Kolkata**

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>PREVENTION</th>
<th>MITIGATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Upsurge</td>
<td>Bunds on river channels, drainage</td>
<td>Early Warning System</td>
</tr>
<tr>
<td>Cyclone</td>
<td>Retrofitting Building Roofs, Green Belt Barricade Creation</td>
<td>Safe Houses/Shelters, Community Awareness, Early Warning System</td>
</tr>
<tr>
<td>Flooding &amp; water logging by heavy rain</td>
<td>The city has an old canal system on its flanks which had acted as natural drains. These must be restored.</td>
<td>Community Awareness, Early Warning System Better Pumping System Cleaning of drains/sewer.</td>
</tr>
</tbody>
</table>

Apparently, mitigation measures in the city are too slow to be appreciated. Carbon emission could be checked by clean technology but administration reacted rather too slow to change over; green autorickshaws have come up but old private vehicles still ply. The city is yet to catch up ‘renewable energy’ as thermal power remains the mainstay.
**Vulnerable Areas:**
A list of the KMC wards which lie along the Ganga along with their vulnerability with reference to presence of slum population, maximum number of industries, are given below:

### Table 4: KMC wards along the Ganga

<table>
<thead>
<tr>
<th>KMC Wards along the Ganga</th>
<th>KMC Wards along the Ganga with slum population</th>
<th>KMC wards along the Ganga with maximum total industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 6, 7, 8, 9, 19, 20, 21, 22, 23, 24, 42, 45, 75, 76, 80, 134, 135, 136, 137, 138, 140 and 141</td>
<td>1, 6, 7, 9, 19, 20, 21, 22, 23, 24, 75, 76, 80, 134, 135, 136, 137, 138, 140 and 141</td>
<td>1, 6, 7, 8, 19, 20, 21, 22, 23 and 80</td>
</tr>
<tr>
<td>Total Population – 7,00,974 (15.36%)</td>
<td>Total Population - 6,34,001 (13.89%)</td>
<td>Total Population - 3,50,225 (7.67%)</td>
</tr>
</tbody>
</table>

From the above data, it can be observed that the most vulnerable population (63%) along the river side of the city belongs to the poorer section of the city; it is further observed that 15.36% population of Kolkata remain vulnerable being nearest to the river side.

### Table 5: Tabular Representation of hazards and vulnerable areas

<table>
<thead>
<tr>
<th>HAZARD</th>
<th>VULNERABLE AREAS OF KOLKATA</th>
<th>VULNERABLE COMMUNITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal Upsurge</td>
<td>Low lying areas near the River Hooghly e.g. Garden Reach, Kidderpur, Tollygunge</td>
<td>People, mainly poor or lower middle class living in shanties and old houses in congested areas near the canals</td>
</tr>
<tr>
<td>Cyclone</td>
<td>Exposed areas near the Maidan, South Calcutta and River adjacent West Kolkata</td>
<td>Tile roofed houses; houses near big trees; kuccha houses of shanties</td>
</tr>
<tr>
<td>Flooding &amp; Water logging by heavy rain</td>
<td>Major parts of the city, including Camac Street, Amherst Street, Theatre Road, College Street, M.G Road, Ultadanga, Kankurgachi, Phoolbagan, New Alipore, Southern Avenue, Rashbehari Avenue, Deshapriya Park, Sovabazar, Shyambazar and AJC Bose Road</td>
<td>Single storied houses at level lower than road, kuccha houses, houses in low water collecting areas like end of flyovers/bridges</td>
</tr>
</tbody>
</table>

Conclusion:
The two major uncertainties viz. heavy rainfall and storm surge combined with high tide is a major cause for concern for the river-side dwellers of the city. Since there are no prevalent mitigation measures, these may lead to flooding of the embankments. A 80-100 kmph storm surge may affect the electrical installations including power, water supply, port and harbour facilities located along the river bank. High wind speeds may lead to uprooting of trees which in turn can cause serious impact on the energy transmission lines as well as overhead telephone connections, severing communication lines.

Flooding of streets can cause serious impediment for traffic movement and disruption of civic life. Water-logging especially in slum areas can lead to fast breeding of vector and quicker spread of vector-borne diseases. Flooding can also affect the slum water supply system and past records show that contamination of drinking water has lead to serious outbreak of enteric diseases among poorer sections of the people. Currently, there is no effective management system in place to cope up with the disasters that can be caused by the events due to climate change. The City still lacks a well-designed and implementable “Disaster Management Plan”. There is no infrastructure and man-power support even if the DMP is prepared, for implementing it in to action. There is no dedicated and trained volunteer corps to deal with climate change-related events. Evacuation shelter for the population in the slum areas are still wanting, especially for the river-side population.

The required emergency medical services including transport of medical personnel and medicines are still being done in an ad-hoc manner. Varied combinations of these natural phenomena affect the daily wage earners and the commuters to the highest degree; the “poorest of the poor” continue to be the worst affected.

Currently, the Disaster Management Programme and facilities is less than adequate. A coordination cell to relate the activities of the service sector and relief operations is still to come up. The city still lacks a mock-drill and evacuation system.
References:
b) KMC/ KMDA Websites, Calcutta Gazetteer, Manual of Relief, NIDMWBI Courseware, ABP & Times of India, BBC, Various Websites and Magazines, SPADE Leaflet
[18] Integrated City Making, Governance, Planning and transport- London School of Economics and Political Science
b) KMC/ KMDA Websites, Calcutta Gazetteer, Manual of Relief, NIDMWBI Courseware, ABP & Times of India, BBC, Various Websites and Magazines, SPADE Leaflet
Source of the Pictures:
[3] www.dia.about.com...Howrah-Bridge.htm
[6] Picture by Sucheta Das- Photojournalist
[7] httpcdn.wn.com/20090427923eca66c5d0b4f6330e8dfb667f8d1e-grande.jpg
[9] httpa.abcnews.com/images/Blottercdc_malaria_mosquito_070607_ssh.jpg
[10] httpimages.google.co.in/imgresimgurl=httpwww.indialine.comtravelimages/kolkata-citytransportation.jpg&imgrefurl=httpwww.indialine.com/ travelwestbengalpackages.html&usg=__nVws1KH67Dq
[12] Picture by Green Peace
Regional Policy Action Platform on Climate Change

Climate change can be viewed as one of the most critical environmental problems to confront us as it is most immediately and inextricably linked to wellbeing, development and economic growth. Thus the solutions to it cannot be left to the confines of the environment but needs to seek clarity and consolidate its response relating the agendas and interests of the multiple constituencies.

Recognising the need for a coordinated proactive response to climate change, WWF-India has developed the concept of “Talking Solutions”, which is a process that builds a consolidated understanding, informing a strategic response from among the various key constituencies. As a part of this initiative, a Regional Policy Action Platform on Climate Change (RPAPCC) was formed in the state of West Bengal, India.

Papers in this series are:

1. Climate change adaptation in flood plain of West Bengal
2. Climate change adaptation in coastal region of West Bengal
3. Climate change adaptation in arid region of West Bengal

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